NC Residential Code
Ad-Hoc Committee

Submitted to
the NC Building Code Council on
December 13, 2016

Recommended Amendments for
the 2018 NC Residential Code
# NORTH CAROLINA STATE BUILDING CODE COUNCIL

**OCTOBER 12, 2016**

[Website Link]

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PREFACE

Introduction

Internationally, code officials recognize the need for a modern, up-to-date residential code addressing the design and construction of one- and two-family dwellings and townhouses. The *International Residential Code®,* in this 2015 edition, is designed to meet these needs through model code regulations that safeguard the public health and safety in all communities, large and small.


The *International Residential Code®* provisions provide many benefits, among which is the model code development process that offers an international forum for residential construction professionals to discuss prescriptive code requirements. This forum provides an excellent arena to debate proposed revisions. This model code also encourages international consistency in the application of provisions.

Development

The first edition of the *International Residential Code* (2000) was the culmination of an effort initiated in 1996 by a development committee appointed by ICC and consisting of representatives from the three statutory members of the International Code Council at the time, including: Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO) and Southern Building Code Congress International (SBCCI), and representatives from the National Association of Home Builders (NAHB). The intent was to draft a stand-alone residential code consistent with and inclusive of the scope of the existing model codes. Technical content of the 1998 *International One- and Two-Family Dwelling Code* and the latest model codes promulgated by BOCA, ICBO, SBCCI and ICC was used as the basis for the development, followed by public hearings in 1998 and 1999 to consider proposed changes. This 2015 edition represents the code as originally issued, with changes reflected in the 2009 through 2012 editions, and further changes developed through the ICC Code Development Process through 2013. Residential electrical provisions are based
on the 2014 *National Electrical Code*® (NFPA 70). A new edition such as this is promulgated every three years.

Energy provisions in Chapter 11 are duplicated from the *International Energy Conservation Code*®—Residential Provisions applicable to residential buildings which fall under the scope of this code.

Fuel gas provisions have been included through an agreement with the American Gas Association (AGA). Electrical provisions have been included through an agreement with the National Fire Protection Association (NFPA).

This code is founded on principles intended to establish provisions consistent with the scope of a residential code that adequately protects public health, safety and welfare; provisions that do not unnecessarily increase construction costs; provisions that do not restrict the use of new materials, products or methods of construction; and provisions that do not give preferential treatment to particular types or classes of materials, products or methods of construction.

**Adoption**

The International Code Council maintains a copyright in all of its codes and standards. Maintaining copyright allows ICC to fund its mission through sales of books, in both print and electronic formats. The *International Residential Code* is designed for adoption and use by jurisdictions that recognize and acknowledge the ICC’s copyright in the code, and further acknowledge the substantial shared value of the public/private partnership for code development between jurisdictions and the ICC.

The ICC also recognizes the need for jurisdictions to make laws available to the public. All ICC codes and ICC standards, along with the laws of many jurisdictions, are available for free in a non-downloadable form on the ICC’s website. Jurisdictions should contact the ICC at adoptions@icc.safe.org to learn how to adopt and distribute laws based on the *International Residential Code* in a manner that provides necessary access, while maintaining the ICC’s copyright.

**Maintenance**

The *International Residential Code* is kept up-to-date through the review of proposed changes submitted by code enforcing officials, industry representatives, design professionals and other interested parties. Proposed changes are carefully considered through an open code development process in which all interested and affected parties may participate.

The contents of this work are subject to change both through the code development cycles and the governmental body that enacts the code into law. For more information regarding the code development process, contact the Codes and Standards Development Department of the International Code Council.

The maintenance process for the fuel gas provisions is based upon the process used to maintain the *International Fuel Gas Code*, in conjunction with the American Gas Association.
The maintenance process for the electrical provisions is undertaken by the National Fire Protection Association.

While the development procedure of the *International Residential Code* ensures the highest degree of care, ICC, the founding members of ICC, its members and those participating in the development of this code do not accept any liability resulting from compliance or noncompliance with the provisions because ICC and its founding members do not have the power or authority to police or enforce compliance with the contents of this code. Only the governmental body that enacts the code into law has such authority.

**Code Development Committee Responsibilities**

In each code development cycle, proposed changes to the code are considered at the Committee Action Hearings by the applicable International Code Development Committee as follows:

[RBC] = IRC—Building Code Development Committee
(RE) = Residential Energy Code Development Committee
[RMP] = IRC—Mechanical/Plumbing Code Development Committee

The [RE] committee is also responsible for the IECC—Residential Provisions.

For the development of the 2018 edition of the I-Codes, there will be three groups of code development committees and they will meet in separate years. Note that these are tentative groups.

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<tr>
<td>International Building Code – Fire Safety (Chapters 7, 8, 9, 14, 26) – Means of Egress (Chapters 10, 11, Appendix E) – General (Chapters 2-6, 12, 27-33, Appendices A, B, C, D, K)</td>
<td>Administrative Provisions (Chapter 1 all codes except the IRC and IECC, administrative updates to currently referenced standards, and designated definitions)</td>
<td>International Green Construction Code</td>
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<td>International Mechanical Code</td>
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<td>International Private Sewage Disposal Code</td>
<td>International Wildland-Urban Interface Code</td>
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2018 North Carolina Residential Code
### Marginal Markings

Solid vertical lines in the margins within the body of the code indicate a technical change from the requirements of the 2012 edition. Deletion indicators in the form of an arrow (☐) are provided in the margin where an entire section, paragraph, exception or table has been deleted or an item in a list of items or a table has been deleted.

A single asterisk (*) placed in the margin indicates that text or a table has been relocated within the code. A double asterisk (**) placed in the margin indicates that the text or table immediately following it has been relocated there from elsewhere in the code. The following table indicates such relocations in the 2015 edition of the *International Residential Code*.

#### 2015 LOCATION
<table>
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<tr>
<th>2012 LOCATION</th>
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<tr>
<td>R302.13</td>
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<td>R404.1.1</td>
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### Italicized Terms

2018 North Carolina Residential Code
Selected terms set forth in Chapter 2, Definitions, are italicized where they appear in code text. Such terms are not italicized where the definition set forth in Chapter 2 does not impart the intended meaning in the use of the term. The terms selected have definitions that the user should read carefully to better understand the code.
Effective Use of the International Residential Code

The International Residential Code® (IRC®) was created to serve as a complete, comprehensive code regulating the construction of single-family houses, two-family houses (duplexes) and buildings consisting of three or more townhouse units. All buildings within the scope of the IRC are limited to three stories above grade plane. For example, a four-story single-family house would fall within the scope of the International Building Code® (IBC®), not the IRC. The benefits of devoting a separate code to residential construction include the fact that the user need not navigate through a multitude of code provisions that do not apply to residential construction in order to locate that which is applicable. A separate code also allows for residential and nonresidential code provisions to be distinct and tailored to the structures that fall within the appropriate code’s scopes.

The IRC contains coverage for all components of a house or townhouse, including structural components, fireplaces and chimneys, thermal insulation, mechanical systems, fuel gas systems, plumbing systems and electrical systems.

The IRC is a prescriptive-oriented (specification) code with some examples of performance code language. It has been said that the IRC is the complete cookbook for residential construction. Section R301.1, for example, is written in performance language, but states that the prescriptive requirements of the code will achieve such performance.

It is important to understand that the IRC contains coverage for what is conventional and common in residential construction practice. While the IRC will provide all of the needed coverage for most residential construction, it might not address construction practices and systems that are atypical or rarely encountered in the industry. Sections such as R301.1.3, R301.2.2.1.1, R320.1, M1301.1, G2401.1 and P2601.1 refer to other codes either as an alternative to the provisions of the IRC or where the IRC lacks coverage for a particular type of structure, design, system, appliance or method of construction. In other words, the IRC is meant to be all inclusive for typical residential construction and it relies on other codes only where alternatives are desired or where the code lacks coverage for the uncommon aspect of residential construction. Of course, the IRC constantly evolves to address new technologies and construction practices that were once uncommon, but now common.

The IRC is unique in that much of it, including Chapters 3 through 9 and Chapters 34 through 43, is presented in an ordered format that is consistent with the normal progression of construction, starting with the design phase and continuing through the final trim-out phase. This is consistent with the “cookbook” philosophy of the IRC.

The following provides a brief description of the content of each chapter and appendix of the IRC:

Chapter 1 Scope and Administration. This chapter contains provisions for the application, enforcement and administration of subsequent requirements of the code. In addition to establishing the scope of the code, Chapter 1 identifies which buildings and structures come under its purview. Chapter 1 is largely concerned with maintaining “due process of law” in enforcing the building criteria contained in the body of the code. Only through careful observation of the administrative provisions can the building official reasonably expect to demonstrate that “equal protection under the law” has been provided.

Chapter 2 Definitions. Terms defined in the code are listed alphabetically in Chapter 2. It is important to note that two chapters have their own definitions sections: Chapter 24 for the defined terms that are unique to fuel gas and Chapter 35 containing terms that are applicable to electrical Chapters 34 through 43. In the case where Chapter 2 and another chapter both define the same term differently, the definition found in Chapter 24 and/or 35 is intended to prevail where the term is used in Chapter 24 and/or 35 and the definition contained in Chapter 2 is intended to prevail where the term is used in all other locations in the code. Except where Chapter 24 or 35 has a definition that will prevail therein, the definitions in Chapter 2 are applicable throughout the code.

Where understanding a term’s definition is key to or necessary for understanding a particular code provision, the term is shown in italics where it appears in the code. This is true only for those terms that have a meaning that is unique to the code. In other words, the generally understood meaning of a term or phrase might not be sufficient or consistent with the meaning prescribed by the code; therefore, it is essential that the code-defined meaning be known.

Guidance regarding not only tense, gender and plurality of defined terms, but also terms not defined in this code, is provided.

Chapter 3 Building Planning. Chapter 3 provides guidelines for a minimum level of structural integrity, life safety, fire safety and livability for inhabitants of dwelling units regulated by this code. Chapter 3 is a compilation of the code requirements specific to the building planning sector of the design and construction process. This chapter sets forth code requirements dealing with light, ventilation, sanitation, minimum room size, ceiling height and environmental comfort. Chapter 3 establishes life-safety provisions including limitations on glazing used in hazardous areas, specifications on stairways, use of guards at elevated surfaces, window and fall protection, and rules for means of egress. Snow, wind and seismic design live and dead loads and flood-resistant construction, as well as solar energy systems, and swimming pools, spas and hot tubs, are addressed in this chapter.

Chapter 4 Foundations. Chapter 4 provides the requirements for the design and construction of foundation systems for buildings regulated by this code. Provisions for seismic load, flood load and frost protection are contained in this chapter. A foundation system consists of two interdependent components: the foundation structure itself and the supporting soil.

The prescriptive provisions of this chapter provide requirements for constructing footings and walls for foundations of wood, masonry, concrete and precast concrete. In addition to a foundation’s ability to support the required design loads, this chapter addresses several other
factors that can affect foundation performance. These include controlling surface water and subsurface drainage, requiring soil tests where conditions warrant and evaluating proximity to slopes and minimum depth requirements. The chapter also provides requirements to minimize adverse effects of moisture, decay and pests in basements and crawl spaces.

Chapter 5 Floors. Chapter 5 provides the requirements for the design and construction of floor systems that will be capable of supporting minimum required design loads. This chapter covers four different types: wood floor framing, wood floors on the ground, cold-formed steel floor framing and concrete slabs on the ground. Allowable span tables are provided that greatly simplify the determination of joist, girder and sheathing sizes for raised floor systems of wood framing and cold-formed steel framing. This chapter also contains prescriptive requirements for wood-framed exterior decks and their attachment to the main building.

Chapter 6 Wall Construction. Chapter 6 contains provisions that regulate the design and construction of walls. The wall construction covered in Chapter 6 consists of five different types: wood framed, cold-formed steel framed, masonry, concrete and structural insulated panel (SIP). The primary concern of this chapter is the structural integrity of wall construction and transfer of all imposed loads to the supporting structure. This chapter provides the requirements for the design and construction of wall systems that are capable of supporting the minimum design vertical loads (dead, live and snow loads) and lateral loads (wind or seismic loads). This chapter contains the prescriptive requirements for wall bracing and/or shear walls to resist the imposed lateral loads due to wind and seismic.

Chapter 6 also regulates exterior windows and doors installed in walls. The chapter contains criteria for the performance of exterior windows and doors and includes provisions for testing and labeling, garage doors, wind-borne debris protection and anchorage details.

Chapter 7 Wall Covering. Chapter 7 contains provisions for the design and construction of interior and exterior wall coverings. This chapter establishes the various types of materials, materials standards and methods of application permitted for use as interior coverings, including interior plaster, gypsum board, ceramic tile, wood veneer paneling, hardboard paneling, wood shakes and wood shingles. Chapter 7 also contains requirements for the use of vapor retarders for moisture control in walls.

Exterior wall coverings provide the weather-resistant exterior envelope that protects the building’s interior from the elements. Chapter 7 provides the requirements for wind resistance and water-resistive barrier for exterior wall coverings. This chapter prescribes the exterior wall coverings as well as the water-resistive barrier required beneath the exterior materials. Exterior wall coverings regulated by this section include aluminum, stone and masonry veneer, wood, hardboard, particleboard, wood structural panel siding, wood shakes and shingles, exterior plaster, steel, vinyl, fiber cement and exterior insulation finish systems.

Chapter 8 Roof-ceiling Construction. Chapter 8 regulates the design and construction of roof-ceiling systems. This chapter contains two roof-ceiling framing systems: wood framing and cold-formed steel framing. Allowable span tables are provided to simplify the selection of rafter and ceiling joist size for wood roof framing and cold-formed steel framing. Chapter 8 also provides requirements for the application of ceiling finishes, the proper ventilation of concealed spaces in roofs (e.g., enclosed attics and rafter spaces), unvented attic assemblies and attic access.
Chapter 9 Roof Assemblies. Chapter 9 regulates the design and construction of roof assemblies. A roof assembly includes the roof deck, vapor retarder, substrate or thermal barrier, insulation, vapor retarder and roof covering. This chapter provides the requirement for wind resistance of roof coverings.

The types of roof covering materials and installation regulated by Chapter 9 are: asphalt shingles, clay and concrete tile, metal roof shingles, mineral-surfaced roll roofing, slate and slate-type shingles, wood shakes and shingles, built-up roofs, metal roof panels, modified bitumen roofing, thermoset and thermoplastic single-ply roofing, sprayed polyurethane foam roofing, liquid applied coatings and photovoltaic shingles. Chapter 9 also provides requirements for roof drainage, flashing, above deck thermal insulation, rooftop-mounted photovoltaic systems and recovering or replacing an existing roof covering.

Chapter 10 Chimneys and Fireplaces. Chapter 10 contains requirements for the safe construction of masonry chimneys and fireplaces and establishes the standards for the use and installation of factory-built chimneys, fireplaces and masonry heaters. Chimneys and fireplaces constructed of masonry rely on prescriptive requirements for the details of their construction; the factory-built type relies on the listing and labeling method of approval. Chapter 10 provides the requirements for seismic reinforcing and anchorage of masonry fireplaces and chimneys.

Chapter 11 [RE] Energy Efficiency. The purpose of Chapter 11 [RE] is to provide minimum design requirements that will promote efficient utilization of energy in buildings. The requirements are directed toward the design of building envelopes with adequate thermal resistance and low air leakage, and toward the design and selection of mechanical, water heating, electrical and illumination systems that promote effective use of depletable energy resources. The provisions of Chapter 11 [RE] are duplicated from the International Energy Conservation Code—Residential Provisions, as applicable for buildings which fall under the scope of the IRC.

For ease of use and coordination of provisions, the corresponding IECC—Residential Provisions section number is indicated following the IRC section number [e.g. N1102.1 (R402.1)].

Chapter 12 Mechanical Administration. Chapter 12 establishes the limits of applicability of the code and describes how the code is to be applied and enforced. A mechanical code, like any other code, is intended to be adopted as a legally enforceable document and it cannot be effective without adequate provisions for its administration and enforcement. The provisions of Chapter 12 establish the authority and duties of the code official appointed by the jurisdiction having authority and also establish the rights and privileges of the design professional, contractor and property owner. It also relates this chapter to the administrative provisions in Chapter 1.

Chapter 13 General Mechanical System Requirements. Chapter 13 contains broadly applicable requirements related to appliance listing and labeling, appliance location and installation, appliance and systems access, protection of structural elements and clearances to combustibles, among others.

Chapter 14 Heating and Cooling Equipment and Appliances. Chapter 14 is a collection of requirements for various heating and cooling appliances, dedicated to single topics by section. The common theme is that all of these types of appliances use energy in one form or another,
and the improper installation of such appliances would present a hazard to the occupants of the dwellings, due to either the potential for fire or the accidental release of refrigerants. Both situations are undesirable in dwellings that are covered by this code.

Chapter 15 Exhaust Systems. Chapter 15 is a compilation of code requirements related to residential exhaust systems, including kitchens and bathrooms, clothes dryers and range hoods. The code regulates the materials used for constructing and installing such duct systems. Air brought into the building for ventilation, combustion or makeup purposes is protected from contamination by the provisions found in this chapter.

Chapter 16 Duct Systems. Chapter 16 provides requirements for the installation of ducts for supply, return and exhaust air systems. This chapter contains no information on the design of these systems from the standpoint of air movement, but is concerned with the structural integrity of the systems and the overall impact of the systems on the fire-safety performance of the building. This chapter regulates the materials and methods of construction which affect the performance of the entire air distribution system.

Chapter 17 Combustion Air. Complete combustion of solid and liquid fuel is essential for the proper operation of appliances, control of harmful emissions and achieving maximum fuel efficiency. If insufficient quantities of oxygen are supplied, the combustion process will be incomplete, creating dangerous byproducts and wasting energy in the form of unburned fuel (hydrocarbons). The byproducts of incomplete combustion are poisonous, corrosive and combustible, and can cause serious appliance or equipment malfunctions that pose fire or explosion hazards.

The combustion air provisions in this code from previous editions have been deleted from Chapter 17 in favor of a single section that directs the user to NFPA 31 for oil-fired appliance combustion air requirements and the manufacturer's installation instructions for solid fuel-burning appliances. If fuel gas appliances are used, the provisions of Chapter 24 must be followed.

Chapter 18 Chimneys and Vents. Chapter 18 regulates the design, construction, installation, maintenance, repair and approval of chimneys, vents and their connections to fuel-burning appliances. A properly designed chimney or vent system is needed to conduct the flue gases produced by a fuel-burning appliance to the outdoors. The provisions of this chapter are intended to minimize the hazards associated with high temperatures and potentially toxic and corrosive combustion gases. This chapter addresses factory-built and masonry chimneys, vents and venting systems used to vent oil-fired and solid fuel-burning appliances.

Chapter 19 Special Appliances, Equipment and Systems. Chapter 19 regulates the installation of fuel-burning appliances that are not covered in other chapters, such as ranges and ovens, sauna heaters, fuel cell power plants and hydrogen systems. Because the subjects in this chapter do not contain the volume of text necessary to warrant individual chapters, they have been combined into a single chapter. The only commonality is that the subjects use energy to perform some task or function. The intent is to provide a reasonable level of protection for the occupants of the dwelling.

Chapter 20 Boilers and Water Heaters. Chapter 20 regulates the installation of boilers and water heaters. Its purpose is to protect the occupants of the dwelling from the potential hazards associated with such appliances. A water heater is any appliance that heats potable water and
supplies it to the plumbing hot water distribution system. A boiler either heats water or generates steam for space heating and is generally a closed system.

**Chapter 21 Hydronic Piping.** Hydronic piping includes piping, fittings and valves used in building space conditioning systems. Applications include hot water, chilled water, steam, steam condensate, brines and water/antifreeze mixtures. Chapter 21 regulates installation, alteration and repair of all hydronic piping systems to insure the reliability, serviceability, energy efficiency and safety of such systems.

**Chapter 22 Special Piping and Storage Systems.** Chapter 22 regulates the design and installation of fuel oil storage and piping systems. The regulations include reference to construction standards for above-ground and underground storage tanks, material standards for piping systems (both above-ground and underground) and extensive requirements for the proper assembly of system piping and components. The purpose of this chapter is to prevent fires, leaks and spills involving fuel oil storage and piping systems, whether inside or outside structures and above or underground.

**Chapter 23 Solar Thermal Energy Systems.** Chapter 23 contains requirements for the construction, alteration and repair of all systems and components of solar thermal energy systems used for space heating or cooling, and domestic hot water heating or processing. The provisions of this chapter are limited to those necessary to achieve installations that are relatively hazard free.

A solar thermal energy system can be designed to handle 100 percent of the energy load of a building, although this is rarely accomplished. Because solar energy is a low-intensity energy source and dependent on the weather, it is usually necessary to supplement a solar thermal energy system with traditional energy sources.

As our world strives to find alternate means of producing power for the future, the requirements of this chapter will become more and more important over time.

**Chapter 24 Fuel Gas.** Chapter 24 regulates the design and installation of fuel gas distribution piping and systems, appliances, appliance venting systems and combustion air provisions. The definition of “Fuel gas” includes natural, liquefied petroleum and manufactured gases and mixtures of these gases.

The purpose of this chapter is to establish the minimum acceptable level of safety and to protect life and property from the potential dangers associated with the storage, distribution and use of fuel gases and the byproducts of combustion of such fuels. This code also protects the personnel who install, maintain, service and replace the systems and appliances addressed herein.

Chapter 24 is composed entirely of text extracted from the IFGC; therefore, whether using the IFGC or the IRC, the fuel gas provisions will be identical. Note that to avoid the potential for confusion and conflicting definitions, Chapter 24 has its own definition section.

**Chapter 25 Plumbing Administration.** The requirements of Chapter 25 do not supersede the administrative provisions of Chapter 1. Rather, the administrative guidelines of Chapter 25 pertain to plumbing installations that are best referenced and located within the plumbing chapters. This chapter addresses how to apply the plumbing provisions of this code to specific
types or phases of construction. This chapter also outlines the responsibilities of the applicant, installer and inspector with regard to testing plumbing installations.

Chapter 26 General Plumbing Requirements. The content of Chapter 26 is often referred to as "miscellaneous," rather than general plumbing requirements. This is the only chapter of the plumbing chapters of the code whose requirements do not interrelate. If a requirement cannot be located in another plumbing chapter, it should be located in this chapter. Chapter 26 contains safety requirements for the installation of plumbing systems and includes requirements for the identification of pipe, pipe fittings, traps, fixtures, materials and devices used in plumbing systems. If specific provisions do not demand that a requirement be located in another chapter, the requirement is located in this chapter.

Chapter 27 Plumbing Fixtures. Chapter 27 requires fixtures to be of the proper type, approved for the purpose intended and installed properly to promote usability and safe, sanitary conditions. This chapter regulates the quality of fixtures and faucets by requiring those items to comply with nationally recognized standards. Because fixtures must be properly installed so that they are usable by the occupants of the building, this chapter contains the requirements for the installation of fixtures.

Chapter 28 Water Heaters. Chapter 28 regulates the design, approval and installation of water heaters and related safety devices. The intent is to minimize the hazards associated with the installation and operation of water heaters. Although this chapter does not regulate the size of a water heater, it does regulate all other aspects of the water heater installation such as temperature and pressure relief valves, safety drip pans and connections. Where a water heater also supplies water for space heating, this chapter regulates the maximum water temperature supplied to the water distribution system.

Chapter 29 Water Supply and Distribution. This chapter regulates the supply of potable water from both public and individual sources to every fixture and outlet so that it remains potable and uncontaminated by cross connections. Chapter 29 also regulates the design of the water distribution system, which will allow fixtures to function properly. Because it is critical that the potable water supply system remain free of actual or potential sanitary hazards, this chapter has the requirements for providing backflow protection devices.

Chapter 30 Sanitary Drainage. The purpose of Chapter 30 is to regulate the materials, design and installation of sanitary drainage piping systems as well as the connections made to the system. The intent is to design and install sanitary drainage systems that will function reliably, are neither undersized nor oversized and are constructed from materials, fittings and connections whose quality is regulated by this section. This chapter addresses the proper use of fittings for directing the flow into and within the sanitary drain piping system. Materials and provisions necessary for servicing the drainage system are also included in this chapter.

Chapter 31 Vents. Venting protects the trap seal of each trap. The vents are designed to limit differential pressures at each trap to 1 inch of water column (249 Pa). Because waste flow in the drainage system creates pressure fluctuations that can negatively affect traps, the sanitary drainage system must have a properly designed venting system. Chapter 31 covers the requirements for vents and venting. All of the provisions set forth in this chapter are intended to limit the pressure differentials in the drainage system to a maximum of 1 inch of water column (249 Pa) above or below atmospheric pressure (i.e., positive or negative pressures).
Chapter 32 Traps. Traps prevent sewer gas from escaping from the drainage piping into the building. Water seal traps are the simplest and most reliable means of preventing sewer gas from entering the interior environment. This chapter lists prohibited trap types as well as specifies the minimum trap size for each type of fixture.

Chapter 33 Storm Drainage. Rainwater infiltration into the ground adjacent to a building can cause the interior of foundation walls to become wet. The installation of a subsoil drainage system prevents the build-up of rainwater on the exterior of the foundation walls. This chapter provides the specifications for subsoil drain piping. Where the discharge of the subsoil drain system is to a sump, this chapter also provides coverage for sump construction, pumps and discharge piping.

Chapter 34 General Requirements. This chapter contains broadly applicable, general and miscellaneous requirements including scope, listing and labeling, equipment locations and clearances for conductor materials and connections and conductor identification.

Chapter 35 Electrical Definitions. Chapter 35 is the repository of the definitions of terms used in the body of Part VIII of the code. To avoid the potential for confusion and conflicting definitions, Part VIII, Electrical, has its own definition chapter.

Codes are technical documents and every word, term and punctuation mark can impact the meaning of the code text and the intended results. The code often uses terms that have a unique meaning in the code, which can differ substantially from the ordinarily understood meaning of the term as used outside of the code.

The terms defined in Chapter 35 are deemed to be of prime importance in establishing the meaning and intent of the electrical code text that uses the terms. The user of the code should be familiar with and consult this chapter because the definitions are essential to the correct interpretation of the code and because the user may not be aware that a term is defined.

Chapter 36 Services. This chapter covers the design, sizing and installation of the building's electrical service equipment and grounding electrode system. It includes an easy-to-use load calculation method and service conductor sizing table. The electrical service is generally the first part of the electrical system to be designed and installed.

Chapter 37 Branch Circuit and Feeder Requirements. Chapter 37 addresses the requirements for designing the power distribution system which consists of feeders and branch circuits emanating from the service equipment. This chapter dictates the ratings of circuits and the allowable loads, the number and types of branch circuits required, the wire sizing for such branch circuits and feeders and the requirements for protection from overcurrent for conductors. A load calculation method specific to feeders is also included. This chapter is used to design the electrical system on the load side of the service.

Chapter 38 Wiring Methods. Chapter 38 specifies the allowable wiring methods, such as cable, conduit and raceway systems, and provides the installation requirements for the wiring methods. This chapter is primarily applicable to the “rough-in” phase of construction.

Chapter 39 Power and Lighting Distribution. This chapter mostly contains installation requirements for the wiring that serves the lighting outlets, receptacle outlets, appliances and switches located throughout the building. The required distribution and spacing of receptacle
outlets and lighting outlets is prescribed in this chapter, as well as the requirements for ground-fault and arc-fault circuit interrupter protection.

**Chapter 40 Devices and Luminaires.** This chapter focuses on the devices, including switches and receptacles, and lighting fixtures that are typically installed during the final phase of construction.

**Chapter 41 Appliance Installation.** Chapter 41 addresses the installation of appliances including HVAC appliances, water heaters, fixed space-heating equipment, dishwashers, garbage disposals, range hoods and suspended paddle fans.

**Chapter 42 Swimming Pools.** This chapter covers the electrical installation requirements for swimming pools, storable swimming pools, wading pools, decorative pools, fountains, hot tubs, spas and hydromassage bathtubs. The allowable wiring methods are specified along with the required clearances between electrical system components and pools, spas and tubs. This chapter includes the special grounding requirements related to pools, spas and tubs, and also prescribes the equipotential bonding requirements that are unique to pools, spas and tubs.

**Chapter 43 Class 2 Remote-control, Signaling and Power-limited Circuits.** This chapter covers the power supplies, wiring methods and installation requirements for the Class 2 circuits found in dwellings. Such circuits include thermostat wiring, alarm systems, security systems, automated control systems and doorbell systems.

**Chapter 44 Referenced Standards.** The code contains numerous references to standards that are used to regulate materials and methods of construction. Chapter 44 contains a comprehensive list of all standards that are referenced in the code. The standards are part of the code to the extent of the reference to the standard. Compliance with the referenced standard is necessary for compliance with this code. By providing specifically adopted standards, the construction and installation requirements necessary for compliance with the code can be readily determined. The basis for code compliance is, therefore, established and available on an equal basis to the code official, contractor, designer and owner.

Chapter 44 is organized in a manner that makes it easy to locate specific standards. It lists all of the referenced standards, alphabetically, by acronym of the promulgating agency of the standard. Each agency’s standards are then listed in either alphabetical or numeric order based upon the standard identification. The list also contains the title of the standard; the edition (date) of the standard referenced; any addenda included as part of the ICC adoption; and the section or sections of this code that reference the standard.

**Chapter 45 High Wind Zones.** This chapter applies to buildings constructed in North Carolina high wind zones. These provisions shall be in addition to or in lieu of the requirements of Chapters 1-10.

**Chapter 46 Coastal and Flood Plain Standards.** The requirements of this chapter apply to all construction location within areas identified by governmental agency (state and federal) as coastal high hazard area, ocean hazard areas, the regulatory flood plain areas, and all areas designated as 150 miles per hour (67 m/s) wind zone.
Appendix A Sizing and Capacities of Gas Piping. This appendix is informative and not part of the code. It provides design guidance, useful facts and data and multiple examples of how to apply the sizing tables and sizing methodologies of Chapter 24.

Appendix B Sizing of Venting Systems Serving Appliances Equipped with Draft Hoods, Category I Appliances and Appliances Listed for Use with Type B Vents. This appendix is informative and not part of the code. It contains multiple examples of how to apply the vent and chimney tables and methodologies of Chapter 24.

Appendix C Exit Terminals of Mechanical Draft and Direct-vent Venting Systems. This appendix is informative and not part of the code. It consists of a figure and notes that visually depict code requirements from Chapter 24 for vent terminals with respect to the openings found in building exterior walls.

Appendix D Recommended Procedure for Safety Inspection of an Existing Appliance Installation. This appendix is informative and not part of the code. It provides recommended procedures for testing and inspecting an appliance installation to determine if the installation is operating safely and if the appliance is in a safe condition.

Appendix E Manufactured Housing Used as Dwellings. The criteria for the construction of manufactured homes are governed by the National Manufactured Housing Construction and Safety Act. While this act may seem to cover the bulk of the construction of manufactured housing, it does not cover those areas related to the placement of the housing on the property. The provisions of Appendix E are not applicable to the design and construction of manufactured homes. Appendix E provides a complete set of regulations in conjunction with federal law for the installation of manufactured housing. This appendix also contains provisions for existing manufactured home installations.

Appendix F Passive Radon Gas Controls. Radon comes from the natural (radioactive) decay of the element radium in soil, rock and water and finds its way into the air. Appendix F contains requirements to mitigate the transfer of radon gases from the soil into the dwelling. The provisions of this appendix regulate the design and construction of radon-resistant measures intended to reduce the entry of radon gases into the living space of residential buildings.

Appendix G Piping Standards for Various Applications. Appendix G provides standards for various types of plastic piping products. This appendix is informative and is not part of the code.

Appendix H Patio Covers. Appendix H sets forth the regulations and limitations for patio covers. The provisions address those uses permitted in patio cover structures, the minimum design loads to be assigned for structural purposes, and the effect of the patio cover on egress and emergency escape or rescue from sleeping rooms. This appendix also contains the special provisions for aluminum screen enclosures in hurricane-prone regions.

Appendix I Private Sewage Disposal. Appendix I simply provides the opportunity to utilize the International Private Sewage Disposal Code for the design and installation of private sewage disposal in one- and two-family dwellings.

Appendix J Existing Buildings and Structures. Appendix J contains the provisions for the repair, renovation, alteration and reconstruction of existing buildings and structures that are within the scope of this code. To accomplish this objective and to make the rehabilitation
process more available, this appendix allows for a controlled departure from full code compliance without compromising minimum life safety, fire safety, structural and environmental features of the rehabilitated existing building or structure.

**Appendix K Sound Transmission.** Appendix K regulates the sound transmission of wall and floor-ceiling assemblies separating dwelling units and townhouse units. Air-borne sound insulation is required for walls. Air-borne sound insulation and impact sound insulation are required for floor-ceiling assemblies. The provisions in Appendix K set forth a minimum Sound Transmission Class (STC) rating for common walls and floor-ceiling assemblies between dwelling units. In addition, a minimum Impact Insulation Class (IIC) rating is also established to limit structure-borne sound through common floor-ceiling assemblies separating dwelling units.

**Appendix L Permit Fees.** Appendix L provides guidance to jurisdictions for setting appropriate permit fees. This appendix will aid many jurisdictions to assess permit fees that will assist to fairly and properly administer the code. This appendix can be used for informational purposes only or may be adopted when specifically referenced in the adopting ordinance.

**Appendix M Home Day Care—R-3 Occupancy.** Appendix M provides means of egress and smoke detection requirements for a Group R-3 Occupancy that is to be used as a home day care for more than five children who receive custodial care for less than 24 hours. This appendix is strictly for guidance and/or adoption by those jurisdictions that have Licensed Home Care Provider laws and statutes that allow more than five children to be cared for in a person’s home. When a jurisdiction adopts this appendix, the provisions for day care and child care facilities in the IBC should be considered also.

**Appendix N Venting Methods.** Because venting of sanitary drainage systems is perhaps the most difficult concept to understand, and Chapter 31 uses only words to describe venting requirements, illustrations can offer greater insight into what the words mean. Appendix N has a number of illustrations for commonly installed sanitary drainage systems in order for the reader to gain a better understanding of this code’s venting requirements.

**Appendix O Automatic Vehicular Gates.** Appendix O provides the requirements for the design and construction of automatic vehicular gates. The provisions are for where automatic gates are installed for use at a vehicular entrance or exit on the lot of a one- or two-family dwelling. The requirements provide protection for individuals from potential entrapment between an automatic gate and a stationary object or surface.

**Appendix P Sizing of Water Piping System.** Appendix P provides two recognized methods for sizing the water service and water distribution piping for a building. The method under Section AP103 provides friction loss diagrams that require the user to “plot” points and read values from the diagrams in order to perform the required calculations and necessary checks. This method is the most accurate of the two presented in this appendix. The method under Section AP201 is known to be conservative; however, very few calculations are necessary in order to determine a pipe size that satisfies the flow requirements of any application.

**Appendix Q ICC International Residential Code Electrical Provisions/National Electrical Code Cross Reference.** This appendix provided a cross reference that allowed the code user to trace the code sections in Chapters 34 through 43 back to their source: the National Electrical Code. This appendix is no longer provided.
Appendix R Light Straw-Clay Construction. This appendix regulates the use of light straw-clay as a construction material. It is limited in application to nonbearing wall infill systems.

Appendix S Strawbale Construction. This appendix provides prescriptive requirements for the use of strawbale as a construction material. It is limited in application to the walls of one-story structures, except where additional engineering is provided.

Appendix T Recommended Procedure for Worst-Case Testing of Atmospheric Venting Systems under N1102.4 or N1105 Conditions $\leq 5\text{ACH}_{50}$. This appendix is an informative appendix that is provided for testing of atmospheric venting conditions in a house when the leak tightness is less than five air changes per hour at 50 Pascals. The air leakage limitations in the energy provisions of Chapter 11 could have a direct impact on the building pressure boundary affecting the safe operation of combustion equipment.

Appendix T is intended to provide clear guidance to builders, code officials and home performance contractors for worst-case testing of atmospheric venting systems where air-sealing techniques and air-leakage performance testing requirements of Chapter 11 or the 2015 IECC are employed. Worst-case testing is used by home performance contractors to identify problems that weaken draft and restrict combustion air. Worst-case vent testing uses the home’s exhaust fans, air-handling appliances and chimneys to create worst-case depressurization in the combustion appliance zone (CAZ).

Appendix U Solar-Ready Provisions—Detached One- and Two-Family Dwellings, Multiple Single-Family Dwellings (Townhouses). This appendix provides requirements for preparation of a house for future installation of solar equipment for electrical power or heating. Given the growing popularity of solar power and the possible need for the equipment in the future, this appendix, if adopted, would require an area be provided on the building roof that would accommodate solar equipment. In addition, pathways for routing of plumbing and conduit need to be provided.
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(For supplemental use. Not part of NCRC amendments.)

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CHAPTER 1
SCOPE AND ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION R101
GENERAL

R101.1 Title.
These provisions shall be known as the North Carolina Residential Code for One- and Two-family Dwellings of [NAME OF JURISDICTION], and shall be cited as such and will be referred to herein as “this code.” These regulations were adopted by the North Carolina Building Code Council on Month Day, Year, to be effective Month Day, Year. References to the International Codes shall mean the North Carolina Codes. The North Carolina Amendments to the International Codes are underlined.

R101.2 Scope.
The provisions of the International Residential Code for One- and Two-family Dwellings shall apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, removal and demolition of detached one- and two-family dwellings and townhouses not more than three stories above grade plane in height with a separate means of egress and their accessory structures not more than three stories above grade plane in height. Single family dwellings otherwise permitted by this code shall include bed and breakfast homes.

Exceptions:

1. Live/work units located in townhouses and complying with the requirements of Section 419 of the International Building Code shall be permitted to be built as one- and two-family dwellings or townhouses, constructed in accordance with the International Residential Code for One- and Two-Family Dwellings. Fire suppression required by Section 419.5 of the International Building Code where constructed under the International Residential Code for One- and Two-family Dwellings shall conform to Section P2904.

2. Owner-occupied lodging houses with five or fewer guestrooms shall be permitted to be constructed in accordance with the International Residential Code for One- and Two-family Dwellings where equipped with a fire sprinkler system in accordance with Section P2904. Deleted.

R101.2.1 Accessory buildings.
Accessory buildings with any dimension greater than 12 feet (3658 mm) shall meet the provisions of this code. Accessory buildings are permitted to be constructed without a masonry or concrete foundation, except in coastal high hazard or ocean hazard areas, provided all of the following conditions are met:
1. The accessory building shall not exceed 400 square feet (37 m²) or one story in height;

2. The building is supported on a wood foundation of minimum 2” x 6” (51 mm x 152 mm) or 3” x 4” (76 mm x 102 mm) mudsill of approved wood in accordance with Section R317; and

3. The building is anchored to resist overturning and sliding by installing a minimum of one ground anchor at each corner of the building. The total resisting force of the anchors shall be equal to 20 psf (958 Pa) times the plan area of the building.

**R101.2.2 Accessory structures.**
The following accessory structures shall meet the provisions of this code.

1. Decks, see Appendix M,

2. Gazebos,

3. Retaining walls, see Section R404.4,

4. Detached masonry chimneys located less than 10 feet (3048 mm) from other buildings or lot lines,

5. Swimming pools and spas, see Appendix V,

6. Detached carports,

7. Docks, piers, bulkheads, and waterway structures, see Section R327.

**Exception:** Portable lightweight carports not exceeding 400 square feet (37 m²) or 12 foot (3658 mm) mean roof height.

**R101.3 Intent Purpose.**
The purpose of this code is to establish minimum requirements to safeguard the public safety, health and general welfare through affordability, structural strength, means of egress facilities, stability, sanitation, light and ventilation, energy conservation and safety to life and property from fire and other hazards attributed to the built environment and to provide safety to fire fighters and emergency responders during emergency operations.

**SECTION R102**
APPLICABILITY

**R102.1 General.**
Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable. Where, in any specific case, different sections of this code
specify different materials, methods of construction or other requirements, the most restrictive shall govern.

**R102.2 Other laws.**
The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.

**R102.3 Application of references.**
References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

**R102.4 Referenced codes and standards.**
The codes and standards referenced in this code shall be considered part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections R102.4.1 and R102.4.2.

**Exception:** Where enforcement of a code provision would violate the conditions of the listing of the equipment or appliance, the conditions of the listing and manufacturer’s instructions shall apply.

**R102.4.1 Conflicts. Deleted.**
Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

**R102.4.2 Provisions in referenced codes and standards. Deleted.**
Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

**R102.5 Appendices.**
Provisions in the appendices shall not apply unless specifically referenced in the adopting ordinance.

**R102.6 Partial invalidity.**
In the event any part or provision of this code is held to be illegal or void, this shall not have the effect of making void or illegal any of the other parts or provisions.

**R102.7 Existing structures.**
The legal occupancy of any structure existing on the date of adoption of this code shall be permitted to continue without change, except as is specifically covered in this code, the International Property Maintenance Code, or the International Fire Code, or as is deemed necessary by the building official for the general safety and welfare of the occupants and the public. For requirements of existing structures, refer to the North Carolina Administrative Code and Policies and the North Carolina Existing Building Code.

**R102.7.1 Additions, alterations or repairs.**
Additions, alterations or repairs to any structure shall conform to the requirements for a new structure without requiring the existing structure to comply with the requirements of this code, unless otherwise stated. Additions, alterations, repairs and relocations shall not cause an existing structure to become unsafe or adversely affect the performance of the building.
PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION R103
DEPARTMENT OF BUILDING SAFETY

Deleted. See the North Carolina Administrative Code and Policies.

R103.1 Creation of enforcement agency.
The department of building safety is hereby created and the official in charge thereof shall be known as the building official.

R103.2 Appointment.
The building official shall be appointed by the jurisdiction.

R103.3 Deputies.
In accordance with the prescribed procedures of this jurisdiction and with the concurrence of the appointing authority, the building official shall have the authority to appoint a deputy building official, the related technical officers, inspectors, plan examiners and other employees. Such employees shall have powers as delegated by the building official.

SECTION R104
DUTIES AND POWERS OF THE BUILDING OFFICIAL

Deleted. See the North Carolina Administrative Code and Policies.

R104.1 General.
The building official is hereby authorized and directed to enforce the provisions of this code. The building official shall have the authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in conformance with the intent and purpose of this code. Such policies and procedures shall not have the effect of waiving requirements specifically provided for in this code.

R104.2 Applications and permits.
The building official shall receive applications, review construction documents and issue permits for the erection and alteration of buildings and structures, inspect the premises for which such permits have been issued and enforce compliance with the provisions of this code.

R104.3 Notices and orders.
The building official shall issue necessary notices or orders to ensure compliance with this code.

R104.4 Inspections.
The building official shall make the required inspections, or the building official shall have the authority to accept reports of inspection by approved agencies or individuals. Reports of such inspections shall be in writing and be certified by a responsible officer of such approved agency or by the responsible individual. The building official is authorized to engage such expert opinion as deemed necessary to report upon unusual technical issues that arise, subject to the approval of the appointing authority.
R104.5 Identification.
The building official shall carry proper identification when inspecting structures or premises in the performance of duties under this code.

R104.6 Right of entry.
Where it is necessary to make an inspection to enforce the provisions of this code, or where the building official has reasonable cause to believe that there exists in a structure or upon a premises a condition that is contrary to or in violation of this code that makes the structure or premises unsafe, dangerous or hazardous, the building official or designee is authorized to enter the structure or premises at reasonable times to inspect or to perform the duties imposed by this code, provided that if such structure or premises be occupied that credentials be presented to the occupant and entry requested. If such structure or premises is unoccupied, the building official shall first make a reasonable effort to locate the owner, the owner's authorized agent, or other person having charge or control of the structure or premises and request entry. If entry is refused, the building official shall have recourse to the remedies provided by law to secure entry.

R104.7 Department records.
The building official shall keep official records of applications received, permits and certificates issued, fees collected, reports of inspections, and notices and orders issued. Such records shall be retained in the official records for the period required for the retention of public records.

R104.8 Liability.
The building official, member of the board of appeals or employee charged with the enforcement of this code, while acting for the jurisdiction in good faith and without malice in the discharge of the duties required by this code or other pertinent law or ordinance, shall not thereby be rendered civilly or criminally liable personally and is hereby relieved from personal liability for any damage accruing to persons or property as a result of any act or by reason of an act or omission in the discharge of official duties.

R104.8.1 Legal defense.
Any suit or criminal complaint instituted against an officer or employee because of an act performed by that officer or employee in the lawful discharge of duties and under the provisions of this code shall be defended by legal representatives of the jurisdiction until the final termination of the proceedings. The building official or any subordinate shall not be liable for cost in any action, suit or proceeding that is instituted in pursuance of the provisions of this code.

R104.9 Approved materials and equipment.
Materials, equipment and devices approved by the building official shall be constructed and installed in accordance with such approval.

R104.9.1 Used materials and equipment.
Used materials, equipment and devices shall not be reused unless approved by the building official.

R104.10 Modifications.
Where there are practical difficulties involved in carrying out the provisions of this code, the building official shall have the authority to grant modifications for individual cases, provided the building official shall first find that special individual reason makes the strict letter of this code impractical and the modification is in compliance with the intent and purpose of this code and
that such modification does not lessen health, life and fire safety or structural requirements. The details of action granting modifications shall be recorded and entered in the files of the department of building safety.

R104.10.1 Flood hazard areas.
The building official shall not grant modifications to any provisions required in flood hazard areas as established by Table R301.2(1) unless a determination has been made that:

1. There is good and sufficient cause showing that the unique characteristics of the size, configuration or topography of the site render the elevation standards of Section R322 inappropriate.

2. Failure to grant the modification would result in exceptional hardship by rendering the lot undevelopable.

3. The granting of modification will not result in increased flood heights, additional threats to public safety, extraordinary public expense, cause fraud on or victimization of the public, or conflict with existing laws or ordinances.

4. The modification is the minimum necessary to afford relief, considering the flood hazard.

5. Written notice specifying the difference between the design flood elevation and the elevation to which the building is to be built, stating that the cost of flood insurance will be commensurate with the increased risk resulting from the reduced floor elevation and stating that construction below the design flood elevation increases risks to life and property, has been submitted to the applicant.

R104.11 Alternative materials, design and methods of construction and equipment.
The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code. Compliance with the specific performance-based provisions of the International Codes shall be an alternative to the specific requirements of this code. Where the alternative material, design or method of construction is not approved, the building official shall respond in writing, stating the reasons why the alternative was not approved.

R104.11.1 Tests.
Where there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the building official for the period required for retention of public records.
SECTION R105
PERMITS

Deleted. See the North Carolina Administrative Code and Policies.

R105.1 Required.
Any owner or owner’s authorized agent who intends to construct, enlarge, alter, repair, move, demolish or change the occupancy of a building or structure, or to erect, install, enlarge, alter, repair, remove, convert or replace any electrical, gas, mechanical or plumbing system, the installation of which is regulated by this code, or to cause any such work to be performed, shall first make application to the building official and obtain the required permit.

R105.2 Work exempt from permit.
Exemption from permit requirements of this code shall not be deemed to grant authorization for any work to be done in any manner in violation of the provisions of this code or any other laws or ordinances of this jurisdiction. Permits shall not be required for the following:

Building:
1. One-story detached accessory structures, provided that the floor area does not exceed 200 square feet (18.58 m²).
2. Fences not over 7 feet (2134 mm) high.
3. Retaining walls that are not over 4 feet (1219 mm) in height measured from the bottom of the footing to the top of the wall, unless supporting a surcharge.
4. Water tanks supported directly upon grade if the capacity does not exceed 5,000 gallons (18 927 L) and the ratio of height to diameter or width does not exceed 2 to 1.
5. Sidewalks and driveways.
6. Painting, papering, tiling, carpeting, cabinets, counter tops and similar finish work.
7. Prefabricated swimming pools that are less than 24 inches (610 mm) deep.
8. Swings and other playground equipment.
9. Window awnings supported by an exterior wall that do not project more than 54 inches (1372 mm) from the exterior wall and do not require additional support.
10. Decks not exceeding 200 square feet (18.58 m²) in area, that are not more than 30 inches (762 mm) above grade at any point, are not attached to a dwelling do not serve the exit door required by Section R311.4.

Electrical:
1. Listed cord-and-plug-connected temporary decorative lighting.

2. Reinstallation of attachment plug receptacles but not the outlets therefor.

3. Replacement of branch circuit overcurrent devices of the required capacity in the same location.

4. Electrical wiring, devices, appliances, apparatus or equipment operating at less than 25 volts and not capable of supplying more than 50 watts of energy.

5. Minor repair work, including the replacement of lamps or the connection of approved portable electrical equipment to approved permanently installed receptacles.

**Gas:**

1. Portable heating, cooking or clothes drying appliances.

2. Replacement of any minor part that does not alter approval of equipment or make such equipment unsafe.

3. Portable fuel-cell appliances that are not connected to a fixed piping system and are not interconnected to a power grid.

**Mechanical:**

1. Portable heating appliances.

2. Portable ventilation appliances.

3. Portable cooling units.

4. Steam, hot- or chilled-water piping within any heating or cooling equipment regulated by this code.

5. Replacement of any minor part that does not alter approval of equipment or make such equipment unsafe.

6. Portable evaporative coolers.

7. Self-contained refrigeration systems containing 10 pounds (4.54 kg) or less of refrigerant or that are actuated by motors of 1 horsepower (746 W) or less.

8. Portable fuel-cell appliances that are not connected to a fixed piping system and are not interconnected to a power grid.

**Plumbing:**
1. The stopping of leaks in drains, water, soil, waste or vent pipe; provided, however, that if any concealed trap, drainpipe, water, soil, waste or vent pipe becomes defective and it becomes necessary to remove and replace the same with new material, such work shall be considered as new work and a permit shall be obtained and inspection made as provided in this code.

2. The clearing of stoppages or the repairing of leaks in pipes, valves or fixtures, and the removal and reinstallation of water closets, provided such repairs do not involve or require the replacement or rearrangement of valves, pipes or fixtures.

R105.2.1 Emergency repairs.
Where equipment replacements and repairs must be performed in an emergency situation, the permit application shall be submitted within the next working business day to the building official.

R105.2.2 Repairs.
Application or notice to the building official is not required for ordinary repairs to structures, replacement of lamps or the connection of approved portable electrical equipment to approved permanently installed receptacles. Such repairs shall not include the cutting away of any wall, partition or portion thereof, the removal or cutting of any structural beam or load-bearing support, or the removal or change of any required means of egress, or rearrangement of parts of a structure affecting the egress requirements; nor shall ordinary repairs include addition to, alteration of, replacement or relocation of any water supply, sewer, drainage, drain leader, gas, soil, waste, vent or similar piping, electric wiring or mechanical or other work affecting public health or general safety.

R105.2.3 Public service agencies.
A permit shall not be required for the installation, alteration or repair of generation, transmission, distribution, metering or other related equipment that is under the ownership and control of public service agencies by established right.

R105.3 Application for permit.
To obtain a permit, the applicant shall first file an application therefor in writing on a form furnished by the department of building safety for that purpose. Such application shall:

1. Identify and describe the work to be covered by the permit for which application is made.

2. Describe the land on which the proposed work is to be done by legal description, street address or similar description that will readily identify and definitely locate the proposed building or work.

3. Indicate the use and occupancy for which the proposed work is intended.

4. Be accompanied by construction documents and other information as required in Section R106.1.

5. State the valuation of the proposed work.

6. Be signed by the applicant or the applicant’s authorized agent.
7. Give such other data and information as required by the building official.

R105.3.1 Action on application.
The building official shall examine or cause to be examined applications for permits and amendments thereto within a reasonable time after filing. If the application or the construction documents do not conform to the requirements of pertinent laws, the building official shall reject such application in writing stating the reasons therefor. If the building official is satisfied that the proposed work conforms to the requirements of this code and laws and ordinances applicable thereto, the building official shall issue a permit therefor as soon as practicable.

R105.3.1.1 Determination of substantially improved or substantially damaged existing buildings in flood hazard areas.
For applications for reconstruction, rehabilitation, addition, alteration, repair or other improvement of existing buildings or structures located in a flood hazard area as established by Table R301.2(1), the building official shall examine or cause to be examined the construction documents and shall make a determination with regard to the value of the proposed work. For buildings that have sustained damage of any origin, the value of the proposed work shall include the cost to repair the building or structure to its predamaged condition. If the building official finds that the value of proposed work equals or exceeds 50 percent of the market value of the building or structure before the damage has occurred or the improvement is started, the proposed work is a substantial improvement or restoration of substantial damage and the building official shall require existing portions of the entire building or structure to meet the requirements of Section R322.

For the purpose of this determination, a substantial improvement shall mean any repair, reconstruction, rehabilitation, addition or improvement of a building or structure, the cost of which equals or exceeds 50 percent of the market value of the building or structure before the improvement or repair is started. Where the building or structure has sustained substantial damage, repairs necessary to restore the building or structure to its predamaged condition shall be considered substantial improvements regardless of the actual repair work performed. The term shall not include either of the following:

1. Improvements to a building or structure that are required to correct existing health, sanitary or safety code violations identified by the building official and that are the minimum necessary to ensure safe living conditions.

2. Any alteration of a historic building or structure, provided that the alteration will not preclude the continued designation as a historic building or structure. For the purposes of this exclusion, a historic building shall be any of the following:

2.1. Listed or preliminarily determined to be eligible for listing in the National Register of Historic Places.

2.2. Determined by the Secretary of the U.S. Department of Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined to qualify as an historic district.
R105.3.2 Time limitation of application.
An application for a permit for any proposed work shall be deemed to have been abandoned 180 days after the date of filing unless such application has been pursued in good faith or a permit has been issued; except that the building official is authorized to grant one or more extensions of time for additional periods not exceeding 180 days each. The extension shall be requested in writing and justifiable cause demonstrated.

R105.4 Validity of permit.
The issuance or granting of a permit shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of this code or of any other ordinance of the jurisdiction. Permits presuming to give authority to violate or cancel the provisions of this code or other ordinances of the jurisdiction shall not be valid. The issuance of a permit based on construction documents and other data shall not prevent the building official from requiring the correction of errors in the construction documents and other data. The building official is authorized to prevent occupancy or use of a structure where in violation of this code or of any other ordinances of this jurisdiction.

R105.5 Expiration.
Every permit issued shall become invalid unless the work authorized by such permit is commenced within 180 days after its issuance, or if the work authorized by such permit is suspended or abandoned for a period of 180 days after the time the work is commenced. The building official is authorized to grant, in writing, one or more extensions of time, for periods not more than 180 days each. The extension shall be requested in writing and justifiable cause demonstrated.

R105.6 Suspension or revocation.
The building official is authorized to suspend or revoke a permit issued under the provisions of this code wherever the permit is issued in error or on the basis of incorrect, inaccurate or incomplete information, or in violation of any ordinance or regulation or any of the provisions of this code.

R105.7 Placement of permit.
The building permit or a copy shall be kept on the site of the work until the completion of the project.

R105.8 Responsibility.
It shall be the duty of every person who performs work for the installation or repair of building, structure, electrical, gas, mechanical or plumbing systems, for which this code is applicable, to comply with this code.

R105.9 Preliminary inspection.
Before issuing a permit, the building official is authorized to examine or cause to be examined buildings, structures and sites for which an application has been filed.
R106.1 Submittal documents.
Submittal documents consisting of construction documents, and other data shall be submitted in two or more sets with each application for a permit. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the building official is authorized to require additional construction documents to be prepared by a registered design professional.

Exception: The building official is authorized to waive the submission of construction documents and other data not required to be prepared by a registered design professional if it is found that the nature of the work applied for is such that reviewing of construction documents is not necessary to obtain compliance with this code.

R106.1.1 Information on construction documents.
Construction documents shall be drawn upon suitable material. Electronic media documents are permitted to be submitted where approved by the building official. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this code and relevant laws, ordinances, rules and regulations, as determined by the building official.

R106.1.2 Manufacturer’s installation instructions.
Manufacturer’s installation instructions, as required by this code, shall be available on the job site at the time of inspection.

R106.1.3 Information on braced wall design.
For buildings and structures utilizing braced wall design, and where required by the building official, braced wall lines shall be identified on the construction documents. Pertinent information including, but not limited to, bracing methods, location and length of braced wall panels and foundation requirements of braced wall panels at top and bottom shall be provided.

R106.1.4 Information for construction in flood hazard areas.
For buildings and structures located in whole or in part in flood hazard areas as established by Table R301.2(1), construction documents shall include:

1. Delineation of flood hazard areas, floodway boundaries and flood zones and the design flood elevation, as appropriate.

2. The elevation of the proposed lowest floor, including basement, in areas of shallow flooding (AO Zones), the height of the proposed lowest floor, including basement, above the highest adjacent grade.

3. The elevation of the bottom of the lowest horizontal structural member in coastal high hazard areas (V Zone) and in Coastal A Zones where such zones are delineated on flood hazard maps identified in Table R301.2(1) or otherwise delineated by the jurisdiction.
4. If design flood elevations are not included on the community’s Flood Insurance Rate Map (FIRM), the building official and the applicant shall obtain and reasonably utilize any design flood elevation and floodway data available from other sources.

R106.2 Site plan or plot plan.
The construction documents submitted with the application for permit shall be accompanied by a site plan showing the size and location of new construction and existing structures on the site and distances from lot lines. In the case of demolition, the site plan shall show construction to be demolished and the location and size of existing structures and construction that are to remain on the site or plot. The building official is authorized to waive or modify the requirement for a site plan where the application for permit is for alteration or repair or where otherwise warranted.

R106.3 Examination of documents.
The building official shall examine or cause to be examined construction documents for code compliance.

R106.3.1 Approval of construction documents.
Where the building official issues a permit, the construction documents shall be approved in writing or by a stamp that states “REVIEWED FOR CODE COMPLIANCE.” One set of construction documents so reviewed shall be retained by the building official. The other set shall be returned to the applicant, shall be kept at the site of work and shall be open to inspection by the building official or a duly authorized representative.

R106.3.2 Previous approvals.
This code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.

R106.3.3 Phased approval.
The building official is authorized to issue a permit for the construction of foundations or any other part of a building or structure before the construction documents for the whole building or structure have been submitted, provided that adequate information and detailed statements have been filed complying with pertinent requirements of this code. The holder of such permit for the foundation or other parts of a building or structure shall proceed at the holder’s own risk with the building operation and without assurance that a permit for the entire structure will be granted.

R106.4 Amended construction documents.
Work shall be installed in accordance with the approved construction documents, and any changes made during construction that are not in compliance with the approved construction documents shall be resubmitted for approval as an amended set of construction documents.

R106.5 Retention of construction documents.
One set of approved construction documents shall be retained by the building official for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.
SECTION R107
TEMPORARY STRUCTURES AND USES

Deleted. See the North Carolina Administrative Code and Policies.

R107.1 General.
The building official is authorized to issue a permit for temporary structures and temporary uses. Such permits shall be limited as to time of service, but shall not be permitted for more than 180 days. The building official is authorized to grant extensions for demonstrated cause.

R107.2 Conformance.
Temporary structures and uses shall conform to the structural strength, fire safety, means of egress, light, ventilation and sanitary requirements of this code as necessary to ensure the public health, safety and general welfare.

R107.3 Temporary power.
The building official is authorized to give permission to temporarily supply and use power in part of an electric installation before such installation has been fully completed and the final certificate of completion has been issued. The part covered by the temporary certificate shall comply with the requirements specified for temporary lighting, heat or power in NFPA 70.

R107.4 Termination of approval.
The building official is authorized to terminate such permit for a temporary structure or use and to order the temporary structure or use to be discontinued.

SECTION R108
FEES

Deleted. See the North Carolina Administrative Code and Policies.

R108.1 Payment of fees.
A permit shall not be valid until the fees prescribed by law have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

R108.2 Schedule of permit fees.
On buildings, structures, electrical, gas, mechanical and plumbing systems or alterations requiring a permit, a fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

R108.3 Building permit valuations.
Building permit valuation shall include total value of the work for which a permit is being issued, such as electrical, gas, mechanical, plumbing equipment and other permanent systems, including materials and labor.

R108.4 Related fees.
The payment of the fee for the construction, alteration, removal or demolition for work done in connection to or concurrently with the work authorized by a building permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.
R108.5 Refunds.
The building official is authorized to establish a refund policy.

R108.6 Work commencing before permit issuance.
Any person who commences work requiring a permit on a building, structure, electrical, gas, mechanical or plumbing system before obtaining the necessary permits shall be subject to a fee established by the applicable governing authority that shall be in addition to the required permit fees.

SECTION R109
INSPECTIONS

Deleted. See the North Carolina Administrative Code and Policies.

R109.1 Types of inspections.
For on-site construction, from time to time the building official, upon notification from the permit holder or his agent, shall make or cause to be made any necessary inspections and shall either approve that portion of the construction as completed or shall notify the permit holder or his or her agent wherein the same fails to comply with this code.

R109.1.1 Foundation inspection.
Inspection of the foundation shall be made after poles or piers are set or trenches or basement areas are excavated and any required forms erected and any required reinforcing steel is in place and supported prior to the placing of concrete. The foundation inspection shall include excavations for thickened slabs intended for the support of bearing walls, partitions, structural supports, or equipment and special requirements for wood foundations.

R109.1.2 Plumbing, mechanical, gas and electrical systems inspection.
Rough inspection of plumbing, mechanical, gas and electrical systems shall be made prior to covering or concealment, before fixtures or appliances are set or installed, and prior to framing inspection.

   Exception: Backfilling of ground source heat pump loop systems tested in accordance with Section M2105.1 prior to inspection shall be permitted.

R109.1.3 Floodplain inspections.
For construction in flood hazard areas as established by Table R301.2(1), upon placement of the lowest floor, including basement, and prior to further vertical construction, the building official shall require submission of documentation, prepared and sealed by a registered design professional, of the elevation of the lowest floor, including basement, required in Section R322.

R109.1.4 Frame and masonry inspection.
Inspection of framing and masonry construction shall be made after the roof, masonry, framing, firestopping, draftstopping and bracing are in place and after the plumbing, mechanical and electrical rough inspections are approved.

R109.1.5 Other inspections.
In addition to inspections in Sections R109.1.1 through R109.1.4, the building official shall have the authority to make or require any other inspections to ascertain compliance with this code and other laws enforced by the building official.
R109.1.5.1 Fire-resistance-rated construction inspection.
Where fire-resistance-rated construction is required between dwelling units or due to location on property, the building official shall require an inspection of such construction after lathing or gypsum board or gypsum panel products are in place, but before any plaster is applied, or before board or panel joints and fasteners are taped and finished.

R109.1.6 Final inspection.
Final inspection shall be made after the permitted work is complete and prior to occupancy.

R109.1.6.1 Elevation documentation.
If located in a flood hazard area, the documentation of elevations required in Section R322.1.10 shall be submitted to the building official prior to the final inspection.

R109.2 Inspection agencies.
The building official is authorized to accept reports of approved agencies, provided such agencies satisfy the requirements as to qualifications and reliability.

R109.3 Inspection requests.
It shall be the duty of the permit holder or their agent to notify the building official that such work is ready for inspection. It shall be the duty of the person requesting any inspections required by this code to provide access to and means for inspection of such work.

R109.4 Approval required.
Work shall not be done beyond the point indicated in each successive inspection without first obtaining the approval of the building official. The building official upon notification, shall make the requested inspections and shall either indicate the portion of the construction that is satisfactory as completed, or shall notify the permit holder or an agent of the permit holder wherein the same fails to comply with this code. Any portions that do not comply shall be corrected and such portion shall not be covered or concealed until authorized by the building official.

SECTION R110
CERTIFICATE OF OCCUPANCY

Deleted. See the North Carolina Administrative Code and Policies.

R110.1 Use and occupancy.
A building or structure shall not be used or occupied, and a change in the existing use or occupancy classification of a building or structure or portion thereof shall not be made, until the building official has issued a certificate of occupancy therefor as provided herein. Issuance of a certificate of occupancy shall not be construed as an approval of a violation of the provisions of this code or of other ordinances of the jurisdiction. Certificates presuming to give authority to violate or cancel the provisions of this code or other ordinances of the jurisdiction shall not be valid.

Exceptions:

1. Certificates of occupancy are not required for work exempt from permits under Section R105.2.
2. Accessory buildings or structures.

R110.2 Change in use.
Changes in the character or use of an existing structure shall not be made except as specified in Sections 3408 and 3409 of the International Building Code.

R110.3 Certificate issued.
After the building official inspects the building or structure and does not find violations of the provisions of this code or other laws that are enforced by the department of building safety, the building official shall issue a certificate of occupancy containing the following:

1. The building permit number.
2. The address of the structure.
3. The name and address of the owner or the owner’s authorized agent.
4. A description of that portion of the structure for which the certificate is issued.
5. A statement that the described portion of the structure has been inspected for compliance with the requirements of this code.
6. The name of the building official.
7. The edition of the code under which the permit was issued.
8. If an automatic sprinkler system is provided and whether the sprinkler system is required.
9. Any special stipulations and conditions of the building permit.

R110.4 Temporary occupancy.
The building official is authorized to issue a temporary certificate of occupancy before the completion of the entire work covered by the permit, provided that such portion or portions shall be occupied safely. The building official shall set a time period during which the temporary certificate of occupancy is valid.

R110.5 Revocation.
The building official shall, in writing, suspend or revoke a certificate of occupancy issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the building or structure or portion thereof is in violation of any ordinance or regulation or any of the provisions of this code.

SECTION R111
SERVICE UTILITIES

Deleted. See the North Carolina Administrative Code and Policies.
R111.1 Connection of service utilities.
A person shall not make connections from a utility, source of energy, fuel or power to any building or system that is regulated by this code for which a permit is required, until approved by the building official.

R111.2 Temporary connection.
The building official shall have the authority to authorize the temporary connection of the building or system to the utility, source of energy, fuel or power.

R111.3 Authority to disconnect service utilities.
The building official shall have the authority to authorize disconnection of utility service to the building, structure or system regulated by this code and the referenced codes and standards set forth in Section R102.4 in case of emergency where necessary to eliminate an immediate hazard to life or property or where such utility connection has been made without the approval required by Section R111.1 or R111.2. The building official shall notify the serving utility and where possible the owner or the owner’s authorized agent and occupant of the building, structure or service system of the decision to disconnect prior to taking such action. If not notified prior to disconnection, the owner, the owner’s authorized agent or occupant of the building, structure or service system shall be notified in writing as soon as practical thereafter.

SECTION R112
BOARD OF APPEALS

Deleted. See the North Carolina Administrative Code and Policies.

R112.1 General.
In order to hear and decide appeals of orders, decisions or determinations made by the building official relative to the application and interpretation of this code, there shall be and is hereby created a board of appeals. The building official shall be an ex officio member of said board but shall not have a vote on any matter before the board. The board of appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business, and shall render decisions and findings in writing to the appellant with a duplicate copy to the building official.

R112.2 Limitations on authority.
An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The board shall not have authority to waive requirements of this code.

R112.3 Qualifications.
The board of appeals shall consist of members who are qualified by experience and training to pass judgement on matters pertaining to building construction and are not employees of the jurisdiction.

R112.4 Administration.
The building official shall take immediate action in accordance with the decision of the board.
SECTION R113
VIOLATIONS

Deleted. See the North Carolina Administrative Code and Policies.

R113.1 Unlawful acts.
It shall be unlawful for any person, firm or corporation to erect, construct, alter, extend, repair, move, remove, demolish or occupy any building, structure or equipment regulated by this code, or cause same to be done, in conflict with or in violation of any of the provisions of this code.

R113.2 Notice of violation.
The building official is authorized to serve a notice of violation or order on the person responsible for the erection, construction, alteration, extension, repair, moving, removal, demolition or occupancy of a building or structure in violation of the provisions of this code, or in violation of a detail statement or a plan approved thereunder, or in violation of a permit or certificate issued under the provisions of this code. Such order shall direct the discontinuance of the illegal action or condition and the abatement of the violation.

R113.3 Prosecution of violation.
If the notice of violation is not complied with in the time prescribed by such notice, the building official is authorized to request the legal counsel of the jurisdiction to institute the appropriate proceeding at law or in equity to restrain, correct or abate such violation, or to require the removal or termination of the unlawful occupancy of the building or structure in violation of the provisions of this code or of the order or direction made pursuant thereto.

R113.4 Violation penalties.
Any person who violates a provision of this code or fails to comply with any of the requirements thereof or who erects, constructs, alters or repairs a building or structure in violation of the approved construction documents or directive of the building official, or of a permit or certificate issued under the provisions of this code, shall be subject to penalties as prescribed by law.

SECTION R114
STOP WORK ORDER

Deleted. See the North Carolina Administrative Code and Policies.

R114.1 Notice to owner or the owner’s authorized agent.
Upon notice from the building official that work on any building or structure is being executed contrary to the provisions of this code or in an unsafe and dangerous manner, such work shall be immediately stopped. The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner’s authorized agent or to the person performing the work and shall state the conditions under which work will be permitted to resume.

R114.2 Unlawful continuance.
Any person who shall continue any work in or about the structure after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to penalties as prescribed by law.
Part II—Definitions

CHAPTER 2
DEFINITIONS

Code change proposals to definitions in this chapter preceded by a bracketed letter are considered by the IRC-Building Code Development Committee [RB] or the IECC-Residential Code Development Committee [RE] during the Group B (2016) Code Development cycle. See page xvii for explanation.

Definitions in this chapter preceded by a bracketed letter correlate with the abridged chapters for Energy [RE], Plumbing [RP], Fuel Gas [RG], and Mechanical [RM] of this code. Definitions that are not preceded by a bracket are general definitions utilized throughout this code.

SECTION R201
GENERAL

R201.1 Scope.
Unless otherwise expressly stated, the following words and terms shall, for the purposes of this code, have the meanings indicated in this chapter.

R201.2 Interchangeability.
Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural, the singular.

R201.3 Terms defined in other codes.
Where terms are not defined in this code such terms shall have the meanings ascribed in other code publications of the International North Carolina Building Code Council.

R201.4 Terms not defined.
Where terms are not defined through the methods authorized by this section, such terms shall have ordinarily accepted meanings such as the context implies.

SECTION R202
DEFINITIONS

[RE] ABOVE-GRADE WALL. A wall more than 50 percent above grade and enclosing conditioned space. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

[RP] ACCEPTED ENGINEERING PRACTICE. That which conforms to accepted principles, tests or standards of nationally recognized technical or scientific authorities.

ACCESS (TO). That which enables a device, appliance or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel, door or similar obstruction.
ACCESS COVER. A removable plate, usually secured by bolts or screws, to permit access to a pipe or pipe fitting for the purposes of inspection, repair or cleaning.

ACCESSIBLE. Signifies access that requires the removal of an access panel or similar removable obstruction. For energy purposes, ACCESSIBLE means admitting close approach as a result of not being guarded by locked doors, elevation or other effective means (see “Readily accessible”).

ACCESSIBLE, READILY. Signifies access without the necessity for removing a panel or similar obstruction.

ACCESSORY BUILDING. In one- and two-family dwellings not more than three stories above grade plane in height with a separate means of egress, a building, the use of which is incidental to that of the main building and which is detached and located on the same lot. An accessory building is a building that is roofed over and more than 50% of its exterior walls are enclosed. Examples of accessory buildings are garages, storage buildings, workshops, boat houses, treehouses, etc.

ACCESSORY STRUCTURE. A structure that is accessory to and incidental to that of the dwelling(s) and that is located on the same lot not defined as an accessory building. Examples of accessory structures are fencing, decks, gazebos, arbors, retaining walls, barbecue pits, detached chimneys, playground equipment, yard art, docks, piers, etc.

ACH50. Air changes per hour of measured airflow in relation to the building volume while the building is maintained at a pressure difference of 50 Pascals.

ADAPTER FITTING. An approved connecting device that suitably and properly joins or adjusts pipes and fittings that do not otherwise fit together.

ADDITION. An extension or increase in floor area or height of a building or structure. For energy purposes, an extension or increase in the conditioned space floor area or height of a building or structure.

ADHERED STONE OR MASONRY VENEER. Stone or masonry veneer secured and supported through the adhesion of an approved bonding material applied to an approved backing.

AIR ADMITTANCE VALVE. A one-way valve designed to allow air into the plumbing drainage system where a negative pressure develops in the piping. This device shall close by gravity and seal the vent terminal under conditions of zero differential pressure (no flow conditions) and under positive internal pressure. The purpose of an air admittance valve is to provide a method of allowing air to enter the plumbing drainage system without the use of a vent extended to open air and to prevent sewer gases from escaping into a building.

AIR BARRIER. See Section N1101.6 for definition applicable in Chapter 11.

AIR BARRIER MATERIAL. Material(s) that have an air permeability not to exceed 0.004 cfm/ft² under a pressure differential of 0.3 in. water (1.57 psf) (0.02 L/s.m²@75 Pa) when tested in accordance with ASTM E 2178.

AIR BARRIER SYSTEM. Material(s) assembled and joined together to provide a barrier to
air leakage through the building envelope. An air barrier is a combination of air barrier materials and sealants.

[RP] AIR BREAK (DRAINAGE SYSTEM). An arrangement where a discharge pipe from a fixture, appliance or device drains indirectly into a receptor below the flood-level rim of the receptor and above the trap seal.

AIR CIRCULATION, FORCED. A means of providing space conditioning utilizing movement of air through ducts or plenums by mechanical means.

[RG] AIR CONDITIONER, GAS-FIRED. A gas-burning, automatically operated appliance for supplying cooled and/or dehumidified air or chilled liquid.

[RG] AIR CONDITIONING. The treatment of air so as to control simultaneously the temperature, humidity, cleanness and distribution of the air to meet the requirements of a conditioned space.

AIR-CONDITIONING SYSTEM. A system that consists of heat exchangers, blowers, filters, supply, exhaust and return-air systems, and shall include any apparatus installed in connection therewith.

[RG] AIR, EXHAUST. Air being removed from any space or piece of equipment or appliance and conveyed directly to the atmosphere by means of openings or ducts.

AIR GAP, DRAINAGE SYSTEM. The unobstructed vertical distance through free atmosphere between the outlet of a waste pipe and the flood-level rim of the fixture or receptor into which it is discharging.

AIR GAP, WATER-DISTRIBUTION SYSTEM. The unobstructed vertical distance through free atmosphere between the lowest opening from a water supply discharge to the flood-level rim of a plumbing fixture.

[RG] AIR-HANDLING UNIT. A blower or fan used for the purpose of distributing supply air to a room, space or area.

AIR-IMPERMEABLE INSULATION. An insulation having an air permanence equal to or less than 0.02 L/s-m$^2$ at 75 Pa pressure differential as tested in accordance with ASTM E 2178 or E 283.

[RG] AIR, MAKEUP. Any combination of outdoor and transfer air intended to replace exhaust air and exfiltration.

[RM] AIR, OUTDOOR. Ambient air that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.

[RM] AIR, TRANSFER. Air moved from one indoor space to another.

ALTERATION. Any construction, retrofit or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a building, electrical, gas, mechanical or
plumbing system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.

**[RP] ALTERNATE ON-SITE NON-POTABLE WATER.** Non-potable water from other than public utilities, on-site surface sources and subsurface natural freshwater sources. Examples of such water are gray water, on-site reclaimed water, collected rainwater, captured condensate and rejected water from reverse osmosis systems.

**[RP] ALTERNATIVE ENGINEERED DESIGN.** A plumbing system that performs in accordance with the intent of Chapters 29 through 33 and provides an equivalent level of performance for the protection of public health, safety and welfare. The system design is not specifically regulated by Chapters 29 through 33.

**ALTERNATING TREAD DEVICE.** A device that has a series of steps between 50 and 70 degrees (0.87 and 1.22 rad) from horizontal, usually attached to a center support rail in an alternating manner so that the user does not have both feet on the same level at the same time.

**ANCHORED STONE OR MASONRY VENEER.** Stone or masonry veneer secured with approved mechanical fasteners to an approved backing.

**ANCHORS.** See “Supports.”

**[RG] ANODELESS RISER.** A transition assembly in which plastic piping is installed and terminated above ground outside of a building.

**ANTISIPHON.** A term applied to valves or mechanical devices that eliminate siphonage.

**APPLIANCE.** A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

**[RG] APPLIANCE, AUTOMATICALLY CONTROLLED.** Appliances equipped with an automatic burner ignition and safety shut-off device and other automatic devices, which accomplish complete turn-on and shut-off of the gas to the main burner or burners, and graduate the gas supply to the burner or burners, but do not affect complete shut-off of the gas.

**[RG] APPLIANCE, FAN-ASSISTED COMBUSTION.** An appliance equipped with an integral mechanical means to either draw or force products of combustion through the combustion chamber or heat exchanger.

**[RG] APPLIANCE, UNVENTED.** An appliance designed or installed in such a manner that the products of combustion are not conveyed by a vent or chimney directly to the outside atmosphere.

**[RG] APPLIANCE, VENTED.** An appliance designed and installed in such a manner that all of the products of combustion are conveyed directly from the appliance to the outside atmosphere through an approved chimney or vent system.

**APPROVED.** Acceptable to the building code official.
APPROVED AGENCY. An established and recognized agency that is regularly engaged in conducting tests or furnishing inspection services, where such agency has been approved by the building official.

[RP] AREA DRAIN. A receptacle designed to collect surface or storm water from an open area.

ASPECT RATIO. The ratio of longest to shortest perpendicular dimensions, or for wall sections, the ratio of height to length.

[RP] ASPIRATOR. A fitting or device supplied with water or other fluid under positive pressure that passes through an integral orifice or constriction, causing a vacuum. Aspirators are also referred to as suction apparatus, and are similar in operation to an ejector.

[RG] ATMOSPHERIC PRESSURE. The pressure of the weight of air and water vapor on the surface of the earth, approximately 14.7 pounds per square inch (psia) (101 kPa absolute) at sea level.

ATTIC. The unfinished space between the ceiling assembly and the roof assembly.

ATTIC, HABITABLE. A finished or unfinished area, not considered a story, finished attic area meeting the definition of habitable space and complying with all of the following requirements:

1. The occupiable floor area is not less than 70 square feet (17 m²), in accordance with Section R304.
2. The occupiable floor area has a ceiling height in accordance with Section R305.
3. The occupiable space is enclosed by the roof assembly above, knee walls (if applicable) on the sides and the floor-ceiling assembly below.

ATTIC STORAGE. A floored area, regardless of size, within an attic space that is served by an attic access.

Exception: A floor walkway not less than 24 inches (610 mm) wide or greater than 48 inches (1219 mm) wide that serves as an access for the service of utilities or equipment, and a level service space not less than 30 inches (762 mm) deep or greater than 48 inches (1219 mm) deep and not less than 30 inches (762 mm) wide or greater than 48 inches (1219 mm) wide at the front or service side of the appliance, shall not be considered as attic storage. Such floored area shall be labeled at the attic access opening, “NOT FOR STORAGE.” The lettering shall be a minimum of 2 inches (51 mm) in height.

[RE] AUTOMATIC. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature or mechanical configuration (see “Manual”).

[RG] AUTOMATIC IGNITION. Ignition of gas at the burner(s) when the gas controlling device is turned on, including reignition if the flames on the burner(s) have been extinguished by means other than by the closing of the gas controlling device.

[RP] BACKFLOW CONNECTION. Any arrangement whereby backflow is possible.
[RP] BACKFLOW, DRAINAGE. A reversal of flow in the drainage system.

[RP] BACKFLOW PREVENTER. A backflow prevention assembly, a backflow prevention device or other means or method to prevent backflow into the potable water supply.

[RP] BACKFLOW PREVENTER, REDUCED-PRESSURE-ZONE TYPE. A backflow-prevention device consisting of two independently acting check valves, internally force loaded to a normally closed position and separated by an intermediate chamber (or zone) in which there is an automatic relief means of venting to atmosphere internally loaded to a normally open position between two tightly closing shutoff valves and with means for testing for tightness of the checks and opening of relief means.

[RP] BACKFLOW, WATER DISTRIBUTION. The flow of water or other liquids into the potable water-supply piping from any sources other than its intended source. Backsiphonage is one type of backflow.

[RP] BACKPRESSURE. Pressure created by any means in the water distribution system that by being in excess of the pressure in the water supply mains causes a potential backflow condition.

[RP] BACKPRESSURE, LOW HEAD. A pressure less than or equal to 4.33 psi (29.88 kPa) or the pressure exerted by a 10-foot (3048 mm) column of water.

[RP] BACKSIPHONAGE. The flowing back of used or contaminated water from piping into a potable water-supply pipe due to a negative pressure in such pipe.

[RP] BACKWATER VALVE. A device installed in a drain or pipe to prevent backflow of sewage. A device or valve installed in the building drain or sewer pipe where a sewer is subject to backflow, and that prevents drainage or waste from backing up into a lower level or fixtures and causing a flooding condition.

BALCONY, EXTERIOR. An exterior floor projecting from and supported by a structure without additional independent supports.

[RG] BAROMETRIC DRAFT REGULATOR. A balanced damper device attached to a chimney, vent connector, breeching or flue gas manifold to protect combustion appliances by controlling chimney draft. A double-acting barometric draft regulator is one whose balancing damper is free to move in either direction to protect combustion appliances from both excessive draft and backdraft.

BASEMENT. A story that is not a story above grade plane. That portion of a building that is partly or completely below grade. (see “Story above grade plane”).

BASEMENT WALL. The opaque portion of a wall that encloses one side of a basement and has an average below grade wall area that is 50 percent or more of the total opaque and nonopaque area of that enclosing side. For energy purposes, a wall 50 percent or more below grade and enclosing conditioned space.

BASIC WIND SPEED. Three-second gust speed at 33 feet (10 058 mm) above the ground in Exposure C (see Section R301.2.1) as given in Figure Tables R301.2(4)A and R301.2(5).
[RM] BATHROOM. A room containing a bathtub, shower, spa or similar bathing fixture. (see toilet room also).

BATHROOM GROUP. A group of fixtures, including or excluding a bidet, consisting of a water closet, lavatory, and bathtub or shower. Such fixtures are located together on the same floor level.

[RP] BATTERY OF FIXTURES. Any group of two or more similar adjacent fixtures that discharge into a common horizontal waste or soil branch.

BED AND BREAKFAST HOME. A detached single family dwelling occupied by the dwelling owner and containing eight or fewer guest rooms for rent for a period of less than one week.

BEDROOM. Sleeping room.

BEND. A drainage fitting, designed to provide a change in direction of a drain pipe of less than the angle specified by the amount necessary to establish the desired slope of the line (see “Elbow” and “Sweep”).

BOAT SLIP. A berthing place for one or two watercraft where the watercraft can be securely moored to cleats, piling, or other devices while the boats are in the water. Boat slips are commonly configured as “side-ties” or as single or double loaded "U" shaped berths.

BOILER. A self-contained appliance from which hot water is circulated for heating purposes and then returned to the boiler, and that operates at water pressures not exceeding 160 pounds per square inch gage (psig) (1102 kPa gauge) and at water temperatures not exceeding 250°F (121°C).

[RG] BOILER, LOW-PRESSURE. A self-contained appliance for supplying steam or hot water.

- **Hot water heating boiler.** A boiler in which no steam is generated, from which hot water is circulated for heating purposes and then returned to the boiler, and that operates at water pressures not exceeding 160 pounds per square inch gage (psig) (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

- **Hot water supply boiler.** A boiler, completely filled with water, which furnishes hot water to be used externally to itself, and that operates at water pressures not exceeding 160 psig (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

- **Steam heating boiler.** A boiler in which steam is generated and that operates at a steam pressure not exceeding 15 psig (100 kPa gauge).

BOND BEAM. A horizontal grouted element within masonry in which reinforcement is embedded.

[RG] BONDING JUMPER. A conductor installed to electrically connect metallic gas piping to the grounding electrode system.
[RE] BPI ENVELOPE PROFESSIONAL. An individual that has passed the Building Performance Institute written and field examination requirements for the Building Envelope certification and has a current certification.

**BRACED WALL LINE.** A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing.

**BRACED WALL LINE, CONTINUOUSLY SHEATHED.** A braced wall line with structural sheathing applied to all sheathable surfaces including the areas above and below openings.

**BRACED WALL PANEL.** A full-height section of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material and anchors. The panel’s length meets the requirements of its particular bracing method, and contributes toward the total amount of bracing required along its braced wall line in accordance with Section R602.10.1.

**BRANCH.** Any part of the piping system other than a riser, main or stack.

**BRANCH, FIXTURE.** See “Fixture branch, drainage.”

**BRANCH, HORIZONTAL.** See “Horizontal branch, drainage.”

[RP] **BRANCH INTERVAL.** A vertical measurement of distance, 8 feet (2438 mm) or more in developed length, between the connections of horizontal branches to a drainage stack. Measurements are taken down the stack from the highest horizontal branch connection. A distance along a soil or waste stack corresponding, in general, to a story height, but not less than 8 feet (2438 mm) within which the horizontal branches from one floor or story of a structure are connected to the stack. Measurements are taken down the stack from the highest horizontal branch connection.

[RP] **BRANCH, MAIN.** A water-distribution pipe that extends horizontally off a main or riser to convey water to branches or fixture groups.

[RP] **BRANCH, VENT.** A vent connecting two or more individual vents with a vent stack or stack vent.

[RM] **BRAZED JOINT.** A gas-tight joint obtained by the joining of metal parts with metallic mixtures or alloys which melt at a temperature above 1,000°F (538°C), but lower than the melting temperature of the parts to be joined.

[RG] **BRAZING.** A metal-joining process wherein coalescence is produced by the use of a nonferrous filler metal having a melting point above 1,000°F (538°C), but lower than that of the base metal being joined. The filler material is distributed between the closely fitted surfaces of the joint by capillary action.

[RG] **BROILER.** A general term including salamanders, barbecues and other appliances cooking primarily by radiated heat, excepting toasters.

[RG] **BTU.** Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound (454 g) of water 1°F (0.56°C) (1 Btu = 1055 J).

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**BTU/H.** The listed maximum capacity of an appliance, absorption unit or burner expressed in British thermal units input per hour.

**BUILDING.** Building shall mean any one- and two-family dwelling or portion thereof, including townhouses, that is used, or designed or intended to be used for human habitation, for living, sleeping, cooking or eating purposes, or any combination thereof, and shall include accessory structures thereto.

**[RP] BUILDING DRAIN.** The lowest piping that collects the discharge from all other drainage piping inside the house and extends 30 inches (762 mm) in developed length of pipe, to 10 feet (3048 mm) beyond the exterior walls of the building and conveys the drainage to the building sewer.

**Exception:** Drain lines connecting to septic tanks within 25 feet (7620 mm) of the building foundation wall for one- and two-family dwellings with 3 water closets or less shall be considered to be building drain with a minimum size of 3 inches (76.2 mm).

**BUILDING, EXISTING.** Existing building is a building erected prior to the adoption of this code, or one for which a legal building permit has been issued.

**BUILDING-INTEGRATED PHOTOVOLTAIC PRODUCT.** A building product that incorporates photovoltaic modules and functions as a component of the building envelope.

**BUILDING LINE.** The line established by law, beyond which a building shall not extend, except as specifically provided by law.

**BUILDING OFFICIAL.** The officer or other designated authority charged with the administration and enforcement of this code.

**[RP] BUILDING SEWER.** That part of the drainage system that extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage-disposal system or other point of disposal.

**Sanitary.** A building sewer that conveys sewage only.

**Storm.** A building sewer that conveys storm water or other drainage, but not sewage.

**[RE] BUILDING SITE.** A contiguous area of land that is under the ownership or control of one entity.

**[RP] BUILDING SUBDRAIN.** That portion of a drainage system that does not drain by gravity into the building sewer.

**[RE] BUILDING THERMAL ENVELOPE.** The basement walls, exterior walls, floor, roof and any other building element that enclose conditioned spaces. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space.

**BUILT-UP ROOF COVERING.** Two or more layers of felt cemented together and surfaced with a cap sheet, mineral aggregate, smooth coating or similar surfacing material.
**[RG] BURNER.** A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone.

**Induced-draft.** A burner that depends on draft induced by a fan that is an integral part of the appliance and is located downstream from the burner.

**Power.** A burner in which gas, air or both are supplied at pressures exceeding, for gas, the line pressure, and for air, atmospheric pressure, with this added pressure being applied at the burner.

**CAP PLATE.** The top plate of the double top plates used in structural insulated panel (SIP) construction. The cap plate is cut to match the panel thickness such that it overlaps the wood structural panel facing on both sides.

**CEILING HEIGHT.** The clear vertical distance from the finished floor to the finished ceiling.

**CEMENT PLASTER.** A mixture of portland or blended cement, portland cement or blended cement and hydrated lime, masonry cement or plastic cement and aggregate and other approved materials as specified in this code.

**[RE] C-FACTOR (THERMAL CONDUCTANCE).** The coefficient of heat transmission (surface to surface) through a building component or assembly, equal to the time rate of heat flow per unit area and the unit temperature difference between the warm side and cold side surfaces (Btu/h·ft²·°F)/[W/(m²·K)].

**[RE] CFM25.** Cubic Feet per Minute of measured air flow while the building is maintained at a pressure difference of 25 Pascals (0.1 inches w.p.).

**[RE] CFM50.** Cubic Feet per Minute of measured air flow while the building is maintained at a pressure difference of 50 Pascals (0.2 inches w.p.).

**CHIMNEY.** A primarily vertical structure containing one or more flues, for the purpose of carrying gaseous products of combustion and air from a fuel-burning appliance to the outside atmosphere.

**Factory-built chimney.** A listed and labeled chimney composed of factory-made components, assembled in the field in accordance with manufacturer’s instructions and the conditions of the listing.

**Masonry chimney.** A field-constructed chimney composed of solid masonry units, bricks, stones or concrete.

**CHIMNEY CONNECTOR.** A pipe that connects a fuel-burning appliance to a chimney.

**CHIMNEY TYPES.**

**Residential-type appliance.** An approved chimney for removing the products of combustion from fuel-burning, residential-type appliances producing combustion gases not in excess of 1,000°F (538°C) under normal operating conditions, and capable of producing
combustion gases of 1,400°F (760°C) during intermittent forces firing for periods up to 1 hour. All temperatures shall be measured at the appliance flue outlet. Residential-type appliance chimneys include masonry and factory-built types.

[RP] CIRCUIT VENT. A vent that connects to a horizontal drainage branch and vents two traps to not more than eight traps or trapped fixtures connected into a battery.

CIRCULATING HOT WATER SYSTEM. A specifically designed water distribution system where one or more pumps are operated in the service hot water piping to circulate heated water from the water-heating equipment to fixtures and back to the water-heating equipment.

[RP] CISTERN. A small covered tank for storing water for a home or farm. Generally, this tank stores rainwater to be utilized for purposes other than in the potable water supply, and such tank is placed underground in most cases.

CLADDING. The exterior materials that cover the surface of the building envelope that is directly loaded by the wind.

CLEANOUT. An accessible opening in the drainage system used for the removal of possible obstruction. Types of cleanouts include a removable plug or cap, and a removable fixture or fixture trap.

[RG] CLEARANCE. The minimum distance through air measured between the heat-producing surface of the mechanical appliance, device or equipment and the surface of the combustible material or assembly.

[RE] CLIMATE ZONE. A geographical region based on climatic criteria as specified in this code.

CLOSED CRAWLSPACE. A foundation without wall vents that uses air sealed walls, ground and foundation moisture control, and mechanical drying potential to control crawl space moisture. Insulation may be located at the floor level or at the exterior walls.

CLOSET. A small room or chamber used for storage.

[RM] CLOTHES DRYER. An appliance used to dry wet laundry by means of heat.

CODE OFFICIAL. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

COLLECTION PIPE. Unpressurized pipe used within the collection system that drains on-site nonpotable water or rainwater to a storage tank by gravity.

[RG] CLOTHES DRYER. An appliance used to dry wet laundry by means of heated air.

Type 1. Factory-built package, multiple production. Primarily used in the family living environment. Usually the smallest unit physically and in function output.

[RP] COMBINATION FIXTURE. A fixture combining one sink and laundry tray or a two- or three-compartment sink or laundry tray in one unit.
[RP] COMBINATION WASTE AND VENT SYSTEM. A specially designed system of waste piping embodying the horizontal wet venting of one or more sinks, lavatories or floor drains by means of a common waste and vent pipe adequately sized to provide free movement of air above the flow line of the drain.

[RG] COMBUSTIBLE ASSEMBLY. Wall, floor, ceiling or other assembly constructed of one or more component materials that are not defined as noncombustible.

COMBUSTIBLE MATERIAL. Any material not defined as noncombustible.

[RG] COMBUSTION. In the context of this code, refers to the rapid oxidation of fuel accompanied by the production of heat or heat and light.

COMBUSTION AIR. The air provided to fuel-burning equipment including air for fuel combustion, draft hood dilution and ventilation of the equipment enclosure. Air necessary for complete combustion of a fuel, including theoretical air and excess air.

[RG] COMBUSTION CHAMBER. The portion of an appliance within which combustion occurs.

[RG] COMBUSTION PRODUCTS. Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inert gases, but excluding excess air.

COMMERCIAL, BUILDING. See Section N1101.6.

[RP] COMMON VENT. A single pipe venting two trap arms within the same branch interval, either back-to-back or one above the other. A vent connecting at the junction of two fixture drains or to a fixture branch and serving as a vent for both fixtures.

[RP] CONCEALED FOULING SURFACE. Any surface of a plumbing fixture that is not readily visible and is not scoured or cleansed with each fixture operation.

[RG] CONCEALED LOCATION. A location that cannot be accessed without damaging permanent parts of the building structure or finish surface. Spaces above, below or behind readily removable panels or doors shall not be considered as concealed.

[RG] CONCEALED PIPING. Piping that is located in a concealed location (see “Concealed location”).

CONDENSATE. The liquid that separates from a gas due to a reduction in temperature; for example, water that condenses from flue gases and water that condenses from air circulating through the cooling coil in air conditioning equipment.

CONDENSING APPLIANCE. An appliance that condenses water generated by the burning of fuels.

CONDITIONED AIR. Air treated to control its temperature, relative humidity or quality.

[RE] CONDITIONED AREA. That area within a building provided with heating or cooling systems or appliances capable of maintaining, through design or heat loss or gain, 68°F (20°C) during the heating season or 80°F (27°C) during the cooling season, or has a fixed opening directly adjacent to a conditioned area.
CONDITIONED CRAWL SPACE. A conditioned crawl space is a foundation without wall vents that encloses an intentionally heated or cooled space. Insulation is located at the exterior walls.

[RE] CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the conditioned space.

[RE] CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and that is directly heated or cooled or that is indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate thru openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings or where they contain uninsulated ducts, piping or other sources of heating or cooling. A space within a building that is provided with heating or cooling equipment or systems capable of maintaining, through design or heat loss/gain, 50°F (10°C) during the heating season or 85°F (29°C) during the cooling season, or communicates directly with a conditioned space. Spaces within the building thermal envelope are considered conditioned space.

[RG] CONNECTOR, APPLIANCE (Fuel). Rigid metallic pipe and fittings, semirigid metallic tubing and fittings or a listed and labeled device that connects an appliance to the gas piping system.

[RG] CONNECTOR, CHIMNEY OR VENT. The pipe that connects an appliance to a chimney or vent.

CONSTRUCTION DOCUMENTS. Written, graphic and pictorial documents prepared or assembled for describing the design, location and physical characteristics of the elements of a project necessary for obtaining a building permit. Construction drawings shall be drawn to an appropriate scale.

CONTAMINATION. An high-hazard or health hazard impairment of the quality of the potable water that creates an actual hazard to the public health through poisoning or through the spread of disease by sewage, industrial fluids or waste.

[RE] CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

CONTINUOUS WASTE. A drain from two or more similar adjacent fixtures connected to a single trap.

[RG] CONTROL. A manual or automatic device designed to regulate the gas, air, water or electrical supply to, or operation of, a mechanical system.

CONTROL, LIMIT. An automatic control responsive to changes in liquid flow or level, pressure, or temperature for limiting the operation of an appliance.

CONTROL, PRIMARY SAFETY. A safety control responsive directly to flame properties that senses the presence or absence of flame and, in event of ignition failure or unintentional flame extinguishment, automatically causes shutdown of mechanical equipment.
CONVECTOR. A system-incorporating heating element in an enclosure in which air enters an opening below the heating element, is heated and leaves the enclosure through an opening located above the heating element.

[RG] CONVERSION BURNER. A unit consisting of a burner and its controls for installation in an appliance originally utilizing another fuel.

CORE. The lightweight middle section of a structural insulated panel, composed of foam plastic insulation that provides the link between the two facing shells.

CORROSION RESISTANCE. The ability of a material to withstand deterioration of its surface or its properties where exposed to its environment.

COURT. A space, open and unobstructed to the sky, located at or above grade level on a lot and bounded on three or more sides by walls or a building.

[RE] CRAWL SPACE WALL. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

CRIPPLE WALL. A framed wall extending from the top of the foundation to the underside of the floor framing of the first story above grade plane.

[RP] CRITICAL LEVEL (C-L). An elevation (height) reference point that determines the minimum height at which a backflow preventer or vacuum breaker is installed above the flood level rim of the fixture or receptor served by the device. The critical level is the elevation level below which there is a potential for backflow to occur. If the critical level marking is not indicated on the device, the bottom of the device shall constitute the critical level.

[RP] CROSS CONNECTION. Any connection between two otherwise separate piping systems that allows a flow from one system to the other. Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other either water of unknown or questionable safety or steam, gas or chemical, whereby there exists the possibility for flow from one system to the other, with the direction of flow depending on the pressure differential between the two systems (see “Backflow”).

CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or structural composite lumber where the adjacent layers are cross-oriented and bonded with structural adhesive to form a solid wood element.

[RG] CUBIC FOOT. The amount of gas that occupies 1 cubic foot (0.02832 m$^3$) when at a temperature of 60ºF (16ºC), saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury (101 kPa).

[RE] CURTAIN WALL. See Section N1101.6 for definition applicable in Chapter 11.

DALLE GLASS. A decorative composite glazing material made of individual pieces of glass that are embedded in a cast matrix of concrete or epoxy.

[RG] DAMPER. A manually or automatically controlled device to regulate draft or the rate of flow of air or combustion gases.
DAMPER, VOLUME. A device that will restrict, retard or direct the flow of air in any duct, or the products of combustion of heat-producing equipment, vent connector, vent or chimney.

DAMPPROOFING. A coating or the application of coatings applied to retard the penetration of water vapor and moisture through or into walls or into interior spaces.

[RP] DEAD END. A branch leading from a soil, waste or vent pipe; a building drain; or a building sewer, and terminating at a developed length of 2 feet (610 mm) or more by means of a plug, cap or other closed fitting.

DEAD LOADS. The weight of the materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment.

DECK. An exterior floor system supported on at least two opposing sides by an adjoining structure or posts, piers, or other independent supports.

[RG] DECORATIVE APPLIANCE, VENTED. A vented appliance wherein the primary function lies in the aesthetic effect of the flames.

[RG] DECORATIVE APPLIANCES FOR INSTALLATION IN VENTED FIREPLACES. A vented appliance designed for installation within the fire chamber of a vented fireplace, wherein the primary function lies in the aesthetic effect of the flames.

DECORATIVE GLASS. A carved, leaded or Dalle glass or glazing material with a purpose that is decorative or artistic, not functional; with coloring, texture or other design qualities or components that cannot be removed without destroying the glazing material; and with a surface, or assembly into which it is incorporated, that is divided into segments.

[RG] DEMAND. The maximum amount of gas input required per unit of time, usually expressed in cubic feet per hour, or Btu/h (1 Btu/h = 0.2931 W).

[RP] DEMAND RECIRCULATION WATER SYSTEM. See Section N1101.6 for definition applicable in Chapter 11. A water distribution system where pump(s) prime the service hot water piping with heated water upon a demand for hot water.

DESIGN PROFESSIONAL. See “Registered design professional.”

[RM] DESIGN WORKING PRESSURE. The maximum allowable working pressure for which a specific part of a system is designed.

DEVELOPED LENGTH. The length of a pipeline measured along the center line of the pipe and fittings.

DIAMETER. Unless specifically stated, the term “diameter” is the nominal diameter as designated by the approved material standard.
**DIAPHRAGM.** A horizontal or nearly horizontal system acting to transmit lateral forces to the vertical resisting elements. Where the term “diaphragm” is used, it includes horizontal bracing systems.

**DILUTION AIR.** Air that enters a draft hood or draft regulator and mixes with flue gases.

**DIRECT SYSTEM.** A solar thermal system in which the gas or liquid in the solar collector loop is not separated from the load.

**DIRECT-VENT APPLIANCE.** A fuel-burning appliance with a sealed combustion system that draws all air for combustion from the outside atmosphere and discharges all flue gases to the outside atmosphere.

**[RP] DISCHARGE PIPE.** A pipe that conveys the discharge from plumbing fixtures or appliances.

**[RM] DISCRETE PRODUCT.** Products that are noncontinuous, individual, distinct pieces such as, but not limited to, electrical, plumbing and mechanical products and duct straps, duct fittings, duct registers and pipe hangers.

**DOCK.** A structure extending alongshore or out from the shore into a body of water, usually accommodating multiple boat slips, to which boats may be moored in order to load or unload people or cargo.

**DRAFT.** The pressure difference existing between the appliance or any component part and the atmosphere, that causes a continuous flow of air and products of combustion through the gas passages of the appliance to the atmosphere.

- **Induced draft.** The pressure difference created by the action of a fan, blower or ejector that is located between the appliance and the chimney or vent termination.

- **Natural draft.** The pressure difference created by a vent or chimney because of its height, and the temperature difference between the flue gases and the atmosphere.

**DRAFT HOOD.** A device built into an appliance, or a part of the vent connector from an appliance, that is designed to provide for the ready escape of the flue gases from the appliance in the event of no draft, backdraft or stoppage beyond the draft hood; prevent a backdraft from entering the appliance; and neutralize the effect of stack action of the chimney or gas vent on the operation of the appliance.

**DRAFT REGULATOR.** A device that functions to maintain a desired draft in the appliance by automatically reducing the draft to the desired value.

**DRAFT STOP.** A material, device or construction installed to restrict the movement of air within open spaces of concealed areas of building components such as crawl spaces, floor-ceiling assemblies, roof-ceiling assemblies and attics.

**DRAIN.** Any pipe that carries soil and water-borne wastes in a building drainage system.

**DRAIN-BACK SYSTEM.** A solar thermal system in which the fluid in the solar collector loop is drained from the collector into a holding tank under prescribed circumstances.
[RP] DRAINAGE FITTING. A pipe fitting designed to provide connections in the drainage system that have provisions for establishing the desired slope in the system. These fittings are made from a variety of both metals and plastics. The methods of coupling provide for required slope in the system. The type of fitting or fittings utilized in the drainage system. Drainage fittings are similar to cast-iron fittings, except that instead of having a bell and spigot, drainage fittings are recessed and tapped to eliminate ridges on the inside of the installed pipe.

[RP] DRAINAGE SYSTEM. Piping within a public or private premise that conveys sewage, rainwater or other liquid waste to a point of disposal. A drainage system does not include the mains of a public sewer system or a private or public sewage treatment or disposal plant.

Building gravity. A drainage system that drains by gravity into the building sewer.

Sanitary. A drainage system that carries sewage and excludes storm, surface and ground water.

Storm. A drainage system that carries rainwater, surface water, subsurface water and similar liquid waste.

[RG] DRIP. The container placed at a low point in a system of piping to collect condensate and from which the condensate is removable.

[RE] DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

[RG] DUCT FURNACE. A warm-air furnace normally installed in an air-distribution duct to supply warm air for heating. This definition shall apply only to a warm-air heating appliance that depends for air circulation on a blower not furnished as part of the furnace.

[RM] DUCTLESS MINI-SPLIT SYSTEM. A heating and cooling system that is comprised of one or multiple indoor evaporator/air-handling units and an outdoor condensing unit that is connected by refrigerant piping and electrical wiring. A ductless mini-split system is capable of cooling or heating one or more rooms without the use of a traditional ductwork system.

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

For definition applicable in Chapter 11, see Section N1101.6.

DURHAM FITTING. A special type of drainage fitting for use in the durham systems installations in which the joints are made with recessed and tapered threaded fittings, as opposed to bell and spigot lead/oakum or solvent/cemented or soldered joints. The tapping is at an angle (not 90 degrees) to provide for proper slope in otherwise rigid connections.

DURHAM SYSTEM. A term used to describe soil or waste systems where all piping is of threaded pipe, tube or other such rigid construction using recessed drainage fittings to correspond to the types of piping.
DWELLING. Any building that contains one or two dwelling units used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or that are occupied for living purposes.

DWELLING UNIT. A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

DWV. Abbreviated term for drain, waste and vent piping as used in common plumbing practice.

[RP] EFFECTIVE OPENING. The minimum cross-sectional area at the point of water-supply discharge, measured or expressed in terms of diameter of a circle and if the opening is not circular, the diameter of a circle of equivalent cross-sectional area. (This is applicable to used in the determination of the air gap.)

ELBOW. A pressure pipe fitting designed to provide an exact change in direction of a pipe run. An elbow provides a sharp turn in the flow path (see “Bend” and “Sweep”).

[RM] ELECTRIC HEATING APPLIANCE. An appliance that produces heat energy to create a warm environment by the application of electric power to resistance elements, refrigerant compressors or dissimilar material junctions.

EMERGENCY ESCAPE AND RESCUE OPENING. An operable exterior window, door or similar device that provides for a means of escape and access for rescue in the event of an emergency.

[RE] ENERGY ANALYSIS. A method for estimating the annual energy use of the proposed design and standard reference design based on estimates of energy use.

[RE] ENERGY COST. The total estimated annual cost for purchased energy for the building functions regulated by this code, including applicable demand charges.

[RM] ENERGY RECOVERY VENTILATION SYSTEM. Systems that employ air-to-air heat exchangers to recover energy from or reject energy to exhaust air for the purpose of preheating, pre-cooling, humidifying or dehumidifying outdoor ventilation air prior to supplying such air to a space, either directly or as part of an HVAC system.

[RE] ENERGY SIMULATION TOOL. An approved software program or calculation-based methodology that projects the annual energy use of a building.

ENGINEERED WOOD RIM BOARD. A full-depth structural composite lumber, wood structural panel, structural glued laminated timber or prefabricated wood I-joist member designed to transfer horizontal (shear) and vertical (compression) loads, provide attachment for diaphragm sheathing, siding and exterior deck ledgers and provide lateral support at the ends of floor or roof joists or rafters.

[RM] ENVIRONMENTAL AIR. Air that is conveyed to or from occupied areas through ducts which are not part of the heating or air-conditioning system, such as ventilation for human usage, domestic kitchen range exhaust, bathroom exhaust, domestic clothes dryer exhaust.

EQUIPMENT. Piping, ducts, vents, control devices and other components of systems other than appliances that are permanently installed and integrated to provide control of environmental
conditions for buildings. This definition shall also include other systems specifically regulated in this code.

[RM] EQUIPMENT, EXISTING. Any equipment regulated by this code which was legally installed prior to the effective date of this code, or for which a permit to install has been issued.

EQUIVALENT LENGTH. For determining friction losses in a piping system, the effect of a particular fitting equal to the friction loss through a straight piping length of the same nominal diameter.

[RE] ERI REFERENCE DESIGN. A version of the rated design that meets the minimum requirements of the 2006 International Energy Conservation Code.

ESCARPMENT. With respect to topographic wind effects, a cliff or steep slope generally separating two levels or gently sloping areas.

ESSENTIALLY NONTOXIC TRANSFER FLUIDS. Fluids having a Gosselin rating of 1, including propylene glycol; mineral oil; polydimethy oil oxane; hydrochlorofluorocarbon, chlorofluorocarbon and hydrofluorocarbon refrigerants; and FDA-approved boiler water additives for steam boilers.

ESSENTIALLY TOXIC TRANSFER FLUIDS. Soil, water or gray water and fluids having a Gosselin rating of 2 or more including ethylene glycol, hydrocarbon oils, ammonia refrigerants and hydrazine.

EVAPORATIVE COOLER. A device used for reducing air temperature by the process of evaporating water into an airstream.

EXCESS AIR. Air that passes through the combustion chamber and the appliance flue in excess of what is theoretically required for complete combustion.

[RG] EXCESS FLOW VALVE (EFV). A valve designed to activate when the fuel gas passing through it exceeds a prescribed flow rate.

[RM] EXFILTRATION. Uncontrolled outward air leakage from conditioned spaces through unintentional openings in ceilings, floors and walls to unconditioned spaces or the outdoors caused by pressure differences across these openings resulting from wind, the stack effect created by temperature differences between indoors and outdoors, and imbalances between supply and exhaust airflow rates.

[RM] EXHAUST SYSTEM. An assembly of connected ducts, plenums, fittings, registers, grilles and hoods through which air is conducted from the space or spaces and exhausted to the outdoor atmosphere.

[RP] EXISTING INSTALLATIONS. Any plumbing system regulated by this code that was legally installed prior to the effective date of this code, or for which a permit to install has been issued.

EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS). EIFS are nonstructural, nonload-bearing exterior wall cladding systems that consist of an insulation board attached either adhesively or mechanically, or both, to the substrate; an integrally reinforced base coat; and a textured protective finish coat.
EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS) WITH DRAINAGE. An EIFS that incorporates a means of drainage applied over a water-resistive barrier.

[RG] EXTERIOR MASONRY CHIMNEYS. Masonry chimneys exposed to the outdoors on one or more sides below the roof line.

EXTERIOR WALL. An above-grade wall that defines the exterior boundaries of a building. Includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and basement walls with an average below-grade wall area that is less than 50 percent of the total opaque and nonopaque area of that enclosing side.

EXTERIOR WALL COVERING. A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resistive barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, and fascias.

F-FACTOR. The perimeter heat loss factor for slab-on-grade floors (Btu/h x ft x °F) [W/(m x K)].

FACING. The wood structural panel facings that form the two outmost rigid layers of the structural insulated panel.

FACTORY-BUILT CHIMNEY. A listed and labeled chimney composed of factory-made components assembled in the field in accordance with the manufacturer’s instructions and the conditions of the listing.

FACTORY-MADE AIR DUCT. A listed and labeled duct manufactured in a factory and assembled in the field in accordance with the manufacturer’s instructions and conditions of the listing.

FAMILY. Family is an individual, two or more persons related by blood, marriage or law, or a group of not more than any five persons living together in a dwelling unit. Servants having common housekeeping facilities with a family consisting of an individual, or more persons related by blood, marriage or law, are a part of the family for this code.

[RP] FAUCET. A valve end of a water pipe through which water is drawn from or held within the pipe.

[RE] FENESTRATION. Skylights, roof windows, vertical windows (whether fixed or moveable); opaque doors; glazed doors; glass block; and combination opaque and glazed doors.

For definition applicable in Chapter 11, see Section N1101.6.

[RE] FENESTRATION PRODUCT, FIELD-FABRICATED. A fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-built fenestration.
[RE] FENESTRATION PRODUCT, SITE-BUILT. A fenestration designed to be made up of field-glazed or field-assembled units using specific factory cut or otherwise factory-formed framing and glazing units.

[RE] FENESTRATION, VERTICAL. Windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of at least 60 degrees (1.05 rad) from horizontal.

[RE] F-FACTOR. The perimeter heat loss factor for slab-on-grade floors (Btu/h·ft °F) [W/(m K)].

FIBER-CEMENT (BACKERBOARD, SIDING, SOFFIT, TRIM AND UNDERLAYMENT) PRODUCTS. Manufactured thin section composites of hydraulic cementitious matrices and discrete nonasbestos fibers.

FIBER-CEMENT SIDING. A manufactured, fiber-reinforcing product made with an inorganic hydraulic or calcium silicate binder formed by chemical reaction and reinforced with discrete organic or inorganic nonasbestos fibers, or both. Additives which enhance manufacturing or product performance are permitted. Fiber-cement siding products have either smooth or textured faces and are intended for exterior wall and related applications.

[RP] FILL VALVE. A water supply valve, opened or closed by means of a float or similar device, utilized to supply water to a tank. An antisiphon fill valve contains an antisiphon device in the form of an approved air gap or vacuum breaker that is an integral part of the fill valve unit and that is positioned on the discharge side of the water supply control valve.

FIREBLOCKING. Building materials or materials approved for use as fireblocking, installed to resist the free passage of flame to other areas of the building through concealed spaces.

FIREPLACE. An assembly consisting of a hearth and fire chamber and smoke chamber, beginning at the hearth and ending at the top of the smoke chamber, of noncombustible material and provided with a chimney, for use with solid fuels.

Factory-built fireplace. A listed and labeled fireplace and chimney system composed of factory-made components, and assembled in the field in accordance with manufacturer’s instructions and the conditions of the listing.

Masonry chimney. A field-constructed chimney composed of solid masonry units, bricks, stones or concrete, beginning at the top of the smoke chamber and ending at the flue termination.

Masonry fireplace. A field-constructed fireplace composed of solid masonry units, bricks, stones or concrete, beginning at the hearth and ending at the top of the smoke chamber.

Smoke chamber. That part of a masonry fireplace which extends from the top of the firebox to the start of the chimney flue lining. A smoke chamber shall have a damper and a smoke shelf.

FIREPLACE STOVE. A free-standing, chimney-connected solid-fuel-burning heater designed to be operated with the fire chamber doors in either the open or closed position.
FIREPLACE THROAT. The opening between the top of the firebox and the smoke chamber.

FIRE-RETARDANT-TREATED WOOD. Pressure-treated lumber and plywood that exhibit reduced surface burning characteristics and resist propagation of fire.

Other means during manufacture. A process where the wood raw material is treated with a fire-retardant formulation while undergoing creation as a finished product.

Pressure process. A process for treating wood using an initial vacuum followed by the introduction of pressure above atmospheric.

FIRE SEPARATION DISTANCE. The distance measured from the building face to one of the following:

1. To the closest interior lot line.
2. To the centerline of a street, an alley or public way.
3. To an imaginary line between two buildings on the lot.

The distance shall be measured at a right angle from the face of the wall.

FIXTURE. See “Plumbing fixture.”

[RP] FIXTURE BRANCH, DRAINAGE. A drain serving two or more fixtures that discharges into another portion of the drainage system drain or to a stack.

[RP] FIXTURE BRANCH, WATER-SUPPLY. A water-supply pipe between the fixture supply and a main water-distribution pipe or fixture group main.

[RP] FIXTURE DRAIN. The drain from the trap of a fixture to the junction of that drain with any other drain pipe.

[RP] FIXTURE FITTING.

Supply fitting. A fitting that controls the volume or directional flow or both of water and that is either attached to or accessible from a fixture or is used with an open or atmospheric discharge.

Waste fitting. A combination of components that conveys the sanitary waste from the outlet of a fixture to the connection of the sanitary drainage system.

[RP] FIXTURE GROUP, MAIN. The main water-distribution pipe (or secondary branch) serving a plumbing fixture grouping such as a bath, kitchen or laundry area to which two or more individual fixture branch pipes are connected.

[RP] FIXTURE SUPPLY. The water-supply pipe connecting a fixture or fixture fitting to a fixture branch water supply pipe or directly to a main water supply pipe branch.
[RP] **FIXTURE UNIT, DRAINAGE** (d.f.u.). A measure of probable discharge into the drainage system by various types of plumbing fixtures, used to size DWV piping systems. The drainage fixture-unit value for a particular fixture depends on its volume rate of drainage discharge, on the time duration of a single drainage operation and on the average time between successive operations.

[RP] **FIXTURE UNIT, WATER-SUPPLY** (w.s.f.u.). A measure of the probable hydraulic demand on the water supply by various types of plumbing fixtures used to size water-piping systems. The water-supply fixture-unit value for a particular fixture depends on its volume rate of supply, on the time duration of a single supply operation and on the average time between successive operations.

[RG] **FLAME SAFEGUARD.** A device that will automatically shut off the fuel supply to a main burner or group of burners when the means of ignition of such burners becomes inoperative, and when flame failure occurs on the burner or group of burners.

**FLAME SPREAD.** The propagation of flame over a surface.

**FLAME SPREAD INDEX.** A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame versus time for a material tested in accordance with ASTM E 84 or UL 723.

[RG] **FLASHBACK ARRESTOR CHECK VALVE.** A device that will prevent the backflow of one gas into the supply system of another gas and prevent the passage of flame into the gas supply system.

**FLEXIBLE AIR CONNECTOR.** A conduit for transferring air between an air duct or plenum and an air terminal unit, an air inlet or an air outlet. Such conduit is limited in its use, length and location.

**FLIGHT.** A continuous run of rectangular treads or winders or combination thereof from one landing to another.

**FLOOD HAZARD AREA.** For definition, see Section R322.

**FLOOD-LEVEL RIM.** The edge of the receptor or fixture from which water overflows.

**FLOOR DRAIN.** A plumbing fixture for recess in the floor having a floor-level strainer intended for the purpose of the collection and disposal of waste water used in cleaning the floor and for the collection and disposal of accidental spillage to the floor.

[RG] **FLOOR FURNACE.** A completely self-contained furnace suspended from the floor of the space being heated, taking air for combustion from outside such space, and with means for lighting the appliance from such space.

  - **Fan type.** A floor furnace equipped with a fan that provides the primary means for circulating air.
  - **Gravity type.** A floor furnace depending primarily upon circulation of air by gravity. This classification shall also include floor furnaces equipped with booster-type fans that do not materially restrict free circulation of air by gravity flow when such fans are not in operation.
FLOW PRESSURE. The static pressure reading in the water-supply pipe near the faucet or water outlet while the faucet or water outlet is open and flowing at capacity.

FLUE. See “Vent.”

FLUE, APPLIANCE. The passages within an appliance through which combustion products pass from the combustion chamber to the flue collar.

FLUE COLLAR. The portion of a fuel-burning appliance designed for the attachment of a draft hood, vent connector or venting system.

[RM] FLUE CONNECTION (BREECHING). A passage for conducting the products of combustion from a fuel-fired appliance to the vent or chimney (see also “Chimney connector” and “Vent connector”).

FLUE GASES. Products of combustion plus excess air in appliance flues or heat exchangers.

[RG] FLUE LINER (LINING). A system or material used to form the inside surface of a flue in a chimney or vent, for the purpose of protecting the surrounding structure from the effects of combustion products and for conveying combustion products without leakage to the atmosphere.

[RP] FLUSH VALVE. A device located at the bottom of a flush tank that is operated to flush water closets.

[RP] FLUSH TANK. A tank designed with a fill valve and flush valve to flush the contents of the bowl or usable portion of the fixture.

[RP] FLUSHOMETER TANK. A device integrated within an air accumulator vessel that is designed to discharge a predetermined quantity of water to fixtures for flushing purposes.

[RP] FLUSHOMETER VALVE. A flushometer valve is a device that discharges a predetermined quantity of water to fixtures for flushing purposes and is actuated by direct water pressure. A valve attached to a pressurized water supply pipe and so designed that when activated it opens the line for direct flow into the fixture at a rate and quantity to operate the fixture properly, and then gradually closes to reseal fixture traps and avoid water hammer.

FOAM BACKER BOARD. Foam plastic used in siding applications where the foam plastic is a component of the siding.

FOAM PLASTIC INSULATION. A plastic that is intentionally expanded by the use of a foaming agent to produce a reduced-density plastic containing voids consisting of open or closed cells distributed throughout the plastic for thermal insulating or acoustic purposes and that has a density less than 20 pounds per cubic foot (320 kg/m³) unless it is used as interior trim.

FOAM PLASTIC INTERIOR TRIM. Exposed foam plastic used as picture molds, chair rails, crown moldings, baseboards, handrails, ceiling beams, door trim and window trim and similar decorative or protective materials used in fixed applications.
[RG] FUEL GAS. A natural gas, manufactured gas, liquefied petroleum gas or mixtures of these gases.

[RM] FUEL OIL. Kerosene or any hydrocarbon oil having a flash point not less than 100°F (38°C).

[RM] FUEL-OIL PIPING SYSTEM. A closed piping system that connects a combustible liquid from a source of supply to a fuel-oil-burning appliance.

FUEL-PIPING SYSTEM. All piping, tubing, valves and fittings used to connect fuel utilization equipment to the point of fuel delivery.

FULLWAY VALVE. A valve that in the full open position has an opening cross-sectional area that is not less than 85 percent of the cross-sectional area of the connecting pipe.

[RE] FULLY ENCLOSED ATTIC FLOOR SYSTEM. The ceiling insulation is enclosed on all six sides by an air barrier system, such as taped drywall below, solid framing joists on the sides, solid blocking on the ends, and solid sheathing on top which totally enclose the insulation.

FURNACE. A vented heating appliance designed or arranged to discharge heated air into a conditioned space or through a duct or ducts.

[RG] FURNACE, CENTRAL. A self-contained appliance for heating air by transfer of heat of combustion through metal to the air, and designed to supply heated air through ducts to spaces remote from or adjacent to the appliance location.

  - Downflow furnace. A furnace designed with airflow discharge vertically downward at or near the bottom of the furnace.

  - Forced air furnace with cooling unit. A single-package unit, consisting of a gas-fired forced-air furnace of one of the types listed below combined with an electrically or fuel gas-powered summer air-conditioning system, contained in a common casing.

  - Forced-air type. A central furnace equipped with a fan or blower that provides the primary means for circulation of air.

  - Gravity furnace with booster fan. A furnace equipped with a booster fan that does not materially restrict free circulation of air by gravity flow when the fan is not in operation.

  - Gravity type. A central furnace depending primarily on circulation of air by gravity.

  - Horizontal forced-air type. A furnace with airflow through the appliance essentially in a horizontal path.

  - Multiple-position furnace. A furnace designed so that it can be installed with the airflow discharge in the upflow, horizontal or downflow direction.

  - Upflow furnace. A furnace designed with airflow discharge vertically upward at or near the top of the furnace. This classification includes “highboy” furnaces with the blower mounted
below the heating element and “lowboy” furnaces with the blower mounted beside the heating element.

[RG] FURNACE, ENCLOSED. A specific heating, or heating and ventilating, furnace incorporating an integral total enclosure and using only outside air for combustion.

FURNACE PLENUM. An air compartment or chamber to which one or more ducts are connected and which forms part of an air distribution system.

[RM] FURNACE ROOM. A room primarily utilized for the installation of fuel-burning, space-heating and water-heating appliances other than boilers.

[RM] FUSIBLE PLUG. A device arranged to relieve pressure by operation of a fusible member at a predetermined temperature.

[RG] GAS CONVENIENCE OUTLET. A permanently mounted, manually operated device that provides the means for connecting an appliance to, and disconnecting an appliance from, the supply piping. The device includes an integral, manually operated valve with a nondisplaceable valve member and is designed so that disconnection of an appliance only occurs when the manually operated valve is in the closed position.

[RG] GAS PIPING. An installation of pipe, valves or fittings installed on a premises or in a building and utilized to convey fuel gas.

GLAZING AREA. The interior surface area of all glazed fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Includes the area of glazed fenestration assemblies in walls bounding conditioned basements.

GRADE. The finished ground level adjoining the building at all exterior walls.

GRADE FLOOR OPENING. A window or other opening located such that the sill height of the opening is not more than 44 inches (1118 mm) above or below the finished ground level adjacent to the opening.

GRADE, PIPING. See “Slope.”

GRADE PLANE. A reference plane representing the average of the finished ground level adjoining the building at all exterior walls. Where the finished ground level slopes away from the exterior walls, the reference plane shall be established by the lowest points within the area between the building and the lot line or, where the lot line is more than 6 feet (1829 mm) from the building between the structure and a point 6 feet (1829 mm) from the building.

GRAY WATER. Waste discharged from lavatories, bathtubs, showers, clothes washers and laundry trays.

GRIDDED WATER DISTRIBUTION SYSTEM. A water distribution system where every water distribution pipe is interconnected so as to provide two or more paths to each fixture supply pipe.

GROSS AREA OF EXTERIOR WALLS. The normal projection of all exterior walls, including the area of all windows and doors installed therein.
GROUND-SOURCE HEAT PUMP LOOP SYSTEM. Piping buried in horizontal or vertical excavations or placed in a body of water for the purpose of transporting heat transfer liquid to and from a heat pump. Included in this definition are closed loop systems in which the liquid is recirculated and open loop systems in which the liquid is drawn from a well or other source.

GUARD. A building component or a system of building components located near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to the lower level.

GUESTROOM. Any room or rooms used or intended to be used by one or more guests for living or sleeping purposes.

GYPSUM BOARD. The generic name for a family of sheet products consisting of a noncombustible core primarily of gypsum with paper surfacing. Gypsum wallboard, gypsum sheathing, gypsum base for gypsum veneer plaster, exterior gypsum soffit board, predecorated gypsum board and water-resistant gypsum backing board complying with the standards listed in Section R702.3 and Part IX of this code are types of gypsum board.

GYPSUM PANEL PRODUCT. The general name for a family of sheet products consisting essentially of gypsum.

HABITABLE SPACE. A space in a building for living, sleeping, eating or cooking. Bathrooms, toilet rooms, closets, halls, storage or utility spaces and similar areas are not considered habitable spaces.

HANDRAIL. A horizontal or sloping rail intended for grasping by the hand for guidance or support.

HANGERS. See “Supports.”

HAZARDOUS LOCATION. Any location considered to be a fire hazard for flammable vapors, dust, combustible fibers or other highly combustible substances.

HAZARDOUS LOCATION, GLAZING. See Section R308.4.

HEAT PUMP. An appliance having heating or heating and cooling capability and that uses refrigerants to extract heat from air, liquid or other sources.

[RM] HEAT TRANSFER LIQUID. The operating or thermal storage liquid in a mechanical system, including water or other liquid base, and additives at the concentration present under operating conditions used to move heat from one location to another. Refrigerants are not included as heat transfer liquids.

HEAT TRAP. An arrangement of piping and fittings, such as elbows, or a commercially available heat trap that prevents thermosyphoning of hot water during standby periods.

HEATED SLAB. Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab.
[RE] HEATING DEGREE DAYS (HDD). The sum, on an annual basis, of the difference between 65°F (18°C) and the mean temperature for each day as determined from “NOAA Annual Degree Days to Selected Bases Derived from the 1960-1990 Normals” or other weather data sources acceptable to the code official.

HEIGHT, BUILDING. The vertical distance from grade plane to the average height of the highest roof surface.

HEIGHT, STORY. The vertical distance from top to top of two successive tiers of beams or finished floor surfaces; and, for the topmost story, from the top of the floor finish to the top of the ceiling joists or, where there is not a ceiling, to the top of the roof rafters.

[RE] HERS RATER. An individual that has completed training and been certified by RESNET (Residential Energy Services Network) Accredited Rating Provider and has a current certification.

[RE] HIGH-EFFICACY LAMPS. See Section N1101.6 for definition applicable in Chapter 11. Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

1. 60 lumens per watt for lamps over 40 watts;
2. 50 lumens per watt for lamps over 15 watts to 40 watts; and
3. 40 lumens per watt for lamps 15 watts or less.

HIGH-TEMPERATURE (H.T.) CHIMNEY. A high temperature chimney complying with the requirements of UL 103. A Type H.T. chimney is identifiable by the markings “Type H.T.” on each chimney pipe section.

HILL. With respect to topographic wind effects, a land surface characterized by strong relief in any horizontal direction.

HISTORIC BUILDING. Buildings that are listed in or eligible for listing in the National Register of Historic Places, or designated as historic under an appropriate state or local law. Any building or structure that is one or more of the following:

1. Listed, or certified as eligible for listing by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, in the National Register of Historic Places.
2. Designated as historic or contributing resource under an applicable state or local law.
3. Certified as a contributing resource within a National Register-listed, state designated or locally designated historic district.

[RM] HOOD, FULL OPENING. An exhaust hood with an opening not less than the diameter of the connecting vent.
[RP] HORIZONTAL BRANCH, DRAINAGE. A drain pipe extending laterally from a soil or waste stack or building drain, that receives the discharge from one or more fixture drains. A drainage branch pipe extending laterally from a soil or waste stack or building drain, with or without vertical sections or branches, that receives the discharge from two or more fixture drains or branches and conducts the discharge to the soil or waste stack or to the building drain.

HORIZONTAL PIPE. Any pipe or fitting that makes an angle of less than 45 degrees (0.79 rad) with the horizontal.

HOT WATER. Water at a temperature greater than or equal to 110°F (43°C).

[RG] HOUSE PIPING. See “Piping system.”

HUMIDISTAT. A regulatory device, actuated by changes in humidity, used for automatic control of relative humidity.

HURRICANE-PRONE REGIONS. Areas vulnerable to hurricanes, defined as the U.S. Atlantic Ocean and Gulf of Mexico coasts where the ultimate design wind speed, \( V_{ult} \), is greater than 115 miles per hour (51 m/s), and Hawaii, Puerto Rico, Guam, Virgin Islands and America Samoa.

HYDROGEN-GENERATING APPLIANCE. A self-contained package or factory-matched packages of integrated systems for generating gaseous hydrogen. Hydrogen-generating appliances utilize electrolysis, reformation, chemical or other processes to generate hydrogen.

[RG] IGNITION PILOT. A pilot that operates during the lighting cycle and discontinues during main burner operation.

IGNITION SOURCE. A flame, spark or hot surface capable of igniting flammable vapors or fumes. Such sources include appliance burners, burner ignitions and electrical switching devices.

INDIRECT SYSTEM. A solar thermal system in which the gas or liquid in the solar collector loop circulates between the solar collector and a heat exchanger and such gas or liquid is not drained from the system or supplied to the load during normal operation.

[RP] INDIRECT WASTE PIPE. A waste pipe that discharges into the drainage system through an air break or air gap into a trap, fixture or receptor.

[RP] INDIRECT WASTE RECEPTOR. A plumbing fixture designed to collect and dispose of liquid waste from other plumbing fixtures, plumbing equipment or appliances that are required to discharge to the drainage system through an air gap. The following types of fixtures fall within the classification of indirect liquid waste receptors: floor sinks, mop receptors, service sinks and standpipe drains with integral air gaps.

[RP] INDIVIDUAL SEWAGE DISPOSAL SYSTEM. A system for disposal of sewage by means of a septic tank or mechanical treatment, designed for use apart from a public sewer to serve a single establishment or building.
**[RP] INDIVIDUAL VENT.** A pipe installed to vent a single fixture drain trap that connects with the vent system above or terminates independently outside the building the fixture served or terminates in the open air.

**[RP] INDIVIDUAL WATER SUPPLY.** A supply other than an approved public water supply that serves one or more families. A water supply that serves one or more families, and that is not an approved public water supply.

**[RE] INfiltrATION.** The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

**[RG] INFRARED RADIANT HEATER.** A heater which directs a substantial amount of its energy output in the form of infrared radiant energy into the area to be heated. Such heaters are of either the vented or unvented type.

**INSULATED SIDING.** A type of continuous insulation, with manufacturer-installed insulating material as an integral part of the cladding product, having a minimum $R$-value of R-2.

**INSULATED VINYL SIDING.** A vinyl cladding product, with manufacturer-installed foam plastic insulating material as an integral part of the cladding product, having a thermal resistance of not less than R-2.

**INSULATING CONCRETE FORM (ICF).** A concrete forming system using stay-in-place forms of rigid foam plastic insulation, a hybrid of cement and foam insulation, a hybrid of cement and wood chips, or other insulating material for constructing cast-in-place concrete walls.

**[RE] INSULATING SHEATHING.** An insulating board having a thermal resistance of not less than R-2 of the core material.

For definition applicable in Chapter 11, see Section N1101.6.

**[RM] INTERLOCK.** A device actuated by another device with which it is directly associated, to govern succeeding operations of the same or allied devices. A circuit in which a given action cannot occur until after one or more other actions have taken place.

**[RP] JOINT.**

**Expansion.** A loop, return bend or return offset that provides for the expansion and contraction in a piping system and is utilized in tall buildings or where there is a rapid change of temperature, as in power plants, steam rooms and similar occupancies.

**Flexible.** Any joint between two pipes that permits one pipe to be deflected or moved without movement or deflection of the other pipe.

**Mechanical.** See “Mechanical joint.”

**Slip.** A type of joint made by means of a washer or a special type of packing compound in which one pipe is slipped into the end of an adjacent pipe.

**[RM] JOINT, FLANGED.** A joint made by bolting together a pair of flanged ends.
[RG] JOINT, FLARED. A metal-to-metal compression joint in which a conical spread is made on the end of a tube that is compressed by a flare nut against a mating flare.

[RG] JOINT, PLASTIC ADHESIVE. A joint made in thermoset plastic piping by the use of an adhesive substance which forms a continuous bond between the mating surfaces without dissolving either one of them.

[RM] JOINT, PLASTIC HEAT FUSION. A joint made in thermoplastic piping by heating the parts sufficiently to permit fusion of the materials when the parts are pressed together.

[RM] JOINT, PLASTIC SOLVENT CEMENT. A joint made in thermoplastic piping by the use of a solvent or solvent cement which forms a continuous bond between the mating surfaces.

[RM] JOINT, SOLDERED. A gas-tight joint obtained by the joining of metal parts with metallic mixtures of alloys which melt at temperatures between 400ºF (204ºC) and 1,000ºF (538ºC).

[RM] JOINT, WELDED. A gas-tight joint obtained by the joining of metal parts in molten state.

JURISDICTION. The governmental unit that has adopted this code under due legislative authority.

KITCHEN. Kitchen shall mean an area used, or designated to be used, for the preparation of food.

LABEL. An identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material, and the name and identification of an approved agency and that indicates that the representative sample of the product or material has been tested and evaluated by an approved agency. (See also “Manufacturer’s designation” and “Mark.”)

Labeled. Appliances, equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization as approved by the North Carolina Building Code Council concerned with product evaluation that maintains periodic inspection of the production of the above labeled items and whose labeling indicates either that the appliance, equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LAMP. The device in a lighting fixture that provides illumination, typically a bulb, fluorescent tube, or light emitting diode (LED).

[RP] LAUNDRY TRAY: a fixed tub with running water and drainpipe for washing clothes and other household linens, also called set tub.

[RP] LEAD-FREE PIPE AND FITTINGS. Containing not more than a weighted average of 8.0 0.25-percent lead when used with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures.

[RP] LEAD-FREE SOLDER AND FLUX. Containing not more than 0.2-percent lead.
[RP] LEADER. An exterior drainage pipe for conveying storm water from roof or gutter drains to an approved means of disposal.

[RG] LEAK CHECK. An operation performed on a gas piping system to verify that the system does not leak.

LIGHT-FRAME CONSTRUCTION. A type of construction with vertical and horizontal structural elements that are primarily formed by a system of repetitive wood or cold-formed steel framing members.

[RG] LIQUEFIED PETROLEUM GAS or LPG (LP-GAS). Liquefied petroleum gas composed predominately of propane, propylene, butanes or butylenes, or mixtures thereof that is gaseous under normal atmospheric conditions, but is capable of being liquefied under moderate pressure at normal temperatures.

LISTED. Appliances, equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the appliance, equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

LIVE LOADS. Those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load or dead load.

LIVING SPACE. Space within a dwelling unit utilized for living, sleeping, eating, cooking, bathing, washing and sanitation purposes.

LOCAL EXHAUST. An exhaust system that uses one or more fans to exhaust air from a specific room or rooms within a dwelling.

LODGING HOUSE. A one-family dwelling where one or more occupants are primarily permanent in nature, and rent is paid for guestrooms.

[RG] LOG LIGHTER. A manually operated solid-fuel ignition appliance for installation in a vented solid-fuel-burning fireplace.

LOT. A portion or parcel of land considered as a unit.

LOT LINE. A line dividing one lot from another, or from a street or any public place.

[RM] LOW-PRESSURE HOT-WATER-HEATING BOILER. A boiler furnishing hot water at pressures not exceeding 160 psi (1103 kPa) and at temperatures not exceeding 250ºF (121ºC).

[RM] LOW-PRESSURE STEAM-HEATING BOILER. A boiler furnishing steam at pressures not exceeding 15 psi (103 kPa).

[RE] LOW-VOLTAGE LIGHTING. Lighting equipment powered through a transformer such as a cable conductor, a rail conductor and track lighting.
Macerating Toilet Systems. A system comprised of a sump with macerating pump and with connections for a water closet and other plumbing fixtures, that is designed to accept, grind and pump wastes to an approved point of discharge.

Main. The principal pipe artery to which branches may be connected.

Main Burner. A device or group of devices essentially forming an integral unit for the final conveyance of gas or a mixture of gas and air to the combustion zone, and on which combustion takes place to accomplish the function for which the appliance is designed.

Main Sewer. See “Public sewer.”

Manifold Water Distribution Systems. A fabricated piping arrangement in which a large supply main is fitted with multiple branches in close proximity in which water is distributed separately to fixtures from each branch.

Manual. Capable of being operated by personal intervention (see “Automatic”).

Manufactured Home. Manufactured home means a structure, transportable in one or more sections, that in the traveling mode is 8 body feet (2438 body mm) or more in width or 40 body feet (12 192 body mm) or more in length, or, where erected on site, is 320 square feet (30 m²) or more, and that is built on a permanent chassis and designed to be used as a dwelling with or without a permanent foundation where connected to the required utilities, and includes the plumbing, heating, air conditioning and electrical systems contained therein; except that such term shall include any structure that meets all the requirements of this paragraph except the size requirements and with respect to which the manufacturer voluntarily files a certification required by the secretary (HUD) and complies with the standards established under this title. For mobile homes built prior to June 15, 1976, a label certifying compliance to the Standard for Mobile Homes, NFPA 501, in effect at the time of manufacture is required. For the purpose of these provisions, a mobile home shall be considered to be a manufactured home.

Manufacturer’s Designation. An identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set of rules. (See also “Mark” and “Label.”)

Manufacturer’s Installation Instructions. Printed instructions included with equipment as part of the conditions of their listing and labeling.

Mark. An identification applied on a product by the manufacturer indicating the name of the manufacturer and the function of a product or material. (See also “Manufacturer’s designation” and “Label.”)

Masonry Chimney. A field-constructed chimney composed of solid masonry units, bricks, stones or concrete.

Masonry Heater. A masonry heater is a solid fuel burning heating appliance constructed predominantly of concrete or solid masonry having a mass of not less than 1,100 pounds (500 kg), excluding the chimney and foundation. It is designed to absorb and store a substantial portion of heat from a fire built in the firebox by routing exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox includes not less than one
180-degree (3.14-rad) change in flow direction before entering the chimney and that deliver heat by radiation through the masonry surface of the heater.

**MASONRY, SOLID.** Masonry consisting of solid masonry units laid contiguously with the joints between the units filled with mortar.

**MASONRY UNIT.** Brick, tile, stone, architectural cast stone, glass block or concrete block conforming to the requirements specified in Section 2103 of the *International Building Code*.

- **Clay.** A building unit larger in size than a brick, composed of burned clay, shale, fire clay or mixtures thereof.

- **Concrete.** A building unit or block larger in size than 12 inches by 4 inches by 4 inches (305 mm by 102 mm by 102 mm) made of cement and suitable aggregates.

- **Glass.** Nonload-bearing masonry composed of glass units bonded by mortar.

- **Hollow.** A masonry unit with a net cross-sectional area in any plane parallel to the loadbearing surface that is less than 75 percent of its gross cross-sectional area measured in the same plane.

- **Solid.** A masonry unit with a net cross-sectional area in every plane parallel to the loadbearing surface that is 75 percent or more of its cross-sectional area measured in the same plane.

**[RE] MASS WALL.** Masonry or concrete walls having a mass greater than or equal to 30 pounds per square foot (146 kg/m$^2$), solid wood walls having a mass greater than or equal to 20 pounds per square foot (98 kg/m$^2$), and any other walls having a heat capacity greater than or equal to 6 Btu/ft$^2$·°F [123 J/(m$^2$·K)].

**MEAN ROOF HEIGHT.** The average of the roof eave height and the height to the highest point on the roof surface, except that eave height shall be used for roof angle of less than or equal to 10 degrees (0.18 rad).

**MECHANICAL DRAFT SYSTEM.** A venting system designed to remove flue or vent gases by mechanical means, that consists of an induced draft portion under nonpositive static pressure or a forced draft portion under positive static pressure.

- **Forced-draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under positive static pressure.

- **Induced draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under nonpositive static vent pressure.

- **Power venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under positive static vent pressure.
MECHANICAL EXHAUST SYSTEM. A system for removing air from a room or space by mechanical means.

[RM] MECHANICAL JOINT.

1. A connection between pipes, fittings or pipes and fittings that is not welded, brazed, caulked, soldered, solvent cemented or heat-fused.

2. A general form of gas- or liquid-tight connections obtained by the joining of parts through a positive holding mechanical construction such as, but not limited to, flanged, screwed, clamped or flared connections.

MECHANICAL SYSTEM. A system specifically addressed and regulated in this code and composed of components, devices, appliances and equipment.

METAL ROOF PANEL. An interlocking metal sheet having an installed weather exposure of not less than 3 square feet (0.28 m\(^2\)) per sheet.

METAL ROOF SHINGLE. An interlocking metal sheet having an installed weather exposure less than 3 square feet (0.28 m\(^2\)) per sheet.

METER. The instrument installed to measure the volume of gas delivered through it or a measuring device used to collect data and indicate water usage.

MEZZANINE. An intermediate level or levels between the floor and ceiling of any story.

MODIFIED BITUMEN ROOF COVERING. One or more layers of polymer modified asphalt sheets. The sheet materials shall be fully adhered or mechanically attached to the substrate or held in place with an approved ballast layer.

[RG] MODULATING. Modulating or throttling is the action of a control from its maximum to minimum position in either predetermined steps or increments of movement as caused by its actuating medium.

MULTIPLE STATION SMOKE ALARM. Two or more single station alarm devices that are capable of interconnection such that actuation of one causes all integral or separate audible alarms to operate.

NAILABLE SUBSTRATE. A product or material such as framing, sheathing or furring, composed of wood or wood-based materials, or other materials and fasteners providing equivalent fastener withdrawal resistance.

NATURAL DRAFT SYSTEM. A venting system designed to remove flue or vent gases under nonpositive static vent pressure entirely by natural draft.

[RM] NATURAL VENTILATION. The movement of air into and out of a space through intentionally provided openings, such as windows and doors, or through nonpowered ventilators.
NATURALLY DURABLE WOOD. The heartwood of the following species with the exception that an occasional piece with corner sapwood is permitted if 90 percent or more of the width of each side on which it occurs is heartwood.

  Decay resistant. Redwood, cedar, black locust and black walnut.

  Termite resistant. Alaska yellow cedar, redwood, Eastern red cedar and Western red cedar including all sapwood of Western red cedar.

NONCOMBUSTIBLE MATERIAL. Materials that pass the test procedure for defining noncombustibility of elementary materials set forth in ASTM E 136.

NONCONDITIONED SPACE. A space that is not a conditioned space by insulated walls, floors or ceilings.

NOSING. The leading edge of treads of stairs and of landings at the top of stairway flights.

[RM] OCCUPIABLE SPACE. An enclosed space intended for human activities, excluding those spaces intended primarily for other purposes, such as storage rooms and equipment rooms, that are only intended to be occupied occasionally and for short periods of time.

OCCUPIED SPACE. The total area of all buildings or structures on any lot or parcel of ground projected on a horizontal plane, excluding permitted projections as allowed by this code.

OFFSET. A combination of fittings that makes two changes in direction, bringing one section of the pipe out of line and into a line parallel with the other section.

[RG] OFFSET (VENT). A combination of approved bends that make two changes in direction bringing one section of the vent out of line, but into a line parallel with the other section.

ON-SITE NONPOTABLE WATER REUSE SYSTEMS. Water systems for the collection, treatment, storage, distribution, and reuse of nonpotable water generated on site, including but not limited to graywater systems. This definition does not include rainwater harvesting systems.

[RE] ON-SITE RENEWABLE ENERGY. Includes solar photovoltaic; active solar thermal that employs collection panels, heat transfer mechanical components; wind; small hydro; tidal; wave energy; geothermal (core earth); biomass energy systems; landfill gas and bio-fuel based electrical production. Onsite energy shall be generated on or adjacent to the project site and shall not be delivered to the project through the utility service.

[RP] OPEN AIR. Outside the structure.

[RM] OUTDOOR AIR. Air taken from the outdoors, and therefore not previously circulated through the system.

[RM] OUTDOOR OPENING. A door, window, louver or skylight openable to the outdoor atmosphere.

[RG] OUTLET. The point at which a gas-fired appliance connects to the gas piping system.
OWNER. Any person, agent, firm or corporation having a legal or equitable interest in the property.

[RG] OXYGEN DEPLETION SAFETY SHUTOFF SYSTEM (ODS). A system designed to act to shut off the gas supply to the main and pilot burners if the oxygen in the surrounding atmosphere is reduced below a predetermined level.

PAN FLASHING. Corrosion-resistant flashing at the base of an opening that is integrated into the building exterior wall to direct water to the exterior and is premanufactured, fabricated, formed or applied at the job site.

[RM] PANEL HEATING. A method of radiant space heating in which heat is supplied by large heated areas of room surfaces. The heating element usually consists of warm water piping, warm air ducts, or electrical resistance elements embedded in or located behind ceiling, wall or floor surfaces.

PANEL THICKNESS. Thickness of core plus two layers of structural wood panel facings.

PELLET FUEL-BURNING APPLIANCE. A closed combustion, vented appliance equipped with a fuel feed mechanism for burning processed pellets of solid fuel of a specified size and composition.

PELLET VENT. A vent listed and labeled for use with a listed pellet fuel-burning appliance.

PERFORMANCE CATEGORY. A designation of wood structural panels as related to the panel performance used in Chapters 4, 5, 6 and 8.

PERMIT. An official document or certificate issued by the authority having jurisdiction that authorizes performance of a specified activity.

PERSON. An individual, heirs, executors, administrators or assigns, and a firm, partnership or corporation, its or their successors or assigns, or the agent of any of the aforesaid.

PHOTOVOLTAIC MODULE. A complete, environmentally protected unit consisting of solar cells, optics and other components, exclusive of a tracker, designed to generate DC power where exposed to sunlight.

PHOTOVOLTAIC PANEL. A collection of photovoltaic modules mechanically fastened together, wired, and designed to provide a field-installable unit.

PHOTOVOLTAIC PANEL SYSTEM. A system that incorporates discrete photovoltaic panels that convert solar radiation into electricity, including rack support systems.

PHOTOVOLTAIC SHINGLES. A roof covering that resembles shingles and that incorporates photovoltaic modules.

PIER. An elevated deck structure, usually pile supported, extending out into the water from the shore.

[RG] PILOT. A small flame that is utilized to ignite the gas at the main burner or burners.
[RP] PIPE SIZES. For the purposes of determining the minimum size of pipe required, cross-sectional areas are the essential characteristic, not the pipe diameter. When the Code instructs to “increase by one pipe size,” some pipe sizes may not be commercially available. The following pipe sizes are presumed to be commercially available: 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 3-1/2, 4, 4-1/2, 5, 6, 7, 8, 9, 10.

[RM] PIPING. Where used in this code, “piping” refers to either pipe or tubing, or both.

**Pipe.** A rigid conduit of iron, steel, copper, brass or plastic.

**Tubing.** Semirigid conduit of copper, aluminum, plastic or steel.

PITCH. See “Slope.”

[RG] PIPING. Where used in this code, “piping” refers to either pipe or tubing, or both.

**Pipe.** A rigid conduit of iron, steel, copper, brass or plastic.

**Tubing.** Semirigid conduit of copper, aluminum, plastic or steel.

[RG] PIPING SYSTEM. All fuel piping, valves and fittings from the outlet of the point of delivery to the outlets of the appliance shutoff valves.

PLANS. Construction documents.

PLASTIC COMPOSITE. A generic designation that refers to wood-plastic composites and plastic lumber.

[RG] PLASTIC, THERMOPLASTIC. A plastic that is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

PLATFORM CONSTRUCTION. A method of construction by which floor framing bears on load bearing walls that are not continuous through the story levels or floor framing.

PLENUM. A chamber that forms part of an air-circulation system other than the occupied space being conditioned.

[RM] PLENUM. An enclosed portion of the building structure, other than an occupiable space being conditioned, that is designed to allow air movement, and thereby serve as part of an air distribution system.

[RP] PLUMBING. The practice, materials and fixtures utilized in the installation, maintenance, extension and alteration of all piping, fixtures, plumbing appliances and plumbing appurtenances, within or adjacent to any structure, in connection with sanitary drainage or storm drainage facilities; venting systems; and public or private water supply systems. For the purpose of this code, plumbing refers to those installations, repairs, maintenance and alterations regulated by Chapters 25 through 33.
[RP] PLUMBING APPLIANCE. An energized household appliance with plumbing connections, such as a dishwasher, food waste disposer, clothes washer or water heater. Water or drain-connected devices intended to perform a special function. These devices have their operation or control dependent on one or more energized components, such as motors, controls or heating elements. Such devices are manually adjusted or controlled by the owner or operator, or are operated automatically through one or more of the following actions: a time cycle, a temperature range, a pressure range, a measured volume or weight.

[RP] PLUMBING APPURTENANCE. A device or assembly that is an adjunct to the basic plumbing system and does not demand additional water supply or add any discharge load to the system. It is presumed that it performs some useful function in the operation, maintenance, servicing, economy or safety of the plumbing system. A manufactured device, prefabricated assembly or on-the-job assembly of component parts that is an adjunct to the basic piping system and plumbing fixtures. An appurtenance demands no additional water supply and does not add any discharge load to a fixture or to the drainage system. Examples include filters, relief valves and aerators.

[RP] PLUMBING FIXTURE. A receptacle or device that is connected to a water supply system or discharges to a drainage system or both. Such receptacles or devices require a supply of water; or discharge liquid waste or liquid-borne solid waste; or require a supply of water and discharge waste to a drainage system. A receptacle or device that is either permanently or temporarily connected to the water distribution system of the premises and demands a supply of water therefrom; or discharges wastewater, liquid-borne waste materials or sewage either directly or indirectly to a drainage system of the premises; or requires both a water supply connection and a discharge to the drainage system of the premises.

[RP] PLUMBING SYSTEMS. Includes the water distribution pipes; plumbing fixtures and traps; water-treating or water-using equipment; soil, waste and vent pipes; and building drains; in addition to their respective connections, devices and appurtenances within a structure or premises; and the water service, building sewer and building storm sewer serving such structure or premises.

[RG] POINT OF DELIVERY. For natural gas systems, the point of delivery is the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where a meter is not provided. Where a valve is provided at the outlet of the service meter assembly, such valve shall be considered to be downstream of the point of delivery. For undiluted liquefied petroleum gas systems, the point of delivery shall be considered to be the outlet of the first regulator that reduces pressure.

POLLUTION. An low-hazard or non-health hazard impairment of the quality of the potable water to a degree that does not create a hazard to the public health but [and] that does adversely and unreasonably affect the aesthetic qualities of such potable water for domestic use.

POLYPROPYLENE SIDING. A shaped material, made principally from polypropylene homopolymer, or copolymer, that in some cases contains fillers or reinforcements, that is used to clad exterior walls or buildings.

PORTABLE-FUEL-CELL APPLIANCE. A fuel cell generator of electricity that is not fixed in place. A portable-fuel-cell appliance utilizes a cord and plug connection to a grid-isolated load and has an integral fuel supply.
POSITIVE ROOF DRAINAGE. The drainage condition in which consideration has been made for the loading deflections of the roof deck, and additional slope has been provided to ensure drainage of the roof within 48 hours of precipitation.

[RP] POTABLE WATER. Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects and conforming in bacteriological and chemical quality of the Public Health Service Drinking Water Standards or to the requirements regulations of the public health authority having jurisdiction.

PRECAST CONCRETE. A structural concrete element cast elsewhere than its final position in the structure.

PRECAST CONCRETE FOUNDATION WALLS. Pre-engineered, precast concrete wall panels that are designed to withstand specified stresses and used to build below-grade foundations.

[RM] PRESS JOINT. A permanent mechanical joint incorporating an elastomeric seal or an elastomeric seal and corrosion-resistant grip ring. The joint is made with a pressing tool and jaw or ring approved by the fitting manufacturer.

[RG] PRESSURE DROP. The loss in pressure due to friction or obstruction in pipes, valves, fittings, regulators and burners.

[RM] PRESSURE RELIEF DEVICE. A pressure-actuated valve or rupture member designed to relieve excessive pressure automatically.

PRESSURE-RELIEF VALVE. A pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure at the pressure at which it is set.

[RG] PRESSURE TEST. An operation performed to verify the gas-tight integrity of gas piping following its installation or modification.

[RE] PROPOSED DESIGN. A description of the proposed building used to estimate annual energy use for determining compliance based on total building performance.

[RM] PROTECTIVE ASSEMBLY (REDUCED CLEARANCE). Any noncombustible assembly that is labeled or constructed in accordance with Table M1306.2 and is placed between combustible materials or assemblies and mechanical appliances, devices or equipment, for the purpose of reducing required airspace clearances. Protective assemblies attached directly to a combustible assembly shall not be considered as part of that combustible assembly.

[RP] PUBLIC SEWER. A common sewer directly controlled by public authority.

[RP] PUBLIC WATER MAIN. A water-supply pipe for public use controlled by public authority.

PUBLIC WAY. Any street, alley or other parcel of land open to the outside air leading to a public street, that has been deeded, dedicated or otherwise permanently appropriated to the public for public use and that has a clear width and height of not less than 10 feet (3048 mm).

PURGE. To clear of air, gas or other foreign substances.
**[RM] PUSH-FIT JOINTS.** A type of mechanical joint consisting of elastomeric seals and corrosion-resistant tube grippers. Such joints are permanent or removable depending on the design.

**[RP] QUICK-CLOSING VALVE.** A valve or faucet that closes automatically where released manually or controlled by mechanical means for fast-action closing.

**[RE] R-VALUE, THERMAL RESISTANCE.** The inverse of the time rate of heat flow through a building thermal envelope element from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (h • ft² • °F/Btu).

**[RM] RADIANT HEATER.** A heater designed to transfer heat primarily by direct radiation.

**[RP] RAINWATER.** Water from natural precipitation.

**RAMP.** A walking surface that has a running slope steeper than 1 unit vertical in 20 units horizontal (5-percent slope).

**[RE] RATED DESIGN.** A description of the proposed building, used to determine the energy rating index.

**READY ACCESS (TO).** That which enables a device, appliance or equipment to be directly reached, without requiring the removal or movement of any panel, door or similar obstruction [see "Access (to)"].

**RECEPTOR.** A fixture or device that receives the discharge from indirect waste pipes.

**[RM] RECIRCULATED AIR.** Air removed from a conditioned space and intended for reuse as supply air.

**RECLAIMED WATER.** Nonpotable water that has been derived from the treatment of waste water by a facility or system licensed or permitted to produce water meeting the jurisdiction’s water requirements for its intended uses. Also known as “Recycled Water.”

**[RP] REDUCED PRESSURE PRINCIPLE BACKFLOW PREVENTION ASSEMBLY.** A backflow prevention device consisting of two independently acting check valves, internally force-loaded to a normally closed position and separated by an intermediate chamber (or zone) in which there is an automatic relief means of venting to the atmosphere, internally loaded to a normally open position between two tightly closing shutoff valves and with a means for testing for tightness of the checks and opening of the relief means.

**[RE] REFLECTIVE DUCT INSULATION.** A thermal insulation assembly consisting of one or more surfaces that have an emittance of 0.1 or less, and that bound an enclosed air space or spaces.

**REFRIGERANT.** A substance used to produce refrigeration by its expansion or evaporation.

**REFRIGERANT COMPRESSOR.** A specific machine, with or without accessories, for compressing a given refrigerant vapor.
REFRIGERATING SYSTEM. A combination of interconnected parts forming a closed circuit in
which refrigerant is circulated for the purpose of extracting, then rejecting, heat. A direct
refrigerating system is one in which the evaporator or condenser of the refrigerating system is in
direct contact with the air or other substances to be cooled or heated. An indirect refrigerating
system is one in which a secondary coolant cooled or heated by the refrigerating system is
circulated to the air or other substance to be cooled or heated.

REGISTERED DESIGN PROFESSIONAL. An individual who is registered or licensed to
practice their respective design profession as defined by the statutory requirements of the
professional registration laws of the state or jurisdiction in which the project is to be constructed.
Design by a registered design professional is not required where exempt under the registration
or licensure laws.

[RG] REGULATOR. A device for controlling and maintaining a uniform gas supply pressure,
either pounds-to-inches water column (MP regulator) or inches-to-inches water column
(appliance regulator).

[RG] REGULATOR, GAS APPLIANCE. A pressure regulator for controlling pressure to the
manifold of the gas appliance.

Adjustable.

1. Spring type, limited adjustment. A regulator in which the regulating force acting upon
the diaphragm is derived principally from a spring, the loading of which is adjustable
over a range of not more than 15 percent of the outlet pressure at the midpoint of the
adjustment range.

2. Spring type, standard adjustment. A regulator in which the regulating force acting
upon the diaphragm is derived principally from a spring, the loading of which is
adjustable. The adjustment means shall be concealed.

Multistage. A regulator for use with a single gas whose adjustment means is capable of
being positioned manually or automatically to two or more predetermined outlet pressure
settings. Each of these settings shall be adjustable or nonadjustable. The regulator may
modulate outlet pressures automatically between its maximum and minimum predetermined
outlet pressure settings.

Nonadjustable.

1. Spring type, nonadjustable. A regulator in which the regulating force acting upon the
diaphragm is derived principally from a spring, the loading of which is not field
adjustable.

2. Weight type. A regulator in which the regulating force acting upon the diaphragm is
derived from a weight or combination of weights.
[RG] REGULATOR, LINE GAS PRESSURE. A device placed in a gas line between the service pressure regulator and the appliance for controlling, maintaining or reducing the pressure in that portion of the piping system downstream of the device.

[RG] REGULATOR, MEDIUM-PRESSURE (MP Regulator). A line pressure regulator that reduces gas pressure from the range of greater than 0.5 psig (3.4 kPa) and less than or equal to 5 psig (34.5 kPa) to a lower pressure.

[RG] REGULATOR, PRESSURE. A device placed in a gas line for reducing, controlling and maintaining the pressure in that portion of the piping system downstream of the device.

[RG] REGULATOR, SERVICE PRESSURE. For natural gas systems, a device installed by the serving gas supplier to reduce and limit the service line pressure to delivery pressure. For undiluted liquefied petroleum gas systems, the regulator located upstream from all line gas pressure regulators, where installed, and downstream from any first stage or a high pressure regulator in the system.

[RG] RELIEF OPENING. The opening provided in a draft hood to permit the ready escape to the atmosphere of the flue products from the draft hood in the event of no draft, backdraft or stoppage beyond the draft hood, and to permit air into the draft hood in the event of a strong chimney updraft.

[RG] RELIEF VALVE (DEVICE). A safety valve designed to forestall the development of a dangerous condition by relieving either pressure, temperature or vacuum in the hot water supply system.

RELIEF VALVE, PRESSURE. An automatic valve that opens and closes a relief vent, depending on whether the pressure is above or below a predetermined value.

RELIEF VALVE, TEMPERATURE.

   Manual reset type. A valve that automatically opens a relief vent at a predetermined temperature and that must be manually returned to the closed position.

   Reseating or self-closing type. An automatic valve that opens and closes a relief vent, depending on whether the temperature is above or below a predetermined value.

RELIEF VALVE, VACUUM. A device to prevent excessive buildup of vacuum in a pressure vessel.

[RP] RELIEF VENT. A vent whose primary function is to provide circulation of air between drainage and vent systems.

REPAIR. The restoration or renewal of any part of an existing building for the purpose of its maintenance or to correct damage.

For definition applicable in Chapter 11, see Section N1101.6.

REROOFING. The process of recovering or replacing an existing roof covering. See “Roof recover.”
RETURN AIR. Air removed from an approved conditioned space or location and recirculated or exhausted.

[RM] RETURN AIR SYSTEM. An assembly of connected ducts, plenums, fittings, registers and grilles through which air from the space or spaces to be heated or cooled is conducted back to the supply unit (see also “Supply air system”).

RIDGE. With respect to topographic wind effects, an elongated crest of a hill characterized by strong relief in two directions.

[RP] RIM. An unobstructed open edge of a fixture.

RISER.

1. The vertical component of a step or stair.
2. A water pipe that extends vertically one full story or more to convey water to branches or to a group of fixtures.

[RG] RISER, GAS. A vertical pipe supplying fuel gas.

ROOF ASSEMBLY. A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly includes the roof deck, vapor retarder, substrate or thermal barrier, insulation, vapor retarder, and roof covering.

ROOF COVERING. The covering applied to the roof deck for weather resistance, fire classification or appearance.

ROOF COVERING SYSTEM. See “Roof assembly.”

ROOF DECK. The flat or sloped surface not including its supporting members or vertical supports.

ROOF RECOVER. The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering.

ROOF REPAIR. Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance.

ROOF REPLACEMENT. The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering.
ROOFTOP STRUCTURE. An enclosed structure on or above the roof of any part of a building.

ROOM HEATER. A freestanding heating appliance installed in the space being heated and not connected to ducts.

[RG] ROOM HEATER, UNVENTED. An unvented heating appliance designed for stationary installation and utilized to provide comfort heating. Such appliances provide radiant heat or convection heat by gravity or fan circulation directly from the heater and do not utilize ducts.

[RG] ROOM HEATER, VENTED. A free-standing heating unit used for direct heating of the space in and adjacent to that in which the unit is located.

ROUGH-IN. The installation of the parts of the plumbing system that must be completed prior to the installation of fixtures. This includes DWV, water supply and built-in fixture supports.

RUNNING BOND. The placement of masonry units such that head joints in successive courses are horizontally offset not less than one-quarter the unit length.

[RE] R-VALUE (THERMAL RESISTANCE). The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (h · ft² ·°F/Btu)(m² ·K)/W).

[RG] SAFETY SHUTOFF DEVICE. See Flame safeguard.

[RP] SANITARY SEWER. A sewer that carries sewage and excludes storm, surface and groundwater.

SCREEN ENCLOSURE. A building or part thereof, in whole or in part self-supporting, and having walls of insect screening with or without removable vinyl or acrylic wind break panels 10 mil or less with a Class A Flame Spread, and a roof.

SCREW LAMP HOLDERS. A lamp base that requires a screw-in-type lamp, such as a compact-fluorescent, incandescent, or tungsten-halogen bulb.

SCUPPER. An opening in a wall or parapet that allows water to drain from a roof.

SEISMIC DESIGN CATEGORY (SDC). A classification assigned to a structure based on its occupancy category and the severity of the design earthquake ground motion at the site.

[RP] SELF-CLOSING FAUCET. A faucet containing a valve that automatically closes upon deactivation of the opening means.

[RM] SELF-CONTAINED EQUIPMENT. Complete, factory assembled and tested, heating, air-conditioning or refrigeration equipment installed as a single unit, and having all working parts, complete with motive power, in an enclosed unit of said machinery.

SEMI-CONDITIONED SPACE. A space within the building thermal envelope that is not directly heated and/or cooled.
SEPTIC TANK. A water-tight receptor that receives the discharge of a building sanitary drainage system and is constructed so as to separate solids from the liquid, digest organic matter through a period of detention, and allow the liquids to discharge into the soil outside of the tank through a system of open joint or perforated piping or a seepage pit.

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

[RP] SEWAGE. Any liquid waste containing animal matter, vegetable matter or other impurity in suspension or solution. Any liquid waste containing animal or vegetable matter in suspension or solution, including liquids containing chemicals in solution.

[RP] SEWAGE EJECTOR. A device for lifting sewage by entraining the sewage in a high-velocity jet of steam, air or water.

[RP] SEWAGE PUMP. A permanently installed mechanical device for removing sewage or liquid waste from a sump.

[RP] SEWER.

Building sewer. See “Building sewer.”

Public sewer. That part of the drainage system of pipes, installed and maintained by a city, township, county, public utility company or other public entity, and located on public property, in the street or in an approved dedicated easement of public or community use.

Sanitary sewer. A sewer that carries sewage and excludes storm, surface and ground water.

Storm sewer. A sewer that conveys rainwater, surface water, subsurface water and similar liquid wastes.

SHAFT. An enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and the roof.

SHAFT ENCLOSURE. The walls or construction forming the boundaries of a shaft.

SHALL. The term, where used in the code, is construed as mandatory.

SHEAR WALL. A general term for walls that are designed and constructed to resist racking from seismic and wind by use of masonry, concrete, cold-formed steel or wood framing in accordance with Chapter 6 of this code and the associated limitations in Section R301.2 of this code.

SHINGLE FASHION. A method of installing roof or wall coverings, water-resistive barriers, flashing or other building components such that upper layers of material are placed overlapping lower layers of material to provide drainage and protect against water intrusion at unsealed penetrations and joints or in combination with sealed joints.

SIDE VENT. A vent connecting to the drain pipe through a fitting at an angle less than 45 degrees (0.79 rad) to the horizontal.
SINGLE PLY MEMBRANE. A roofing membrane that is field applied using one layer of membrane material (either homogeneous or composite) rather than multiple layers.

SINGLE STATION SMOKE ALARM. An assembly incorporating the detector, control equipment and alarm sounding device in one unit that is operated from a power supply either in the unit or obtained at the point of installation.

[RE] SITE-RECOVERED ENERGY. Waste energy recovered at the building site that is used to off-set consumption of purchased fuel or electrical energy supplies.

[RE] SKYLIGHT. See Section N1101.6 for definition applicable in Chapter 11. Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition.

SKYLIGHT AND SLOPED GLAZING. Glass or other transparent or translucent glazing material installed at a slope of 15 degrees (0.26 rad) or more from vertical. Glazing materials in skylights, including unit skylights, tubular daylighting devices, solariums, sunrooms, roofs and sloped walls are included in this definition.

SKYLIGHT, UNIT. A factory assembled, glazed fenestration unit, containing one panel of glazing material, that allows for natural daylighting through an opening in the roof assembly while preserving the weather-resistant barrier of the roof.

SLEEPING ROOM. A room designated as sleeping or bedroom on the plans and permit application.

[RE] SLEEPING UNIT. See Section N1101.6 for definition applicable in Chapter 11.

SLIP JOINT. A mechanical-type joint used primarily on fixture traps. The joint tightness is obtained by compressing a friction-type washer such as rubber, nylon, neoprene, lead or special packing material against the pipe by the tightening of a (slip) nut.

SLOPE. The fall (pitch) of a line of pipe in reference to a horizontal plane. In drainage, the slope is expressed as the fall in units vertical per units horizontal (percent) for a length of pipe.

SMOKE-DEVELOPED INDEX. A comparative measure, expressed as a dimensionless number, derived from measurements of smoke obscuration versus time for a material tested in accordance with ASTM E 84 or UL 723.

[RP] SOIL STACK OR PIPE. A pipe that conveys sewage containing fecal material to the building drain or building sewer.

[RE] SOLAR ENERGY SOURCE. Source of thermal, chemical, or electrical energy derived from direct conversion of incident solar radiation at the building site.

[RE] SOLAR HEAT GAIN COEFFICIENT (SHGC). The solar heat gain through a fenestration or glazing assembly relative to the incident solar radiation (Btu/h • ft² • °F). The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation which is...
then reradiated, conducted or convected into the space. This value is related to the Shading Coefficient (SC) by the formula SHGC = 0.87 x SC.

**SOLID MASONRY.** Load-bearing or nonload-bearing construction using masonry units where the net cross-sectional area of each unit in any plane parallel to the bearing surface is not less than 75 percent of its gross cross-sectional area. Solid masonry units shall conform to ASTM C 55, C 62, C 73, C 145 or C 216.

**[RG] SPECIFIC GRAVITY.** As applied to gas, *specific gravity* is the ratio of the weight of a given volume to that of the same volume of air, both measured under the same condition.

**[RP] SPILLPROOF VACUUM BREAKER.** An assembly consisting of one check valve force-loaded closed and an air-inlet vent valve force-loaded open to atmosphere, positioned downstream of the check valve, and located between and including two tightly closing shutoff valves and a test cock.

**SPLINE.** A strip of wood structural panel cut from the same material used for the panel facings, used to connect two structural insulated panels. The strip (spline) fits into a groove cut into the vertical edges of the two structural insulated panels to be joined. Splines are used behind each facing of the structural insulated panels being connected as shown in Figure R613.8.

**[RP] STACK.** Any main vertical DWV line, including offsets, that extends one or more stories. A general term for any vertical line of soil, waste, vent or inside conductor piping that extends through at least one story with or without offsets as directly as possible to its vent terminal.

**STACK BOND.** The placement of masonry units in a bond pattern is such that head joints in successive courses are vertically aligned. For the purpose of this code, requirements for stack bond shall apply to all masonry laid in other than running bond.

**[RP] STACK VENT.** The extension of soil or waste stack above the highest horizontal drain connected to the stack.

**[RP] STACK VENTING.** A method of venting a fixture or fixtures through the soil or waste stack.

**STAIR.** A change in elevation, consisting of one or more risers.

**STAIRWAY.** One or more flights of stairs, either interior or exterior, with the necessary landings and connecting platforms to form a continuous and uninterrupted passage from one level to another within or attached to a building, porch or deck.

**STAIRWAY, SPIRAL.** A stairway with a plan view of closed circular form and uniform section-shaped treads radiating from a minimum-diameter circle.

**[RE] STANDARD REFERENCE DESIGN.** A version of the *proposed design* that meets the minimum requirements of this code and is used to determine the maximum annual energy use requirement for compliance based on total building performance.

**STANDARD TRUSS.** Any construction that does not permit the roof-ceiling insulation to achieve the required *R*-value over the exterior walls.
STATIONARY FUEL CELL POWER PLANT. A self-contained package or factory-matched packages that constitute an automatically-operated assembly of integrated systems for generating useful electrical energy and recoverable thermal energy that is permanently connected and fixed in place.

[RM] STEAM-HEATING BOILER. A boiler operated at pressures not exceeding 15 psi (103 kPa) for steam.

STORM SEWER, DRAIN. A pipe used for conveying rainwater, surface water, subsurface water and similar liquid waste.

STORY. That portion of a building included between the upper surface of a floor and the upper surface of the floor or roof next above. A flood resistant enclosure, designed to break away so as not to cause collapse, shall not be considered as a story when determining height.

STORY, ATTIC. Any story situated wholly or partly in the roof, so designated, arranged or built as to be used for storage or habitation. If an attic which is accessible by a fixed stairway has a 7 foot clear height for greater than 50 percent of the floor area of the story below, then the space shall be considered as a story.

STORY ABOVE GRADE PLANE. Any story having its finished floor surface entirely above grade plane, or in which the finished surface of the floor next above is either of the following:

1. More than 6 feet (1829 mm) above grade plane.

2. More than 12 feet (3658 mm) above the finished ground level at any point.

Any story having its finished floor surface entirely above grade plane, except that a basement shall be considered as a story above grade plane where the finished surface of the floor above the basement meets any one of the following:

1. Is more than 6 feet (1829 mm) above grade plane.

2. Is more than 6 feet (1829 mm) above the finished ground level for more than 50 percent of the total building perimeter.

3. Is more than 12 feet (3658 mm) above the finished ground level at any point.

STRUCTURAL COMPOSITE LUMBER. Structural members manufactured using wood elements bonded together with exterior adhesives.

Examples of structural composite lumber are:

Laminated veneer lumber (LVL). A composite of wood veneer elements with wood fibers primarily oriented along the length of the member, where the veneer element thicknesses are 0.25 inches (6.4 mm) or less.

Parallel strand lumber (PSL). A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood
strand elements is 0.25 inch (6.4 mm) or less and their average lengths are not less than 300 times the least dimension of the wood strand elements.

**Laminated strand lumber (LSL).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood strand elements is 0.10 inch (2.54 mm) or less and their average lengths are not less than 150 times the least dimension of the wood strand elements.

**Oriented strand lumber (OSL).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood strand elements is 0.10 inch (2.54 mm) or less and their average lengths are not less than 75 times and less than 150 times the least dimension of the wood strand elements.

**STRUCTURAL INSULATED PANEL (SIP).** A structural sandwich panel that consists of a lightweight foam plastic core securely laminated between two thin, rigid wood structural panel facings.

**STRUCTURE.** That which is built or constructed.

**SUBSOIL DRAIN.** A drain that collects subsurface water or seepage water and conveys such water to a place of disposal.

**SUMP.** A tank or pit that receives sewage or waste, located below the normal grade of the gravity system and that must be emptied by mechanical means.

**SUMP PUMP.** A pump installed to empty a sump. These pumps are used for removing storm water only. An automatic water pump powered by an electric motor for the removal of drainage, except raw sewage, from a sump, pit or low point. The pump is selected for the specific head and volume of the load and is usually operated by level controllers.

**[RP] SUMP VENT.** A vent from pneumatic sewage ejectors, or similar equipment, that terminates separately to the open air.

**SUNROOM.** A one-story structure attached to a dwelling with a glazing area in excess of 40 percent of the gross area of the structure’s exterior walls and roof.

For definition applicable in Chapter 11, see Section N1101.6.

**SUPPLY AIR.** Air delivered to a conditioned space through ducts or plenums from the heat exchanger of a heating, cooling or ventilating system.

**[RM] SUPPLY AIR.** That air delivered to each or any space supplied by the air distribution system or the total air delivered to all spaces supplied by the air distribution system, which is provided for ventilating, heating, cooling, humidification, dehumidification and other similar purposes.

**[RM] SUPPLY AIR SYSTEM.** An assembly of connected ducts, plenums, fittings, registers and grilles through which air, heated or cooled, is conducted from the supply unit to the space or spaces to be heated or cooled (see also “Return air system”).

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SUPPORTS. Devices for supporting, hanging and securing pipes, fixtures and equipment.

[RP] SWEEP. A cast iron drainage fitting designed to provide a change in direction of a drain pipe of less than the angle specified by the amount necessary to establish the desired slope of the line. Sweeps provide a longer turning radius than bends and a less turbulent flow pattern (see “Bend” and “Elbow”).

TEMPERATURE- AND PRESSURE-RELIEF (T AND P) VALVE. A combination relief valve designed to function as both a temperature-relief and pressure-relief valve.

TEMPERATURE-RELIEF VALVE. A temperature-actuated valve designed to discharge automatically at the temperature at which it is set.

[RP] TEMPERED WATER. Water having a temperature range between 85°F (29°C) and 110°F (43°C).

TERMITE-RESISTANT MATERIAL. Pressure-preservative treated wood in accordance with the AWPA standards in Section R318.1, naturally durable termite-resistant wood, steel, concrete, masonry or other approved material.

THERMAL ISOLATION. Physical and space conditioning separation from conditioned space(s) consisting of existing or new walls, doors or windows. The conditioned space(s) shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.

For definition applicable in Chapter 11, see Section N1101.6.

[RE] THERMAL RESISTANCE, R-VALUE. The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (h • ft² • °F/Btu) (m² • K)/W.

[RE] THERMAL TRANSMITTANCE, U-FACTOR. The coefficient of heat transmission (air to air) through a building envelope component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h • ft² • °F) W/(m² • K).

[RE] THERMOSTAT. An automatic control device used to maintain temperature at a fixed or adjustable set point.

[RG] THERMOSTAT.

Electric switch type. A device that senses changes in temperature and controls electrically, by means of separate components, the flow of gas to the burner(s) to maintain selected temperatures.

Integral gas valve type. An automatic device, actuated by temperature changes, designed to control the gas supply to the burner(s) in order to maintain temperatures between predetermined limits, and in which the thermal actuating element is an integral part of the device.
1. Graduating thermostat. A thermostat in which the motion of the valve is approximately in direct proportion to the effective motion of the thermal element induced by temperature change.

2. Snap-acting thermostat. A thermostat in which the thermostatic valve travels instantly from the closed to the open position, and vice versa.

THIRD-PARTY CERTIFICATION AGENCY. An approved agency operating a product or material certification system that incorporates initial product testing, assessment and surveillance of a manufacturer’s quality control system.

THIRD PARTY CERTIFIED. Certification obtained by the manufacturer indicating that the function and performance characteristics of a product or material have been determined by testing and ongoing surveillance by an approved third-party certification agency. Assertion of certification is in the form of identification in accordance with the requirements of the third-party certification agency.

THIRD-PARTY TESTED. Procedure by which an approved testing laboratory provides documentation that a product material or system conforms to specified requirements.

TOILET ROOM. A room containing a water closet and, frequently, a lavatory, but not a bathtub, shower, spa or similar bathing fixture.

TOWNHOUSE. A single-family dwelling unit constructed in a group of three or more attached units separated by property lines in which each unit extends from foundation to roof and with a yard or public way on not less than two sides.

[RG] TRANSITION FITTINGS, PLASTIC TO STEEL. An adapter for joining plastic pipe to steel pipe. The purpose of this fitting is to provide a permanent, pressure-tight connection between two materials that cannot be joined directly one to another.

TRAP. A fitting, either separate or built into a fixture, that provides a liquid seal to prevent the emission of sewer gases without materially affecting the flow of sewage or waste water through it.

TRAP ARM. That portion of a fixture drain between a trap weir and the vent fitting.

TRAP PRIMER. A device or system of piping to maintain a water seal in a trap, typically installed where infrequent use of the trap would result in evaporation of the trap seal, such as floor drains.

TRAP SEAL. The trap seal is the maximum vertical depth of liquid that a trap will retain, measured between the crown weir and the top of the dip of the trap.

TRIM. Picture molds, chair rails, baseboards, handrails, door and window frames, and similar decorative or protective materials used in fixed applications.

TRUSS DESIGN DRAWING. The graphic depiction of an individual truss, that describes the design and physical characteristics of the truss.
[RE] TUBULAR DAYLIGHTING DEVICE (TDD). A nonoperable fenestration unit primarily designed to transmit daylight from a roof surface to an interior ceiling via a tubular conduit. The basic unit consists of an exterior glazed weathering surface, a light-transmitting tube with a reflective interior surface, and an interior-sealing device such as a translucent ceiling panel. The unit may be factory assembled, or field assembled from a manufactured kit.

TYPE L VENT. A listed and labeled vent conforming to UL 641 for venting oil-burning appliances listed for use with Type L vents or with gas appliances listed for use with Type B vents.

[RE] U-FACTOR, THERMAL TRANSMITTANCE. See Section N1101.6 for definition applicable in Chapter 11. The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h·ft²·°F)/W/(m²·K).

UNDERLAYMENT. One or more layers of felt, sheathing paper, nonbituminous saturated felt, or other approved material over which a roof covering, with a slope of 2 to 12 (17-percent slope) or greater, is applied.

[RG] UNIT HEATER.

High-static pressure type. A self-contained, automatically controlled, vented appliance having integral means for circulation of air against 0.2 inch w.c. (50 Pa) or greater static pressure. Such appliance is equipped with provisions for attaching an outlet air duct and, where the appliance is for indoor installation remote from the space to be heated, is also equipped with provisions for attaching an inlet air duct.

Low-static pressure type. A self-contained, automatically controlled, vented appliance, intended for installation in the space to be heated without the use of ducts, having integral means for circulation of air. Such units are allowed to be equipped with louvers or face extensions made in accordance with the manufacturer's specifications.

[RM] UNIT HEATER. A self-contained appliance of the fan type, designed for the delivery of warm air directly into the space in which the appliance is located.

[RP] VACUUM. Any pressure less than that exerted by the atmosphere.

VACUUM BREAKER. A device that prevents back-siphonage of water by admitting atmospheric pressure through ports to the discharge side of the device.

[RG] VALVE. A device used in piping to control the gas supply to any section of a system of piping or to an appliance.

Appliance shutoff. A valve located in the piping system, used to isolate individual appliances for purposes such as service or replacement.

Automatic. An automatic or semiautomatic device consisting essentially of a valve and an operator that control the gas supply to the burner(s) during operation of an appliance. The operator shall be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means or by other approved means.
**Automatic gas shutoff.** A valve used in conjunction with an automatic gas shutoff device to shut off the gas supply to a water-heating system. It shall be constructed integrally with the gas shutoff device or shall be a separate assembly.

**Individual main burner.** A valve that controls the gas supply to an individual main burner.

**Main burner control.** A valve that controls the gas supply to the main burner manifold.

**Manual main gas-control.** A manually operated valve in the gas line for the purpose of completely turning on or shutting off the gas supply to the appliance, except to pilot or pilots that are provided with independent shutoff.

**Manual reset.** An automatic shutoff valve installed in the gas supply piping and set to shut off when unsafe conditions occur. The device remains closed until manually reopened.

**Service shutoff.** A valve, installed by the serving gas supplier between the service meter or source of supply and the customer piping system, to shut off the entire piping system.

**VAPOR PERMEABLE.** The property of having a moisture vapor permeance rating of 5 perms (2.9 x 10^{-10} kg/Pa • s • m²) or greater, where tested in accordance with the desiccant method using Procedure A of ASTM E 96. A vapor permeable material permits the passage of moisture vapor.

**VAPOR RETARDER CLASS.** A measure of the ability of a material or assembly to limit the amount of moisture that passes through that material or assembly. Vapor retarder class shall be defined using the desiccant method with Procedure A of ASTM E 96 as follows:

- Class I: 0.1 perm or less
- Class II: 0.1 < perm ≤ 1.0 perm
- Class III: 1.0 < perm ≤ 10 perm

**[RG] VENT.** A passageway for conveying flue gases from fuel-fired appliances, or their vent connectors, to the outside atmosphere. A pipe or other conduit composed of factory-made components, containing a passageway for conveying combustion products and air to the atmosphere, listed and labeled for use with a specific type or class of appliance.

**Special gas vent.** A vent listed and labeled for use with listed Category II, III and IV gas appliances.

**Type B vent.** A vent listed and labeled for use with appliances with draft hoods and other Category I appliances that are listed for use with Type B vents.

**Type BW vent.** A vent listed and labeled for use with wall furnaces.

**Type L vent.** A vent listed and labeled for use with appliances that are listed for use with Type L or Type B vents.
VENT COLLAR. See “Flue collar.”

VENT CONNECTOR. That portion of a venting system that connects the flue collar or draft hood of an appliance to a vent.

VENT DAMPER DEVICE, AUTOMATIC. A device intended for installation in the venting system, in the outlet of an individual, automatically operated fuel burning appliance and that is designed to open the venting system automatically where the appliance is in operation and to close off the venting system automatically where the appliance is in a standby or shutdown condition.

VENT GASES. Products of combustion from fuel-burning appliances, plus excess air and dilution air, in the venting system above the draft hood or draft regulator.

[RP] VENT PIPE. See Vent system.

[RG] VENT PIPING.

Breather. Piping run from a pressure-regulating device to the outdoors, designed to provide a reference to atmospheric pressure. If the device incorporates an integral pressure relief mechanism, a breather vent can also serve as a relief vent.

Relief. Piping run from a pressure-regulating or pressure-limiting device to the outdoors, designed to provide for the safe venting of gas in the event of excessive pressure in the gas piping system.

VENT STACK. A vertical vent pipe installed to provide circulation of air to and from the drainage system and that extends through one or more stories.

[RP] VENT SYSTEM. Piping installed to equalize pneumatic pressure in a drainage system to prevent trap seal loss or blow-back due to siphonage or back pressure. A pipe or pipes installed to provide a flow of air to or from a plumbing drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

[RG] VENTED APPLIANCE CATEGORIES. Appliances that are categorized for the purpose of vent selection are classified into the following four categories:

Category I. An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.

Category II. An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that is capable of causing excessive condensate production in the vent.

Category III. An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.

Category IV. An appliance that operates with a positive vent static pressure and with a vent gas temperature that is capable of causing excessive condensate production in the vent.
**VENTED WALL FURNACE.** A self-contained vented *appliance* complete with grilles or equivalent, designed for incorporation in or permanent attachment to the structure of a building, mobile home or travel trailer, and furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing. This definition shall exclude *floor furnaces, unit heaters* and *central furnaces* as herein defined.

**VENTILATION.** The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

> For definition applicable in Chapter 11, see Section N1101.6.

**VENTILATION AIR.** That portion of supply air that comes from the outside (outdoors), plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

**VENTING.** Removal of combustion products to the outdoors.

**VENTING SYSTEM.** A continuous open passageway from the flue collar of an *appliance* to the outside atmosphere for the purpose of removing flue or vent gases. A venting system is usually composed of a vent or a chimney and vent connector, if used, assembled to form the open passageway.

- **Forced-draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under positive static vent pressure.

- **Induced draft venting system.** A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under nonpositive static vent pressure.

- **Mechanical draft venting system.** A venting system designed to remove flue or vent gases by mechanical means, that consists of an induced draft portion under nonpositive static pressure or a forced draft portion under positive static pressure.

- **Natural draft venting system.** A venting system designed to remove flue or vent gases under nonpositive static vent pressure entirely by natural draft.

**VERTICAL FENESTRATION.** Windows (fixed or movable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of at least 60 degrees (1.05 rad) from horizontal.

**VERTICAL PIPE.** Any pipe or fitting that makes an angle of 45 degrees (0.79 rad) or more with the horizontal.

**VINYL SIDING.** A shaped material, made principally from rigid polyvinyl chloride (PVC), that is used to cover exterior walls of buildings.
[RE] VISIBLE TRANSMITTANCE [VT]. The ratio of visible light entering the space through the fenestration product assembly to the incident visible light. Visible Transmittance, includes the effects of glazing material and frame and is expressed as a number between 0 and 1.

WALL, ABOVE-GRADE. A wall more than 50 percent above grade and enclosing conditioned space. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

WALL, CRAWLSPACE. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

[RG] WALL HEATER, UNVENTED TYPE. A room heater of the type designed for insertion in or attachment to a wall or partition. Such heater does not incorporate concealed venting arrangements in its construction and discharges all products of combustion through the front into the room being heated.

[RG] WATER HEATER. Any heating appliance or equipment that heats potable water and supplies such water to the potable hot water distribution system.

WALL, RETAINING. A wall not laterally supported at the top that resists lateral soil load and other imposed loads.

WALL VENTED CRAWL SPACE. A foundation that uses foundation wall vents as a primary means to control space moisture. Insulation is located at the floor level.

WALLS. Walls shall be defined as follows:

- **Load-bearing wall.** A wall supporting any vertical load in addition to its own weight.
- **Nonbearing wall.** A wall which does not support vertical loads other than its own weight.

[RP] WASTE. Liquid-borne waste that is free of does not contain fecal matter.

WASTE PIPE OR STACK. Piping that conveys only liquid sewage not containing fecal material.

WASTE RECEPTOR. A floor sink, standpipe, hub drain or a floor drain that receives the discharge of one or more indirect waste pipes.

WATER DISTRIBUTION SYSTEM. Piping that conveys water from the service to the plumbing fixtures, appliances, appurtenances, equipment, devices or other systems served, including fittings and control valves.

[RP] WATER-HAMMER ARRESTOR. A device utilized to absorb the pressure surge (water hammer) that occurs when water flow is suddenly stopped in a water supply system.

WATER HEATER. Any heating appliance or equipment that heats potable water and supplies such water to the potable hot water distribution system.

[RP] WATER MAIN. A water supply pipe for public use. A water supply pipe or system of pipes, installed and maintained by a city, township, county, public utility company or other public entity.
on public property, in the street or in an approved dedicated easement of public or community use.

[RP] WATER OUTLET. A valved discharge opening, including a hose bibb, through which water is removed from the potable water system supplying water to a plumbing fixture or plumbing appliance that requires either an air gap or backflow prevention device for protection of the supply system. A discharge opening through which water is supplied to a fixture, into the atmosphere, such as a hose bibb, (except into an open tank that is part of the water supply system), to a boiler or heating system, or to any devices or equipment requiring water to operate but which are not part of the plumbing system.

[RP] WATER PIPE.

  Riser. A water supply pipe that extends one full story or more to convey water to branches or to a group of fixtures.

  Water distribution pipe. A pipe within the structure or on the premises that conveys water from the water service pipe, or from the meter when the meter is at the structure, to the points of utilization.

  Water service pipe. The pipe from the water main or other source of potable water supply, or from the meter when the meter is at the public right of way, to the water distribution system of the building served. Water service pipe shall terminate 5 feet (1524 mm) outside the foundation wall.

WATER-RESISTIVE BARRIER. A material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the exterior wall assembly.

WATER SERVICE PIPE. The outside pipe from the water main or other source of potable water supply to the water distribution system inside the building, terminating at the service valve.

WATER SUPPLY SYSTEM. The water service pipe, the water-distributing pipes and the necessary connecting pipes, fittings, control valves and appurtenances in or adjacent to the building or premises.

WATERPROOFING. A coating or the application of coatings applied to prevent the penetration of water through or into walls or into interior spaces.

[RP] WEIGHTED AVERAGE LEAD CONTENT. The weighted average lead content of a pipe, pipe fitting, plumbing fitting, or fixture shall be calculated by using the following formula: For each wetted component, the percentage of lead in the component shall be multiplied by the ratio of the wetted surface area of that component to the total wetted surface area of the entire product to arrive at the weighted percentage of lead of the component. The weighted percentage of lead of each wetted component shall be added together, and the sum of these wetted percentages shall constitute the weighted average lead content of the product. For lead content of materials that are provided as a range, the maximum content of the range shall be used.

WET VENT. A vent that receives the discharge of wastes from other fixtures.
[RP] WHIRLPOOL BATHTUB. A plumbing appliance consisting of a bathtub fixture that is equipped and fitted with a circulating piping system designed to accept, circulate and discharge bathtub water upon each use.

WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM. An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air for outdoor air where operating continuously or through a programmed intermittent schedule to satisfy the whole-house ventilation rate.

  For definition applicable in Chapter 11, see Section N1101.6.

WINDER. A tread with nonparallel edges.

WINDOW. See Fenestration.

WINDBORNE DEBRIS REGION. Areas within hurricane-prone regions located in accordance with one of the following:

1. Within 1 mile (1.61 km) of the coastal mean high water line where the ultimate design wind speed, $V_{ult}$, is 130 mph (58 m/s) or greater.

2. In areas where the ultimate design wind speed, $V_{ult}$, is 140 mph (63.6 m/s) or greater; or Hawaii.

Areas within hurricane-prone regions defined as that area east of the Intracoastal waterway from the NC/SC state line north to Beaufort Inlet and from that point to include the barrier islands to the NC/VA state line.

WOOD STRUCTURAL PANEL. A panel manufactured from veneers; or wood strands or wafers; bonded together with waterproof synthetic resins or other suitable bonding systems. Examples of wood structural panels are plywood, OSB or composite panels.

YARD. An open space, other than a court, unobstructed from the ground to the sky, except where specifically provided by this code, on the lot on which a building is situated.

[RP] YARD HYDRANT A freeze proof yard hydrant is an outdoor water supply outlet that has a valve and outlet above ground and a drain opening below the frost level.

ZONE. A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.
Part III—Building Planning and Construction

CHAPTER 3
BUILDING PLANNING

SECTION R301
DESIGN CRITERIA

R301.1 Application.
Buildings and structures, and parts thereof, shall be constructed to safely support all loads, including dead loads, live loads, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code. The construction of buildings and structures in accordance with the provisions of this code shall result in a system that provides a complete load path that meets the requirements for the transfer of loads from their point of origin through the load-resisting elements to the foundation. Buildings and structures constructed as prescribed by this code are deemed to comply with the requirements of this section.

R301.1.1 Alternative provisions.
As an alternative to the requirements in Section R301.1, the following standards are permitted subject to the limitations of this code and the limitations therein. Where engineered design is used in conjunction with these standards, the design shall comply with the International Building Code.

1. AF&PA Wood Frame Construction Manual (WFCM).
2. AISI Standard for Cold-Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings (AISI S230).
4. Sunrooms complying with AAMA/NPEA/NSA 2100.

R301.1.2 Construction systems.
The requirements of this code are based on platform and balloon-frame construction for light-frame buildings. The requirements for concrete and masonry buildings are based on a balloon framing system. Other framing systems must have equivalent detailing to ensure force transfer, continuity and compatible deformations.

R301.1.3 Engineered design.
Where a building of otherwise conventional construction contains structural elements exceeding the limits of Section R301 or otherwise not conforming to this code, these elements shall be designed in accordance with accepted engineering practice. The extent of such design need only demonstrate compliance of nonconventional elements with other applicable provisions and shall be compatible with the performance of the conventional framed system. Engineered design in accordance with the International Building Code is permitted for buildings and structures, and parts thereof, included in the scope of this code.
R301.2 Climatic and geographic design criteria.
Buildings shall be constructed in accordance with the provisions of this code as limited by the provisions of this section. Additional criteria shall be established by the local jurisdiction and set forth in Table R301.2(1).

<table>
<thead>
<tr>
<th>GROUND SNOW LOAD</th>
<th>WIND DESIGN</th>
<th>SEISMIC DESIGN CATEGORY</th>
<th>SUBJECT TO DAMAGE FROM</th>
<th>WINTER DESIGN TEMP</th>
<th>ICE BARRIER UNDERLAYERMENT REQUIRED</th>
<th>FLOOD HAZARDS</th>
<th>AIR FREEZING INDEX</th>
<th>MEAN ANNUAL TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (mph)</td>
<td>Topographic effects</td>
<td>Wind-borne debris zone</td>
<td>Seismic Category</td>
<td>Weathering</td>
<td>Frost line depth</td>
<td>Termité</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s.
a. Weathering may require a higher strength concrete or grade of masonry than necessary to satisfy the structural requirements of this code. The weathering column shall be filled in with the weathering index, “negligible,” “moderate,” or “severe” for concrete as determined from Figure R301.2(3). The grade of masonry units shall be determined from ASTM C 34, C 55, C 62, C 73, C 90, C 129, C 145, C 216 or C 652.
b. The frost line depth may require deeper footings than indicated in Figure R403.1(1). The jurisdiction shall fill in the frost line depth column with the minimum depth of footing below finish grade.
c. The jurisdiction shall fill in this part of the table to indicate the need for protection depending on whether there has been a history of local subterranean termite damage.
d. The jurisdiction shall fill in this part of the table with the wind speed from the basic wind speed map [Figure R301.2(4)A]. Wind exposure category shall be determined on a site-specific basis in accordance with Section R301.2.1.4.
e. The outdoor design dry-bulb temperature shall be selected from the columns of 97 1/2-percent values for winter from Appendix D of the International Plumbing Code. Deviations from the Appendix D temperatures shall be permitted to reflect local climates or local weather experience as determined by the building official.
f. The jurisdiction shall fill in this part of the table with the seismic design category determined from Section R301.2.2.1.
g. The jurisdiction shall fill in this part of the table with (a) the date of the jurisdiction’s entry into the National Flood Insurance Program (date of adoption of the first code or ordinance for management of flood hazard areas), (b) the date(s) of the Flood Insurance Study and (c) the panel numbers and dates of the currently effective FIRMs and FBFMs or other flood hazard map adopted by the authority having jurisdiction, as amended.
h. In accordance with Sections R905.1.2, R905.4.3.1, R905.5.3.1, R905.6.3.1, R905.7.3.1 and R905.8.3.1, where there has been a history of local damage from the effects of ice damming, the jurisdiction shall fill in this part of the table with “YES.” Otherwise, the jurisdiction shall fill in this part of the table with “NO.”
i. The jurisdiction shall fill in this part of the table with the 100-year return period air freezing index (BF-days) from Figure R403.3(2) or from the 100-year (99 percent) value on the National Climatic Data Center data table “Air Freezing Index-USA Method (Base 32°F).”
j. The jurisdiction shall fill in this part of the table with the mean annual temperature from the National Climatic Data Center data table “Air Freezing Index-USA Method (Base 32°F).”
k. In accordance with Section R301.2.1.5, where there is local historical data documenting structural damage to buildings due to topographic wind speed-up effects, the jurisdiction shall fill in this part of the table with “YES.” Otherwise, the jurisdiction shall indicate “NO” in this part of the table.
l. In accordance with Figure R301.2(4)A, where there is local historical data documenting unusual wind conditions, the jurisdiction shall fill in this part of the table with “YES” and identify any specific requirements. Otherwise, the jurisdiction shall indicate “NO” in this part of the table.
m. In accordance with Section R301.2.1.2.1, the jurisdiction shall indicate the wind-borne debris wind zone(s). Otherwise, the jurisdiction shall indicate “NO” in this part of the table.
Weathering may require a higher strength concrete or grade of masonry than necessary to satisfy the structural requirements of this code. The grade of masonry units shall be determined from ASTM C 34, C 55, C 62, C 73, C 90, C 129, C 145, C 216 or C 652.

The jurisdiction shall fill in this part of the table with (a) the date of the jurisdiction’s entry into the National Flood Insurance Program (date of adoptions of the first code or ordinance for management of flood hazard areas), (b) the date(s) of the currently effective FIRM and FBFM, or other flood hazard map adopted by the community, as may be amended.

Protection is required in all of North Carolina per Section R318.

Table R301.2(2)

Component and Cladding Loads for a Building with a Mean Roof Height of 30 Feet Located in Exposure B (ASD) (psf)
The effective wind area shall be equal to the span length multiplied by an effective width. This width shall be permitted to be not less than one-third the span length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

For effective areas between those given, the load shall be interpolated or the load associated with the lower effective area shall be used.

Table values shall be adjusted for height and exposure by multiplying by the adjustment coefficient in Table R301.2(3).

See Figure R301.2(72) for location of zones.

Plus and minus signs signify pressures acting toward and away from the building surfaces.

Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall be exempt from the loads listed in Table R301.2(2) and the height and exposure factors listed in Table R301.2(3). Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed".

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.
when wind speeds exceed 75 mph (34 m/s).” Decals shall be placed such that the decal is visible when the panel is installed.

**TABLE R301.2(3)**
HEIGHT AND EXPOSURE ADJUSTMENT COEFFICIENTS FOR TABLE R301.2(2)

<table>
<thead>
<tr>
<th>MEAN ROOF HEIGHT</th>
<th>EXPOSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>15</td>
<td>1.00</td>
</tr>
<tr>
<td>20</td>
<td>1.00</td>
</tr>
<tr>
<td>25</td>
<td>1.00</td>
</tr>
<tr>
<td>30</td>
<td>1.00</td>
</tr>
<tr>
<td>35</td>
<td>1.05</td>
</tr>
<tr>
<td>40</td>
<td>1.09</td>
</tr>
<tr>
<td>45</td>
<td>1.12</td>
</tr>
<tr>
<td>50</td>
<td>1.16</td>
</tr>
<tr>
<td>55</td>
<td>1.19</td>
</tr>
<tr>
<td>60</td>
<td>1.22</td>
</tr>
</tbody>
</table>

For SI: °C = [(°F) - 32]/1.8.

**FIGURE R301.2(1)**
ISOLINES OF THE 97\(\frac{1}{2}\) -PERCENT WINTER (DECEMBER, JANUARY AND FEBRUARY) DESIGN TEMPERATURES (°F)

2018 North Carolina Residential Code
FIGURE R301.2(2)
SEISMIC DESIGN CATEGORIES—SITE CLASS D
(continued)
FIGURE R301.2(2)—continued
SEISMIC DESIGN CATEGORIES—SITE CLASS D
a. Alaska and Hawaii are classified as severe and negligible, respectively.
b. Lines defining areas are approximate only. Local conditions may be more or less severe than indicated by region classification. A severe classification is where weather conditions result in significant snowfall combined with extended periods during which there is little or no natural thawing causing deicing salts to be used extensively.

**FIGURE R301.2(3)**
WEATHERING PROBABILITY MAP FOR CONCRETE

Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.06143, MRI = 703 Years).
FIGURE R301.2(4)A
ULTIMATE DESIGN WIND SPEEDS

Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 Years).

FIGURE R301.2(4)B
For SI: 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 mile = 1.61 km.

a. In CS areas, site-specific Case Studies are required to establish ground snow loads. Extreme local variations in ground snow loads in these areas preclude mapping at this scale.

b. Numbers in parentheses represent the upper elevation limits in feet for the ground snow load values presented below. Site-specific case studies are required to establish ground snow loads at elevations not covered.

FIGURE R301.2(5)
GROUND SNOW LOADS, $P_g$, FOR THE UNITED STATES (lb/ft$^2$)

(continued)
FIGURE R301.2(5)—continued
GROUND SNOW LOADS, $P_g$, FOR THE UNITED STATES (lb/ft$^2$)

For SI: 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
FIGURE R301.2(6)
TERMITE INFESTATION PROBABILITY MAP
FIGURE R301.2(72)
COMPONENT AND CLADDING PRESSURE ZONES

TABLE R301.2(4)
ULTIMATE DESIGN WIND SPEEDS BY COUNTY (mph)

<table>
<thead>
<tr>
<th>Counties not listed</th>
<th>115</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alleghany</td>
<td>special mountain region</td>
</tr>
<tr>
<td>Ashe</td>
<td>special mountain region</td>
</tr>
<tr>
<td>Avery</td>
<td>special mountain region</td>
</tr>
<tr>
<td>Beaufort</td>
<td>130</td>
</tr>
<tr>
<td>Bertie¹</td>
<td>120/130</td>
</tr>
<tr>
<td>Bladen²</td>
<td>130/140</td>
</tr>
<tr>
<td>Brunswick³</td>
<td>140/150</td>
</tr>
<tr>
<td>Buncombe</td>
<td>special mountain region</td>
</tr>
<tr>
<td>Camden</td>
<td>130</td>
</tr>
<tr>
<td>Carteret</td>
<td>150</td>
</tr>
<tr>
<td>Chowan</td>
<td>130</td>
</tr>
<tr>
<td>Columbus</td>
<td>140</td>
</tr>
<tr>
<td>Craven</td>
<td>140</td>
</tr>
<tr>
<td>Cumberland⁴</td>
<td>120/130</td>
</tr>
<tr>
<td>Currituck</td>
<td>130</td>
</tr>
<tr>
<td>Dare⁵</td>
<td>130/140</td>
</tr>
<tr>
<td>Duplin</td>
<td>130</td>
</tr>
<tr>
<td>Gates</td>
<td>120</td>
</tr>
<tr>
<td>Graham</td>
<td>special mountain region</td>
</tr>
<tr>
<td>Greene</td>
<td>130</td>
</tr>
<tr>
<td>Harnett</td>
<td>120</td>
</tr>
<tr>
<td>Haywood</td>
<td>special mountain region</td>
</tr>
<tr>
<td>Hoke</td>
<td>120</td>
</tr>
<tr>
<td>Hyde⁷</td>
<td>130/140</td>
</tr>
<tr>
<td>Jackson</td>
<td>special mountain region</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 degree = 0.0175 rad.
Note:  a = 4 feet in all cases.

1. Bertie County – 120 mph zone west of Hwy. 17, 130 mph zone east of Hwy. 17.
2. Bladen County – 130 mph zone west of Hwy. 701, 140 mph zone east of Hwy. 701.
3. Brunswick County – 140 mph zone west of Hwy. 17, 150 mph zone east of Hwy. 17, 150 mph on Bald Head Island.
4. Cumberland County – 120 mph zone west of I-95, 130 mph zone east of I-95.
5. Dare County - 130 mph zone west of U.S. Route 264, 140 mph zone east of U.S. Route 264.
7. Martin County – 120 mph zone west of Hwy. 17, 130 mph zone east of Hwy 17.
8. New Hanover County – 140 mph zone west of Hwy. 17, 150 mph zone east of Hwy. 17.
9. Onslow County – 130 mph zone west of Hwy. 17, 140 mph zone east of Hwy 17 to the Intracoastal Waterway, 150 mph zone east of the Intracoastal Waterway.
10. Pender County – 140 mph zone in the Township of Topsail west of the Intracoastal Waterway, 150 mph zone east of the Intracoastal Waterway, 130 mph zone in the remainder of the county.
TABLE R301.2(5)
ULTIMATE DESIGN WIND SPEED FOR MOUNTAIN REGIONS

<table>
<thead>
<tr>
<th>FIRST FLOOR FINISH ELEVATION (feet)</th>
<th>ULTIMATE DESIGN WIND SPEED (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 2,700</td>
<td>115</td>
</tr>
<tr>
<td>2,700 to less than 3,000</td>
<td>120</td>
</tr>
<tr>
<td>3,000 to less than 3,500</td>
<td>130</td>
</tr>
<tr>
<td>3,500 to less than 4,500</td>
<td>140</td>
</tr>
<tr>
<td>4,500 or greater</td>
<td>150</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8, 1 mile per hour = 0.44 m/s.

TABLE R301.2(6)
DESIGN PRESSURES FOR DOORS AND WINDOWS 

<table>
<thead>
<tr>
<th>VELOCITY (mph)</th>
<th>MEAN ROOF HEIGHT (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>115</td>
<td>17</td>
</tr>
<tr>
<td>120</td>
<td>23</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8, 1 mile per hour = 0.44 m/s.

a. Alternative design pressures may be determined by using North Carolina Building Code, ASCE-7, or the International Building Code.
b. If window or door is more than 4 feet (1219 mm) from a corner, the pressure from this table shall be permitted to be multiplied by 0.87. This adjustment does not apply to garage doors.
c. For windows and doors in structures with a roof slope of 10 degrees (0.0745 rad) or less (2:12) from the table may be multiplied by 0.90.d. Design pressure ratings based on standards listed in Section R609 are adequate documentation of capacity to resist pressures from the table.
e. Design pressures are for windows and doors located in Exposure Category B.

TABLE R301.2(7)
COUNTIES IN SEISMIC DESIGN CATEGORY C

<table>
<thead>
<tr>
<th>Brunswick</th>
<th>Jackson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buncombe</td>
<td>Macon</td>
</tr>
<tr>
<td>Cherokee</td>
<td>Madison</td>
</tr>
<tr>
<td>Clay</td>
<td>Robeson</td>
</tr>
<tr>
<td>Columbus</td>
<td>Scotland</td>
</tr>
<tr>
<td>Graham</td>
<td>Swain</td>
</tr>
<tr>
<td>Haywood</td>
<td></td>
</tr>
</tbody>
</table>

Note: Counties not listed are in Seismic Design Category A or B.

R301.2.1 Wind design criteria.
Buildings and portions thereof shall be constructed in accordance with the wind provisions of this code using the ultimate design wind speed in Table R301.2(1) as determined from Figure R301.2(4). Table R301.2(4) and Table R301.2(5). The structural provisions of this code for wind loads are not permitted where wind design is required as specified in Section R301.2.1.1. Where different construction methods and structural materials are used for
various portions of a building, the applicable requirements of this section for each portion shall apply. Where not otherwise specified, the wind loads listed in Table R301.2(2) and Table R301.2(6) adjusted for height and exposure using Table R301.2(3) shall be used to determine design load performance requirements for wall coverings, curtain walls, roof coverings, exterior windows, skylights, garage doors and exterior doors. Asphalt shingles shall be designed for wind speeds in accordance with Section R905.2.4. A continuous load path shall be provided to transmit the applicable uplift forces in Section R802.11.1 from the roof assembly to the foundation.

**Exception:** Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall be exempt from the loads listed in Table R301.2(2) and the height and exposure factors listed in Table R301.2(3). Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

**R301.2.1.1 Wind limitations and wind design required.**
The wind provisions of this code shall not apply to the design of buildings where wind design is required in accordance with Figure R301.2(4)B.

**Exceptions:**

1. For concrete construction, the wind provisions of this code shall apply in accordance with the limitations of Sections R404 and R608.

2. For structural insulated panels, the wind provisions of this code shall apply in accordance with the limitations of Section R610.

3. For cold-formed steel light-frame construction, the wind provisions of this code shall apply in accordance with the limitations of Sections R505, R603 and R804.

In regions where wind design is required in accordance with Figure R301.2(4)B, the design of buildings for wind loads shall be in accordance with one or more of the following methods:

Construction in regions where the ultimate wind speeds from Table R301.2(4) and Table R301.2(5) equal or exceed 130 miles per hour (58 m/s) shall be designed in accordance with one of the following:

1. AF&PA Wood Frame Construction Manual (WFCM).

2. ICC Standard for Residential Construction in High-Wind Regions (ICC 600).

3. ASCE Minimum Design Loads for Buildings and Other Structures (ASCE 7)

4. **Deleted**. AISI Standard for Cold-Formed Steel Framing—Prescriptive Method For One- and Two-Family Dwellings (AISI S230).

6. Concrete construction shall be designed in accordance with the provisions of this code.

7. Structural insulated panel (SIP) walls shall be designed in accordance with the provisions of this code.

8. Chapters 45 and 46.

The elements of design not addressed by the methods in Items 1 through 5 8 shall be in accordance with the provisions of this code.

Where ASCE 7 or the *International Building Code* is used for the design of the building, the wind speed map and exposure category requirements as specified in ASCE 7 and the *International Building Code* shall be used.

**R301.2.1.1 Sunrooms. Deleted.**
Sunrooms shall comply with AAMA/NPEA/NSA 2100. For the purpose of applying the criteria of AAMA/NPEA/NSA 2100 based on the intended use, sunrooms shall be identified as one of the following categories by the permit applicant, design professional or the property owner or owner’s agent in the construction documents. Component and cladding pressures shall be used for the design of elements that do not qualify as main windforce resisting systems. Main windforce resisting system pressures shall be used for the design of elements assigned to provide support and stability for the overall sunroom.

**Category I:** A thermally isolated sunroom with walls that are open or enclosed with insect screening or 0.5 mm (20 mil) maximum thickness plastic film. The space is nonhabitable and unconditioned.

**Category II:** A thermally isolated sunroom with enclosed walls. The openings are enclosed with translucent or transparent plastic or glass. The space is nonhabitable and unconditioned.

**Category III:** A thermally isolated sunroom with enclosed walls. The openings are enclosed with translucent or transparent plastic or glass. The sunroom fenestration complies with additional requirements for air infiltration resistance and water penetration resistance. The space is nonhabitable and unconditioned.

**Category IV:** A thermally isolated sunroom with enclosed walls. The sunroom is designed to be heated or cooled by a separate temperature control or system and is thermally isolated from the primary structure. The sunroom fenestration complies with additional requirements for water penetration resistance, air infiltration resistance and thermal performance. The space is nonhabitable and conditioned.
Category V: A sunroom with enclosed walls. The sunroom is designed to be heated or cooled and is open to the main structure. The sunroom fenestration complies with additional requirements for water penetration resistance, air infiltration resistance and thermal performance. The space is habitable and conditioned.

R301.2.1.2 Protection of openings.
Exterior glazing in buildings located in windborne debris regions shall be protected from windborne debris. Glazed opening protection for windborne debris shall meet the requirements of the Large Missile Test of ASTM E 1996 and ASTM E 1886 as modified in Section 301.2.1.2.1. Garage door glazed opening protection for windborne debris shall meet the requirements of an approved impact-resisting standard or ANSI/DASMA 115.

Exceptions:
1. Wood structural panels with a thickness of not less than \( \frac{7}{16} \) inch (11 mm) and a span of not more than 8 feet (2438 mm) shall be permitted for opening protection. Panels shall be precut and attached to the framing surrounding the opening containing the product with the glazed opening. Panels shall be predrilled as required for the anchorage method and shall so that they can be secured with the attachment hardware provided. Attachments shall be designed to resist the component and cladding loads determined in accordance with either Table R301.2(2) or ASCE 7, with the permanent corrosion-resistant attachment hardware provided and anchors permanently installed on the building. Attachment in accordance with Table R301.2.1.2 is permitted for buildings with a mean roof height of 45 feet (13,728 mm) or less where the ultimate design wind speed, \( V_{ult} \), is 180 mph (290 kph) or less.

2. Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall not be required to be protected provided the spaces are separated from the building interior by a wall and all openings in the wall separating the unit from the balcony, deck or porch are protected in accordance with this section. Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

<table>
<thead>
<tr>
<th>TABLE R301.2.1.2</th>
<th>WINDBORNE DEBRIS PROTECTION FASTENING</th>
</tr>
</thead>
<tbody>
<tr>
<td>FASTENER TYPE</td>
<td>SCHEDULE FOR WOOD STRUCTURAL PANELS</td>
</tr>
<tr>
<td>FASTENER SPACING (inches) a, b</td>
<td></td>
</tr>
<tr>
<td>Panel span ≤ 4 feet</td>
<td>4 feet &lt; panel span ≤ 6 feet</td>
</tr>
<tr>
<td>No. 8 wood screw based anchor with 2-inch embedment length</td>
<td>16</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
No. 10 wood screw based anchor with 2-inch embedment length

<table>
<thead>
<tr>
<th></th>
<th>16</th>
<th>12</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4-inch lag screw based anchor with 2-inch embedment length</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.448 N, 1 mile per hour = 0.447 m/s.

a. This table is based on 180 mph ultimate design wind speeds, $V_{ult}$, and a 33-45 foot mean roof height.

b. Fasteners shall be installed at opposing ends of the wood structural panel. Fasteners shall be located not less than 1 inch from the edge of the panel.

c. Anchors. Fasteners shall penetrate through the exterior wall covering with an embedment length of not less than 2 inches into the building frame. Fasteners shall be located not less than $2\frac{1}{2}$ inches from the edge of concrete block or concrete.

d. Panels attached to masonry or masonry/stucco shall be attached using vibration-resistant anchors having an ultimate withdrawal capacity of not less than 1,500 pounds.

**R301.2.1.2.1 Application of ASTM E 1996.**

The text of Section 2.2 of ASTM E 1996 shall be substituted as follows:

2.2 ASCE Standard:

ASCE 7-10 American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures

The text of Section 6.2.2 of ASTM E 1996 shall be substituted as follows:

6.2.2 Unless otherwise specified, select the wind zone based on the ultimate design wind speed, $V_{ult}$, as follows:

6.2.2.1 Wind Zone 1–130 mph ≤ $V_{ult}$ < 140 mph.

6.2.2.2 Wind Zone 2–140 mph ≤ $V_{ult}$ < 150 mph at greater than 1 mile (1.6 km) from the coastline. The coastline shall be measured from the mean high water mark.

6.2.2.3 Wind Zone 3–150 mph (58 m/s) ≤ $V_{ult}$ ≤ 170 mph (76 m/s), or 140 mph (54 m/s) ≤ $V_{ult}$ ≤ 170 mph (76 m/s) and within 1 mile (1.6 km) of the coastline. The coastline shall be measured from the mean high water mark.

6.2.2.4 Wind Zone 4–ultimte design wind speed, $V_{ult}$ > 170 mph (76 m/s).

**R301.2.1.3 Wind speed conversion.**

Where referenced documents are based on nominal design wind speeds and do not
provide the means for conversion between ultimate design wind speeds and nominal design wind speeds, the ultimate design wind speeds, $V_{ult}$, of Figure R301.2(4)A Table R301.2(4) and Table R301.2(5) shall be converted to nominal design wind speeds, $V_{asd}$, using Table R301.2.1.3.

**TABLE R301.2.1.3**

**WIND SPEED CONVERSIONS**

<table>
<thead>
<tr>
<th>$V_{ult}$</th>
<th>110</th>
<th>115</th>
<th>120</th>
<th>130</th>
<th>140</th>
<th>150</th>
<th>160</th>
<th>170</th>
<th>180</th>
<th>190</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{asd}$</td>
<td>85</td>
<td>89</td>
<td>93</td>
<td>101</td>
<td>108</td>
<td>116</td>
<td>124</td>
<td>132</td>
<td>139</td>
<td>147</td>
<td>155</td>
</tr>
</tbody>
</table>

For SI: 1 mile per hour = 0.447 m/s.

a. Linear interpolation is permitted.

**R301.2.1.4 Exposure category.**

For each wind direction considered, an exposure category that adequately reflects the characteristics of ground surface irregularities shall be determined for the site at which the building or structure is to be constructed. For a site located in the transition zone between categories, the category resulting in the largest wind forces shall apply. Account shall be taken of variations in ground surface roughness that arise from natural topography and vegetation as well as from constructed features. For a site where multiple detached one- and two-family dwellings, townhouses or other structures are to be constructed as part of a subdivision or master-planned community, or are otherwise designated as a developed area by the authority having jurisdiction, the exposure category for an individual structure shall be based upon the site conditions that will exist at the time when all adjacent structures on the site have been constructed, provided that their construction is expected to begin within one year of the start of construction for the structure for which the exposure category is determined. For any given wind direction, the exposure in which a specific building or other structure is sited shall be assessed as being one of the following categories:

1. **Exposure B.** Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Exposure B shall be assumed unless the site meets the definition of another type exposure.

2. **Exposure C.** Open terrain with scattered obstructions, including surface undulations or other irregularities, having heights generally less than 30 feet (9144 mm) extending more than 1,500 feet (457 m) from the building site in any quadrant. This exposure shall also apply to any building located within Exposure B type terrain where the building is directly adjacent to open areas of Exposure C type terrain in any quadrant for a distance of more than 600 feet (183 m). This category includes flat, open country and grasslands.

3. **Exposure D.** Flat, unobstructed areas exposed to wind flowing over open water, smooth mud flats, salt flats and unbroken ice for a distance of not less than 5,000 feet (1524 m). This exposure shall apply only to those buildings and other structures exposed to the wind coming from over the unobstructed area.
Exposure D extends downwind from the edge of the unobstructed area a distance of 600 feet (183 m) or 20 times the height of the building or structure, whichever is greater.

R301.2.1.5 Topographic wind effects. Deleted.
In areas designated in Table R301.2(1) as having local historical data documenting structural damage to buildings caused by wind speed-up at isolated hills, ridges and escarpments that are abrupt changes from the general topography of the area, topographic wind effects shall be considered in the design of the building in accordance with Section R301.2.1.5.1 or in accordance with the provisions of ASCE 7. See Figure R301.2.1.5.1(1) for topographic features for wind speed-up effect.

In these designated areas, topographic wind effects shall apply only to buildings sited on the top half of an isolated hill, ridge or escarpment where all of the following conditions exist:

1. The average slope of the top half of the hill, ridge or escarpment is 10 percent or greater.
2. The hill, ridge or escarpment is 60 feet (18 288 mm) or greater in height for Exposure B, 30 feet (9144 mm) or greater in height for Exposure C, and 15 feet (4572 mm) or greater in height for Exposure D.
3. The hill, ridge or escarpment is isolated or unobstructed by other topographic features of similar height in the upwind direction for a distance measured from its high point of 100 times its height or 2 miles (3.2 km), whichever is less. See Figure R301.2.1.5.1(3) for upwind obstruction.
4. The hill, ridge or escarpment protrudes by a factor of two or more above the height of other upwind topographic features located in any quadrant within a radius of 2 miles (3.2 km) measured from its high point.

R301.2.1.5.1 Simplified topographic wind speed-up method. Deleted.
As an alternative to the ASCE 7 topographic wind provisions, the provisions of Section R301.2.1.5.1 shall be permitted to be used to design for wind speed-up effects, where required by Section R301.2.1.5.

Structures located on the top half of isolated hills, ridges or escarpments meeting the conditions of Section R301.2.1.5 shall be designed for an increased basic wind speed as determined by Table R301.2.1.5.1. On the high side of an escarpment, the increased basic wind speed shall extend horizontally downwind from the edge of the escarpment 1.5 times the horizontal length of the upwind slope (1.5L) or 6 times the height of the escarpment (6H), whichever is greater. See Figure R301.2.1.5.1(2) for where wind speed increase is applied.

<table>
<thead>
<tr>
<th>ULTIMATE DESIGN</th>
<th>AVERAGE SLOPE OF THE TOP HALF OF HILL, RIDGE OR ESCARPMENT (percent)</th>
</tr>
</thead>
</table>

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For SI: 1 mile per hour = 0.447 m/s, 1 foot = 304.8 mm.
a. Table applies to a feature height of 500 feet or less and dwellings sited a distance equal or greater than half the feature height.
b. Where the ultimate design wind speed as modified by Table R301.2.1.5.1 equals or exceeds 140 miles per hour, the building shall be considered as "wind design required" in accordance with Section R301.2.1.1.

Note: H/2 determines the measurement point for Lh. L is twice Lh.

**FIGURE R301.2.1.5.1(1)**
TOPOGRAPHIC FEATURES FOR WIND SPEED-UP EFFECT

**FIGURE R301.2.1.5.1(2)**
ILLUSTRATION OF WHERE ON A TOPOGRAPHIC FEATURE, WIND SPEED INCREASE IS APPLIED
R301.2.2 Seismic provisions.
The seismic provisions of this code shall apply as follows:

1. Townhouses in Seismic Design Categories C, D₀, D₁, and D₂.

2. Detached one- and two-family dwellings in Seismic Design Categories, D₀, D₁, and D₂.

R301.2.2.1 Determination of seismic design category.
Buildings shall be assigned a seismic design category in accordance with Figure R301.2.2(2)-Table R301.2(7).

R301.2.2.1.1 Alternate determination of seismic design category. Deleted.
The seismic design categories and corresponding short-period design spectral response accelerations, \( S_{DS} \), shown in Figure R301.2(2) are based on soil Site Class Dₜ as defined in Section 1613.3.2 of the International Building Code. If soil conditions are other than Site Class Dₜ, the short-period design spectral response accelerations, \( S_{DS} \), for a site can be determined in accordance with Section 1613.3 of the International Building Code. The value of \( S_{DS} \) determined in accordance with Section 1613.3 of the International Building Code is permitted to be used to set the seismic design category in accordance with Table R301.2.2.1.1 and to interpolate between values in Tables R602.10.3(3), R603.9.2(1) and other seismic design requirements of this code.

<table>
<thead>
<tr>
<th>CALCULATED ( S_{DS} )</th>
<th>SEISMIC DESIGN CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S_{DS} \leq 0.17g )</td>
<td>A</td>
</tr>
</tbody>
</table>
### R301.2.2.1.2 Alternative determination of Seismic Design Category E

*Deleted.* Buildings located in Seismic Design Category E in accordance with Figure R301.2(2) are permitted to be reclassified as being in Seismic Design Category D provided that one of the following is done:

1. A more detailed evaluation of the seismic design category is made in accordance with the provisions and maps of the *International Building Code*. Buildings located in Seismic Design Category E in accordance with Table R301.2.1.1, but located in Seismic Design Category D in accordance with the *International Building Code*, shall be permitted to be designed using the Seismic Design Category D requirements of this code.

2. Buildings located in Seismic Design Category E that conform to the following additional restrictions are permitted to be constructed in accordance with the provisions for Seismic Design Category D of this code:

   2.1. All exterior shear wall lines or braced wall panels are in one plane vertically from the foundation to the uppermost story.

   2.2. Floors shall not cantilever past the exterior walls.

   2.3. The building is within the requirements of Section R301.2.2.2.5 for being considered as regular.

### R301.2.2.2 Seismic Design Category C

Townhouse structures assigned to Seismic Design Category C shall conform to the requirements of this section.

**R301.2.2.2.1 Weights of materials.**

Average dead loads shall not exceed 15 pounds per square foot (720 Pa) for the combined roof and ceiling assemblies (on a horizontal projection) or 10 pounds per square foot (480 Pa) for floor assemblies, except as further limited by Section R301.2.2. Dead loads for walls above grade shall not exceed:

1. Fifteen pounds per square foot (720 Pa) for exterior light-frame wood walls.

2. Deleted. Fourteen pounds per square foot (670 Pa) for exterior light-frame cold-formed steel walls.
3. Ten pounds per square foot (480 Pa) for interior light-frame wood walls.

4. Deleted. Five pounds per square foot (240 Pa) for interior light-frame cold-formed steel walls.

5. Eighty pounds per square foot (3830 Pa) for 8-inch-thick (203 mm) masonry walls.

6. Eighty-five pounds per square foot (4070 Pa) for 6-inch-thick (152 mm) concrete walls.

7. Ten pounds per square foot (480 Pa) for SIP walls.

Exceptions:

1. Deleted. Roof and ceiling dead loads not exceeding 25 pounds per square foot (1190 Pa) shall be permitted provided that the wall bracing amounts in Section R602.10.3 are increased in accordance with Table R602.10.3(4).

2. Light-frame walls with stone or masonry veneer shall be permitted in accordance with the provisions of Sections R702.1 and R703.

3. Fireplaces and chimneys shall be permitted in accordance with Chapter 10.

R301.2.2.2 Stone and masonry veneer.
Anchored stone and masonry veneer shall comply with the requirements of Sections R702.1 and R703.

R301.2.2.3 Masonry construction.
Masonry construction shall comply with the requirements of Section R606.12.

R301.2.2.4 Concrete construction.
Detached one- and two-family dwellings with exterior above-grade concrete walls shall comply with the requirements of Section R608, PCA 100 or shall be designed in accordance with ACI 318. Townhouses with above-grade exterior concrete walls shall comply with the requirements of PCA 100 or shall be designed in accordance with ACI 318.

R301.2.2.5 Irregular buildings.
The seismic provisions of this code shall not be used for irregular structures located in Seismic Design Categories C, D, D1, and D2. Irregular portions of structures shall be designed in accordance with accepted engineering practice to the extent the irregular features affect the performance of the remaining structural system. Where the forces associated with the irregularity are resisted by a structural system designed in accordance with accepted engineering practice, design of the remainder of the building shall be permitted using the provisions of this code. A building or
portion of a building shall be considered to be irregular where one or more of the following conditions occur:

1. Where exterior shear wall lines or braced wall panels are not in one plane vertically from the foundation to the uppermost story in which they are required.

**Exception:** For wood light-frame construction, floors with cantilevers or setbacks not exceeding four times the nominal depth of the wood floor joists are permitted to support braced wall panels that are out of plane with braced wall panels below provided that:

   1. Floor joists are nominal 2 inches by 10 inches (51 mm by 254 mm) or larger and spaced not more than 16 inches (406 mm) on center.
   
   2. The ratio of the back span to the cantilever is not less than 2 to 1.
   
   3. Floor joists at ends of braced wall panels are doubled.
   
   4. For wood-frame construction, a continuous rim joist is connected to ends of cantilever joists. When spliced, the rim joists shall be spliced using a galvanized metal tie not less than 0.058 inch (1.5 mm) (16 gage) and 1\(\frac{1}{2}\) inches (38 mm) wide fastened with six 16d nails on each side of the splice or a block of the same size as the rim joist of sufficient length to fit securely between the joist space at which the splice occurs fastened with eight 16d nails on each side of the splice; and
   
   5. Gravity loads carried at the end of cantilevered joists are limited to uniform wall and roof loads and the reactions from headers having a span of 8 feet (2438 mm) or less.

2. Where a section of floor or roof is not laterally supported by shear walls or braced wall lines on all edges.

**Exception:** Portions of floors that do not support shear walls or braced wall panels above, or roofs, shall be permitted to extend not more than 6 feet (1829 mm) beyond a shear wall or braced wall line.

3. Where the end of a braced wall panel occurs over an opening in the wall below and ends at a horizontal distance greater than 1 foot (305 mm) from the edge of the opening. This provision is applicable to shear walls and braced wall panels offset in plane and to braced wall panels offset out of plane as permitted by the exception to Item 1.

**Exception:** For wood light-frame wall construction, one end of a braced wall panel shall be permitted to extend more than 1 foot (305 mm) over an opening not more than 8 feet (2438 mm) in width in the wall below.
provided that the opening includes a header in accordance with the following:

1. The building width, loading condition and framing member species limitations of Table R602.7(1) shall apply; and

2. Not less than one 2 × 12 or two 2 × 10 for an opening not more than 4 feet (1219 mm) wide; or

3. Not less than two 2 × 12 or three 2 × 10 for an opening not more than 6 feet (1829 mm) in width; or

4. Not less than three 2 × 12 or four 2 × 10 for an opening not more than 8 feet (2438 mm) in width; and

5. The entire length of the braced wall panel does not occur over an opening in the wall below.

4. Where an opening in a floor or roof exceeds the lesser of 12 feet (3658 mm) or 50 percent of the least floor or roof dimension.

5. Where portions of a floor level are vertically offset.

**Exceptions:**

1. Framing supported directly by continuous foundations at the perimeter of the building.

2. For wood light-frame construction, floors shall be permitted to be vertically offset when the floor framing is lapped or tied together as required by Section R502.6.1.

6. Where shear walls and braced wall lines do not occur in two perpendicular directions.

7. Where stories above grade plane partially or completely braced by wood wall framing in accordance with Section R602 or cold-formed steel wall framing in accordance with Section R603 include masonry or concrete construction. Where this irregularity applies, the entire story shall be designed in accordance with accepted engineering practice.

**Exception:** Fireplaces, chimneys and masonry veneer as permitted by this code.

**R301.2.2.3 Seismic Design Categories D0, D1 and D2.** Deleted. Structures assigned to Seismic Design Categories D, D¹, and D² shall conform to the requirements for Seismic Design Category C and the additional requirements of this section.
R301.2.2.3.1 Height limitations.
Wood-framed buildings shall be limited to three stories above grade plane or the limits given in Table R602.10.3(3). Cold-formed, steel-framed buildings shall be limited to less than or equal to three stories above grade plane in accordance with AISI S230. Mezzanines as defined in Section R202 that comply with Section R325 shall not be considered as stories. Structural insulated panel buildings shall be limited to two stories above grade plane.

R301.2.2.3.2 Stone and masonry veneer.
Anchored stone and masonry veneer shall comply with the requirements of Sections R702.1 and R703.

R301.2.2.3.3 Masonry construction.
Masonry construction in Seismic Design Categories D₀ and D₁ shall comply with the requirements of Section R606.12.1. Masonry construction in Seismic Design Category D₂ shall comply with the requirements of Section R606.12.4.

R301.2.2.3.4 Concrete construction.
Buildings with exterior above grade concrete walls shall comply with PCA 100 or shall be designed in accordance with ACI 318.

R301.2.2.3.5 Cold-formed steel framing in Seismic Design Categories D₀, D₁ and D₂.
In Seismic Design Categories D₀, D₁ and D₂ in addition to the requirements of this code, cold-formed steel framing shall comply with the requirements of AISI S230.

R301.2.2.3.6 Masonry chimneys.
Masonry chimneys shall be reinforced and anchored to the building in accordance with Sections R1003.3 and R1003.4.

R301.2.2.3.7 Anchorage of water heaters.
Water heaters shall be anchored against movement and overturning in accordance with Section M1307.2.

R301.2.2.4 Seismic Design Category E. Deleted.
Buildings in Seismic Design Category E shall be designed to resist seismic loads in accordance with the International Building Code, except where the seismic design category is reclassified to a lower seismic design category in accordance with Section R301.2.2.1. Components of buildings not required to be designed to resist seismic loads shall be constructed in accordance with the provisions of this code.

R301.2.3 Snow loads. Deleted.
Wood-framed construction, cold-formed, steel-framed construction and masonry and concrete construction, and structural insulated panel construction in regions with ground snow loads 70 pounds per square foot (3.35 kPa) or less, shall be in accordance with Chapters 5, 6 and 8. Buildings in regions with ground snow loads greater than 70 pounds per square foot (3.35 kPa) shall be designed in accordance with accepted engineering practice.
R301.2.4 Floodplain construction.
Buildings and structures constructed in whole or in part in flood hazard areas (including A or V Zones) as established in Table R301.2(1), and substantial improvement and restoration of substantial damage of buildings and structures in flood hazard areas, shall be designed and constructed in accordance with Section R322. Buildings and structures that are located in more than one flood hazard area shall comply with the provisions associated with the most restrictive flood hazard area. Buildings and structures located in whole or in part in identified floodways shall be designed and constructed in accordance with ASCE 24.

R301.2.4.1 Alternative provisions.
As an alternative to the requirements in Section R322, ASCE 24 is permitted subject to the limitations of this code and the limitations therein.

R301.3 Story height.
The wind and seismic provisions of this code shall apply to buildings with story heights not exceeding the following:

1. For wood wall framing, the story height shall not exceed 11 feet 7 inches (3531 mm) and the laterally unsupported bearing wall stud height permitted by Table R602.3(5).

2. Deleted
For cold-formed steel wall framing, the story height shall be not more than 11 feet 7 inches (3531 mm) and the unsupported bearing wall stud height shall be not more than 10 feet (3048 mm).

3. For masonry walls, the story height shall be not more than 13 feet 7 inches (4140 mm) and the bearing wall clear height shall be not greater than 12 feet (3658 mm).

   Exception: An additional 8 feet (2438 mm) of bearing wall clear height is permitted for gable end walls.

4. For insulating concrete form walls, the maximum story height shall not exceed 11 feet 7 inches (3531 mm) and the maximum unsupported wall height per story as permitted by Section R608 tables shall not exceed 10 feet (3048 mm).

5. For structural insulated panel (SIP) walls, the story height shall be not greater than 11 feet 7 inches (3531 mm) and the bearing wall height per story as permitted by Section R610 tables shall not exceed 10 feet (3048 mm).

Individual walls or wall studs shall be permitted to exceed these limits as permitted by Chapter 6 provisions, provided that story heights are not exceeded. An engineered design shall be provided for the wall or wall framing members where the limits of Chapter 6 are exceeded. Where the story height limits of this section are exceeded, the design of the building, or the noncompliant portions thereof, to resist wind and seismic loads shall be in accordance with the International Building Code.

R301.4 Dead load.
The actual weights of materials and construction shall be used for determining dead load with consideration for the dead load of fixed service equipment.
R301.5 Live load.
The minimum uniformly distributed live load shall be as provided in Table R301.5.

**TABLE R301.5**
**MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS**
(in pounds per square foot)

<table>
<thead>
<tr>
<th>USE</th>
<th>LIVE LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninhabitable attics without storage</td>
<td>10</td>
</tr>
<tr>
<td>Uninhabitable attics with limited storage</td>
<td>20</td>
</tr>
<tr>
<td>Habitable attics and attics served with fixed stairs</td>
<td>30</td>
</tr>
<tr>
<td>balconies (exterior) and decks</td>
<td>40</td>
</tr>
<tr>
<td>Fire escapes</td>
<td>40</td>
</tr>
<tr>
<td>Guards and handrails</td>
<td>200</td>
</tr>
<tr>
<td>Guard in-fill components</td>
<td>50</td>
</tr>
<tr>
<td>Passenger vehicle garages</td>
<td>50</td>
</tr>
<tr>
<td>Rooms other than sleeping rooms</td>
<td>40</td>
</tr>
<tr>
<td>Sleeping rooms</td>
<td>30</td>
</tr>
<tr>
<td>Stairs</td>
<td>40</td>
</tr>
</tbody>
</table>

For SI: 1 pound per square foot = 0.0479 kPa, 1 square inch = 645 mm², 1 pound = 4.45 N.

a. Elevated garage floors shall be capable of supporting a 2,000-pound load applied over a 20-square-inch area.

b. Uninhabitable attics without storage are those where the clear height between joists and rafters is not more than 42 inches, or where there are not two or more adjacent trusses with web configurations capable of accommodating an assumed rectangle 42 inches in height by 24 inches in width, or greater, within the plane of the trusses. This live load need not be assumed to act concurrently with any other live load requirements.

c. Individual stair treads shall be designed for the uniformly distributed live load or a 300-pound concentrated load acting over an area of 4 square inches, whichever produces the greater stresses.

d. A single concentrated load applied in any direction at any point along the top.

e. See Section R507.1 Appendix M for decks attached to exterior walls.

f. Guard in-fill components (all those except the handrail), balusters and panel fillers shall be designed to withstand a horizontally applied normal load of 50 pounds on an area equal to 1 square foot. This load need not be assumed to act concurrently with any other live load requirement.

g. Uninhabitable attics with limited storage are those where the clear height between joists and rafters is not greater than 42 inches, or where there are two or more adjacent trusses with web configurations capable of accommodating an assumed rectangle 42 inches in height by 24 inches in width, or greater, within the plane of the trusses. The live load need only be applied to those portions of the joists or truss bottom chords where all of the following conditions are met:

1. The attic area is accessible from an opening not less than 20 inches in width by 30 inches in length that is located where the clear height in the attic is not less than 30 inches.
2. The slopes of the joists or truss bottom chords are not greater than 2 inches vertical to 12 units horizontal.
3. Required insulation depth is less than the joist or truss bottom chord member depth.

The remaining portions of the joists or truss bottom chords shall be designed for a uniformly distributed concurrent live load of not less than 10 pounds per square foot.

h. Glazing used in handrail assemblies and guards shall be designed with a safety factor of 4. The safety factor shall be applied to each of the concentrated loads applied to the top of the rail, and to the load on the in-fill components. These loads shall be determined independent of one another, and loads are assumed not to occur with any other live load.
R301.6 Roof load.
The roof shall be designed for the live load indicated in Table R301.6 or the snow load indicated in Table R301.2(1), whichever is greater.

<table>
<thead>
<tr>
<th>ROOF SLOPE</th>
<th>TRIBUTARY LOADED AREA IN SQUARE FEET FOR ANY STRUCTURAL MEMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat or rise less than 4 inches per foot (1:3)</td>
<td>20, 16, 12</td>
</tr>
<tr>
<td>Rise 4 inches per foot (1:3) to less than 12 inches per foot (1:1)</td>
<td>16, 14, 12</td>
</tr>
<tr>
<td>Rise 12 inches per foot (1:1) and greater</td>
<td>12, 12, 12</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.0929 m$^2$, 1 pound per square foot = 0.0479 kPa, 1 inch per foot = 83.3 mm/m.

R301.7 Deflection.
The allowable deflection of any structural member under the live load listed in Sections R301.5 and R301.6 or wind loads determined by Section R301.2.1 shall not exceed the values in Table R301.7.

<table>
<thead>
<tr>
<th>STRUCTURAL MEMBER</th>
<th>ALLOWABLE DEFLECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rafters having slopes greater than 3:12 with finished ceiling not attached to rafters</td>
<td>L/180</td>
</tr>
<tr>
<td>Interior walls and partitions</td>
<td>H/180</td>
</tr>
<tr>
<td>Floors</td>
<td>L/360</td>
</tr>
<tr>
<td>Ceilings with brittle finishes (including plaster and stucco)</td>
<td>L/360</td>
</tr>
<tr>
<td>Ceilings with flexible finishes (including gypsum board)</td>
<td>L/240</td>
</tr>
<tr>
<td>All other structural members</td>
<td>L/240</td>
</tr>
<tr>
<td>Exterior walls—wind loads$^a$ with plaster or stucco finish</td>
<td>H/360</td>
</tr>
<tr>
<td>Exterior walls—wind loads$^a$ with other brittle finishes</td>
<td>H/240</td>
</tr>
<tr>
<td>Exterior walls—wind loads$^a$ with flexible finishes</td>
<td>H/120$^d$</td>
</tr>
<tr>
<td>Lintels supporting masonry veneer walls$^e$</td>
<td>L/600</td>
</tr>
</tbody>
</table>

Note: L = span length, H = span height.
a. For the purpose of the determining deflection limits herein, the wind load shall be permitted to be taken as 0.7 times the component and cladding (ASD) loads obtained from Table R301.2(2).
b. For cantilever members, L shall be taken as twice the length of the cantilever.
c. For aluminum structural members or panels used in roofs or walls of sunroom additions or patio covers, not supporting edge of glass or sandwich panels, the total load deflection shall not exceed \( L/60 \). For continuous aluminum structural members supporting edge of glass, the total load deflection shall not exceed \( L/175 \) for each glass lite or \( L/60 \) for the entire length of the member, whichever is more stringent. For sandwich panels used in roofs or walls of sunroom additions or patio covers, the total load deflection shall not exceed \( L/120 \).

d. Deflection for exterior walls with interior gypsum board finish shall be limited to an allowable deflection of \( H/180 \).

e. Refer to Section R703.8.2.

f. When floor spans exceed 20 feet, joists, built-up beams and trusses shall not be spaced greater than 24 inches and deflection shall not exceed \( L/480 \).

R301.8 Nominal sizes.
For the purposes of this code, dimensions of lumber specified shall be deemed to be nominal dimensions unless specifically designated as actual dimensions.

SECTION R302
FIRE-RESISTANT CONSTRUCTION

R302.1 Exterior walls.
Construction, projections, openings and penetrations of exterior walls of dwellings and accessory buildings shall comply with Table R302.1(1); or dwellings equipped throughout with an automatic sprinkler system installed in accordance with Section P2904 shall comply with Table R302.1(2).

Exceptions:

1. Walls, projections, openings or penetrations in walls perpendicular to the line used to determine the fire separation distance. Townhouse eave projections shall comply with Sections R302.2.5 and R302.2.6.

2. Walls of dwellings and accessory buildings structures located on the same lot.

3. Detached tool sheds and storage sheds, playhouses and similar structures exempted from permits are not required to provide wall protection based on location on the lot. Projections beyond the exterior wall shall not extend over the lot line.

4. Detached garages accessory to a dwelling located within 2 feet (610 mm) of a lot line are permitted to have roof eave projections not exceeding 4 inches (102 mm).

5. Foundation vents installed in compliance with this code are permitted.

R302.1.1 Soffit protection.
In construction using vinyl or aluminum soffit material the following application shall apply. Soffit assemblies located on buildings with less than a 10 feet (3048 mm) fire separation distance shall be securely attached to framing members and applied over fire retardant treated wood, \( \frac{23}{32} \) -inch (18.3 mm) wood sheathing or \( \frac{5}{8} \) -inch (15.9 mm) exterior grade or moisture resistant gypsum board. Venting requirements shall be provided in both soffit and underlayments. Vents shall be either nominal 2-inch (51 mm) continuous or equivalent intermittent and shall not exceed the minimum net free air requirements established in Section R806.2 by more than 50 percent. Townhouse construction shall meet the additional requirements of Sections R302.2.5 and R302.2.6.
Exceptions:

1. Any portion of soffits having 10 feet (3048 mm) or more fire separation distance.

2. Roof rake lines where soffit does not communicate to attic are not required to be protected per this section.

3. Soffits with less than 3 feet (914 mm) fire separation distance shall meet the projection fire rating requirements of Table R302.1.

4. Soffits between buildings located on the same lot.

R302.1.2 Flame spread.
Vinyl siding and vinyl soffit materials shall have a flame spread index of 25 or less as tested in accordance with ASTM E-84.

**TABLE R302.1(4)
EXTERIOR WALLS**

<table>
<thead>
<tr>
<th>EXTERIOR WALL ELEMENT</th>
<th>MINIMUM FIRE-RESISTANCE RATING</th>
<th>MINIMUM FIRE SEPARATION DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>Fire-resistance rated 1 hour—tested in accordance with ASTM E 119 or UL 263 with exposure from both sides</td>
<td>&lt; 5 feet</td>
</tr>
<tr>
<td></td>
<td>Not fire-resistance rated 0 hours</td>
<td>≥ 5 feet</td>
</tr>
<tr>
<td>Projections</td>
<td>Not allowed</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Fire-resistance rated 1 hour on the underside</td>
<td>≥ 2 feet to &lt; 5 feet</td>
</tr>
<tr>
<td></td>
<td>Not fire-resistance rated 0 hours</td>
<td>≥ 5 feet</td>
</tr>
<tr>
<td>Openings in walls</td>
<td>Not allowed</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>25% maximum of wall area 0 hours</td>
<td>3 feet</td>
</tr>
<tr>
<td>Penetrations</td>
<td>All Comply with Section R302.4</td>
<td>None required</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.
N/A = Not Applicable.
a. Roof eave fire-resistance rating shall be permitted to be reduced to 0 hours on the underside of the eave if fireblocking is provided from the wall top plate to the underside of the roof sheathing.
b. Roof eave fire-resistance rating shall be permitted to be reduced to 0 hours on the underside of the eave provided that gable vent openings are not installed.

**TABLE R302.1(2)
EXTERIOR WALLS—DWELLINGS WITH FIRE SPRINKLERS**
<table>
<thead>
<tr>
<th>EXTERIOR WALL ELEMENT</th>
<th>MINIMUM FIRE-RESISTANCE RATING</th>
<th>MINIMUM FIRE SEPARATION DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>Fire-resistance-rated 1 hour—tested in accordance with ASTM E 119 or UL 263 with exposure from the outside</td>
<td>0 feet</td>
</tr>
<tr>
<td></td>
<td>Not-fire-resistance rated 0-hours</td>
<td>3 feet a</td>
</tr>
<tr>
<td>Projections</td>
<td>Not allowed</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Fire-resistance-rated 1 hour on the underside</td>
<td>2 feet a</td>
</tr>
<tr>
<td></td>
<td>Not-fire-resistance rated 0-hours</td>
<td>3 feet</td>
</tr>
<tr>
<td>Openings in walls</td>
<td>Not allowed</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Unlimited</td>
<td>3 feet a</td>
</tr>
<tr>
<td>Penetrations</td>
<td>All Comply with Section R302.4</td>
<td>3 feet a</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.
N/A = Not Applicable

a. For residential subdivisions where all dwellings are equipped throughout with an automatic sprinkler system installed in accordance with Section P2904, the fire separation distance for nonrated exterior walls and rated projections shall be permitted to be reduced to 0 feet, and unlimited unprotected openings and penetrations shall be permitted, where the adjoining lot provides an open setback yard that is 6 feet or more in width on the opposite side of the property line.
b. The roof eave fire-resistance rating shall be permitted to be reduced to 0 hours on the underside of the eave if fireblocking is provided from the wall top plate to the underside of the roof sheathing.
c. The roof eave fire-resistance rating shall be permitted to be reduced to 0 hours on the underside of the eave provided that gable vent openings are not installed.

R302.2 Townhouses.
Common walls separating townhouses shall be assigned a fire-resistance rating in accordance with Section R302.2, Item 1 or 2. The common wall shared by two townhouses shall be constructed without plumbing or mechanical equipment, ducts or vents in the cavity of the common wall. The wall shall be rated for fire exposure from both sides and shall extend to and be tight against exterior walls and the underside of the roof sheathing. Electrical installations shall be in accordance with Chapters 34 through 43. Penetrations of the membrane of common walls for electrical outlet boxes shall be in accordance with Section R302.4.

1. Where a fire sprinkler system in accordance with Section P2904 is provided, the common wall shall be not less than a 1-hour fire-resistance-rated wall assembly tested in accordance with ASTM E 119 or UL 263.

2. Where a fire sprinkler system in accordance with Section P2904 is not provided, the common wall shall be not less than a 2-hour fire-resistance-rated wall assembly tested in accordance with ASTM E 119 or UL 263.

Each townhouse shall be considered a separate building and shall be separated by fire-resistance-rated wall assemblies meeting the requirements of Section R302.1 for exterior walls.

**Exception:** If an automatic residential fire sprinkler is installed, a common 1-hour fire-resistance-rated wall assembly tested in accordance with ASTM E 119 or UL 263 is
permitted for townhouses if such walls do not contain plumbing or mechanical equipment, ducts or vents in the cavity of the common wall. The wall shall be rated for fire exposure from both sides and shall extend to and be tight against exterior wall sheathing and the underside of the roof sheathing. Electrical installations shall be installed in accordance with Section R302.4.

R302.2.1 Continuity.
The fire-resistance-rated wall or assembly separating townhouses shall be continuous from the foundation to the underside of the roof sheathing, deck or slab, or exterior wall sheathing. The fire-resistance rating shall extend the full length of the wall or assembly, including wall extensions through and separating attached enclosed accessory structures.

R302.2.2 Parapets for townhouses.
Parapets constructed in accordance with Section R302.2.3 shall be constructed for townhouses as an extension of exterior walls or common walls in accordance with the following:

1. Where roof surfaces adjacent to the wall or walls are at the same elevation, the parapet shall extend not less than 30 inches (762 mm) above the roof surfaces.

2. Where roof surfaces adjacent to the wall or walls are at different elevations and the higher roof is not more than 30 inches (762 mm) above the lower roof, the parapet shall extend not less than 30 inches (762 mm) above the lower roof surface.

   Exception: A parapet is not required in the preceding two cases where the roof covering complies with a minimum Class C rating as tested in accordance with ASTM E 108 or UL 790 and the roof decking or sheathing is of noncombustible materials or approved fire-retardant-treated wood for a distance of 4 feet (1219 mm) on each side of the wall or walls, or one layer of \( \frac{5}{8} \) -inch (15.9 mm) Type X gypsum board is installed directly beneath the roof decking or sheathing, supported by not less than nominal 2-inch (51 mm) ledgers attached to the sides of the roof framing members, for a distance of not less than 4 feet (1219 mm) on each side of the wall or walls and any openings or penetrations in the roof are not within 4 feet (1219 mm) of the common walls.

3. A parapet is not required where roof surfaces adjacent to the wall or walls are at different elevations and the higher roof is more than 30 inches (762 mm) above the lower roof. The common wall construction from the lower roof to the underside of the higher roof deck shall have not less than a 1-hour fire-resistance rating. The wall shall be rated for exposure from both sides.

R302.2.3 Parapet construction.
Parapets shall have the same fire-resistance rating as that required for the supporting wall or walls. On any side adjacent to a roof surface, the parapet shall have noncombustible faces for the uppermost 18 inches (457 mm), to include counterflashing and coping materials. Where the roof slopes toward a parapet at slopes greater than 2 units vertical in 12 units horizontal (16.7-percent slope), the parapet shall extend to the same height as any portion of the roof within a distance of 3 feet (914 mm), and the height shall be not less than 30 inches (762 mm).
R302.2.4 Structural independence.
Each individual *townhouse* shall be structurally independent.

**Exceptions:**

1. Foundations supporting *exterior walls* or common walls.
2. Structural roof and wall sheathing from each unit fastened to the common wall framing.
3. Nonstructural wall and roof coverings.
4. Flashing at termination of roof covering over common wall.
5. *Townhouses* separated by a common wall as provided in Section R302.2, Item 1 or 2.

R302.2.5 Townhouse eave protection.
In *townhouse* construction (with three or more attached dwellings) projections extending into the fire separation distance shall have not less than 1 hour fire resistive construction on the underside. Soffit material beyond the fire separation distance shall be securely attached to framing members and shall be constructed using either noncombustible soffit material; fire-retardant-treated soffit material; vinyl soffit installed over \( \frac{3}{4} \text{-inch (19 mm) wood sheathing or} \)
\( \frac{5}{8} \text{-inch (15.9 mm) gypsum board; or aluminum soffit installed over} \)
\( \frac{3}{4} \text{-inch (19 mm) wood}
\( \frac{5}{8} \text{-inch (15.9 mm) gypsum board. Venting requirements shall be provided in both soffit and underlayments. Vents shall be either nominal 2-inch (51 mm) continuous or equivalent intermittent and shall not exceed the minimum net free air requirements established in Section R806.2 by more than 50 percent. Vents in soffit are not allowed within 4 feet (1219 mm) of fire walls or property lines.}

R302.2.6 Townhouse eave projections.
Overhang projections not exceeding 12 inches (305 mm) shall be allowed to extend beyond the property line in townhouse buildings provided all the following conditions are met:

1. Required fire resistant rated wall assembly is tight to roof deck; and
2. Eaves shall be protected with roof decking and fascia of non-combustible materials or approved fire-retardant-treated wood; and
3. Eaves shall have not less than one layer of \( \frac{5}{8} \text{-inch (15.9 mm) Type X gypsum board or equivalent fire-resistive construction on the underside.} \)
**R302.2.7 Sound transmission.**
See Appendix K.

**R302.3 Two-family dwellings.**
* Dwelling units in two-family dwellings shall be separated from each other by wall and floor assemblies having not less than a 1-hour fire-resistance rating where tested in accordance with ASTM E 119 or UL 263. Fire-resistance-rated floor/ceiling and wall assemblies shall extend to and be tight against the *exterior wall*, and wall assemblies shall extend from the foundation to the underside of the roof sheathing.

**Exceptions:**

1. A fire-resistance rating of \( \frac{1}{2} \) hour shall be permitted in buildings equipped throughout with an automatic sprinkler system installed in accordance with NFPA 13.

2. Wall assemblies need not extend through attic spaces where the ceiling is protected by not less than \( \frac{5}{8} \) -inch (15.9 mm) Type X gypsum board, an attic draft stop constructed as specified in Section R302.12.1 is provided above and along the wall assembly separating the dwellings and the structural framing supporting the ceiling is protected by not less than \( \frac{1}{2} \) -inch (12.7 mm) gypsum board or equivalent.

**R302.3.1 Supporting construction.**
Where floor assemblies are required to be fire-resistance rated by Section R302.3, the supporting construction of such assemblies shall have an equal or greater fire-resistance rating.

**R302.4 Dwelling unit rated penetrations.**
Penetrations of wall or floor-ceiling assemblies required to be fire-resistance rated in accordance with Section R302.2 or R302.3 shall be protected in accordance with this section.

**R302.4.1 Through penetrations.**
Through penetrations of fire-resistance-rated wall or floor assemblies shall comply with Section R302.4.1.1 or R302.4.1.2.

**Exception:** Where the penetrating items are steel, ferrous or copper pipes, tubes or conduits, the annular space shall be protected as follows:

1. In concrete or masonry wall or floor assemblies, concrete, grout or mortar shall be permitted where installed to the full thickness of the wall or floor assembly or the thickness required to maintain the fire-resistance rating, provided that both of the following are complied with:
   1.1. The nominal diameter of the penetrating item is not more than 6 inches (152 mm).
   1.2. The area of the opening through the wall does not exceed 144 square inches (92 900 mm\(^2\)).
2. The material used to fill the annular space shall prevent the passage of flame and hot gases sufficient to ignite cotton waste where subjected to ASTM E 119 or UL 263 time temperature fire conditions under a positive pressure differential of not less than 0.01 inch of water (3 Pa) at the location of the penetration for the time period equivalent to the fire-resistance rating of the construction penetrated.

R302.4.1.1 Fire-resistance-rated assembly.
Penetrations shall be installed as tested in the approved fire-resistance-rated assembly.

R302.4.1.2 Penetration firestop system.
Penetrations shall be protected by an approved penetration firestop system installed as tested in accordance with ASTM E 814 or UL 1479, with a positive pressure differential of not less than 0.01 inch of water (3 Pa) and shall have an F rating of not less than the required fire-resistance rating of the wall or floor-ceiling assembly penetrated.

R302.4.2 Membrane penetrations.
Membrane penetrations shall comply with Section R302.4.1. Where walls are required to have a fire-resistance rating, recessed fixtures shall be installed so that the required fire-resistance rating will not be reduced.

Exceptions:

1. Membrane penetrations of not more than 2-hour fire-resistance-rated walls and partitions by steel electrical boxes that do not exceed 16 square inches (0.0103 m²) in area provided that the aggregate area of the openings through the membrane does not exceed 100 square inches (0.0645 m²) in any 100 square feet (9.29 m²) of wall area. The annular space between the wall membrane and the box shall not exceed \( \frac{1}{8} \) inch (3.1 mm). Such boxes on opposite sides of the wall shall be separated by one of the following:

   1.1. By a horizontal distance of not less than 24 inches (610 mm) where the wall or partition is constructed with individual noncommunicating stud cavities.

   1.2. By a horizontal distance of not less than the depth of the wall cavity where the wall cavity is filled with cellulose loose-fill, rockwool or slag mineral wool insulation.

   1.3. By solid fireblocking in accordance with Section R302.11.

   1.4. By protecting both boxes with listed putty pads.

   1.5. By other listed materials and methods.

2. Membrane penetrations by listed electrical boxes of any materials provided that the boxes have been tested for use in fire-resistance-rated assemblies and are installed in accordance with the instructions included in the listing. The annular
space between the wall membrane and the box shall not exceed $\frac{1}{8}$ inch (3.1 mm) unless listed otherwise. Such boxes on opposite sides of the wall shall be separated by one of the following:

2.1. By the horizontal distance specified in the listing of the electrical boxes.

2.2. By solid fireblocking in accordance with Section R302.11.

2.3. By protecting both boxes with listed putty pads.

2.4. By other listed materials and methods.

3. The annular space created by the penetration of a fire sprinkler provided that it is covered by a metal escutcheon plate.

### R302.5 Dwelling-garage opening and penetration protection.

Openings and penetrations through the walls or ceilings separating the dwelling from the garage shall be in accordance with Sections R302.5.1 through R302.5.3.

#### R302.5.1 Opening protection.

Openings from a private garage directly into a room used for sleeping purposes shall not be permitted. Other openings between the garage and residence shall be equipped with solid wood doors not less than $1\frac{3}{8}$ inches (35 mm) in thickness, solid or honeycomb-core steel doors not less than $1\frac{3}{8}$ inches (35 mm) thick, or 20-minute fire-rated doors equipped with a self-closing device.

**Exception:** A disappearing/pull-down stairway to uninhabited attic space with minimum 7/8-inch (9.53 mm) (nominal) fire retardant-treated structural panel is equivalent to the separation requirement from attics in Table R302.6.

#### R302.5.2 Duct penetration.

Ducts in the garage and ducts penetrating the walls or ceilings separating the dwelling from the garage shall be constructed of a minimum No. 26 gage (0.48 mm) sheet steel or other approved material and shall not have openings into the garage.

#### R302.5.3 Other penetrations.

Penetrations through the separation required in Section R302.6 shall be protected as required by Section R302.11, Item 4.

### R302.6 Dwelling-garage fire separation.

The garage shall be separated as required by Table R302.6. Openings in garage walls shall comply with Section R302.5. Attachment of gypsum board shall comply with Table R702.3.5. The wall separation provisions of Table R302.6 shall not apply to garage walls that are perpendicular to the adjacent dwelling unit wall.

**TABLE R302.6**
### DWELLING-GARAGE SEPARATION

<table>
<thead>
<tr>
<th>SEPARATION</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the residence and attics</td>
<td>Not less than $\frac{1}{2}$-inch gypsum board or equivalent applied to the garage side</td>
</tr>
<tr>
<td>From habitable rooms above the garage(^a)</td>
<td>Not less than $\frac{5}{8}$-inch Type X gypsum board or equivalent</td>
</tr>
<tr>
<td>Structure(s) supporting floor/ceiling assemblies used for separation required by this section</td>
<td>Not less than $\frac{1}{2}$-inch gypsum board or equivalent</td>
</tr>
<tr>
<td>Garages located less than 3 feet from a dwelling unit on the same lot</td>
<td>Not less than $\frac{1}{2}$-inch gypsum board or equivalent applied to the interior side of exterior walls that are within this area</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

\(^a\) For dwelling units constructed prior to the 2012 North Carolina Residential Code edition, ½" or greater existing gypsum board on the bottom side of the garage ceiling shall be acceptable. Joints shall be taped.

**R302.7 Under-stair protection.**
Enclosed accessible space under stairs shall have walls, under-stair surface and any soffits protected on the enclosed side with $\frac{1}{2}$-inch (12.7 mm) gypsum board.

**R302.8 Foam plastics.**
For requirements for foam plastics, see Section R316.

**R302.9 Flame spread index and smoke-developed index for wall and ceiling finishes.**
Flame spread and smoke developed indexes for wall and ceiling finishes shall be in accordance with Sections R302.9.1 through R302.9.4.

**R302.9.1 Flame spread index.**
Wall and ceiling finishes shall have a flame spread index of not greater than 200.

**Exception:** Flame spread index requirements for finishes shall not apply to trim defined as picture molds, chair rails, baseboards and handrails; to doors and windows or their frames; or to materials that are less than $\frac{1}{28}$ inch (0.91 mm) in thickness cemented to the surface of walls or ceilings if these materials exhibit flame spread index values not greater than those of paper of this thickness cemented to a noncombustible backing.

**R302.9.2 Smoke-developed index.**
Wall and ceiling finishes shall have a smoke-developed index of not greater than 450.

**R302.9.3 Testing.**
Tests shall be made in accordance with ASTM E 84 or UL 723.
R302.9.4 Alternative test method.
As an alternative to having a flame spread index of not greater than 200 and a smoke-developed index of not greater than 450 where tested in accordance with ASTM E 84 or UL 723, wall and ceiling finishes shall be permitted to be tested in accordance with NFPA 286. Materials tested in accordance with NFPA 286 shall meet the following criteria:

The interior finish shall comply with the following:

1. During the 40 kW exposure, flames shall not spread to the ceiling.
2. The flame shall not spread to the outer extremity of the sample on any wall or ceiling.
3. Flashover, as defined in NFPA 286, shall not occur.
4. The peak heat release rate throughout the test shall not exceed 800 kW.
5. The total smoke released throughout the test shall not exceed 1,000 m².

R302.10 Flame spread index and smoke-developed index for insulation.
Flame spread and smoke-developed index for insulation shall be in accordance with Sections R302.10.1 through R302.10.5.

R302.10.1 Insulation.
Insulation materials, including facings, such as vapor retarders and vapor-permeable membranes installed within floor-ceiling assemblies, roof-ceiling assemblies, wall assemblies, crawl spaces and attics shall have a flame spread index not to exceed 25 with an accompanying smoke-developed index not to exceed 450 where tested in accordance with ASTM E 84 or UL 723.

Exceptions:

1. Where such materials are installed in concealed spaces, the flame spread index and smoke-developed index limitations do not apply to the facings, provided that the facing is installed in substantial contact with the unexposed surface of the ceiling, floor or wall finish.
2. Cellulose fiber loose-fill insulation, that is not spray applied, complying with the requirements of Section R302.10.3, shall not be required to meet the smoke-developed index of not more than 450 and shall be required to meet a smoke-developed index of not more than 450 where tested in accordance with CAN/ULC S102.2.
3. Foam plastic insulation shall comply with Section R316.

R302.10.2 Loose-fill insulation.
Loose-fill insulation materials that cannot be mounted in the ASTM E 84 or UL 723 apparatus without a screen or artificial supports shall comply with the flame spread and
smoke-developed limits of Section R302.10.1 where tested in accordance with CAN/ULC S102.2.

Exception: Cellulosic fiber loose-fill insulation shall not be required to be tested in accordance with CAN/ULC S102.2, provided such insulation complies with the requirements of Sections R302.10.1 and R302.10.3.

R302.10.3 Cellulosic fiber loose-fill insulation.
Cellulosic fiber loose-fill insulation shall comply with CPSC 16 CFR, Parts 1209 and 1404. Each package of such insulating material shall be clearly labeled in accordance with CPSC 16 CFR, Parts 1209 and 1404.

R302.10.4 Exposed attic insulation.
Exposed insulation materials installed on attic floors shall have a critical radiant flux not less than 0.12 watt per square centimeter.

R302.10.5 Testing.
Tests for critical radiant flux shall be made in accordance with ASTM E 970.

R302.11 Fireblocking.
In combustible construction, fireblocking shall be provided to cut off both vertical and horizontal concealed draft openings and to form an effective fire barrier between stories, and between a top story and the roof space.

Fireblocking shall be provided in wood-framed construction in the following locations:

1. In concealed spaces of stud walls and partitions, including furred spaces and parallel rows of studs or staggered studs, as follows:
   1.1. Vertically at the ceiling and floor levels.
   1.2. Horizontally at intervals not exceeding 10 feet (3048 mm) in furred spaces and parallel rows of studs or staggered studs.

2. At interconnections between concealed vertical and horizontal spaces such as occur at soffits, drop ceilings and cove ceilings.

3. In concealed spaces between stair stringers at the top and bottom of the run. Enclosed spaces under stairs shall comply with Section R302.7.

4. At openings around vents, pipes, ducts, cables and wires at ceiling and floor level, with an approved material to resist the free passage of flame and products of combustion. The material filling this annular space shall not be required to meet the ASTM E 136 requirements.

5. For the fireblocking of chimneys and fireplaces, see Section R1003.19.

6. Fireblocking of cornices of a two-family dwelling is required at the line of dwelling unit separation.
R302.11.1 Fireblocking materials.
Except as provided in Section R302.11, Item 4, fireblocking shall consist of the following materials.

1. Two-inch (51 mm) nominal lumber.

2. Two thicknesses of 1-inch (25.4 mm) nominal lumber with broken lap joints.

3. One thickness of \( \frac{23}{32} \) -inch (18.3 mm) wood structural panels with joints backed by \( \frac{23}{32} \) -inch (18.3 mm) wood structural panels.

4. One thickness of \( \frac{3}{4} \) -inch (19.1 mm) particleboard with joints backed by \( \frac{3}{4} \) -inch (19.1 mm) particleboard.

5. One-half-inch (12.7 mm) gypsum board.

6. One-quarter-inch (6.4 mm) cement-based millboard.

7. Batts or blankets of mineral wool or glass fiber or other approved materials installed in such a manner as to be securely retained in place.

8. Cellulose insulation installed as tested in accordance with ASTM E 119 or UL 263, for the specific application.

R302.11.1.1 Batts or blankets of mineral or glass fiber.
Batts or blankets of mineral or glass fiber or other approved nonrigid materials shall be permitted for compliance with the 10-foot (3048 mm) horizontal fireblocking in walls constructed using parallel rows of studs or staggered studs.

R302.11.1.2 Unfaced fiberglass.
Unfaced fiberglass batt insulation used as fireblocking shall fill the entire cross section of the wall cavity to a height of not less than 16 inches (406 mm) measured vertically. Where piping, conduit or similar obstructions are encountered, the insulation shall be packed tightly around the obstruction.

R302.11.1.3 Loose-fill insulation material.
Loose-fill insulation material shall not be used as a fireblock unless specifically tested in the form and manner intended for use to demonstrate its ability to remain in place and to retard the spread of fire and hot gases.

R302.11.2 Fireblocking integrity.
The integrity of fireblocks shall be maintained.

R302.12 Draftstopping.
In combustible construction where there is usable space both above and below the concealed space of a floor-ceiling assembly, draftstops shall be installed so that the area of the concealed space does not exceed 1,000 square feet (92.9 m²). Draftstopping shall divide the concealed
space into approximately equal areas. Where the assembly is enclosed by a floor membrane above and a ceiling membrane below, draftstopping shall be provided in floor-ceiling assemblies under the following circumstances:

1. Ceiling is suspended under the floor framing.
2. Floor framing is constructed of truss-type open-web or perforated members.

**R302.12.1 Materials.**
Draftstopping materials shall be not less than $\frac{1}{2}$-inch (12.7 mm) gypsum board, $\frac{3}{8}$-inch (9.5 mm) wood structural panels or other approved materials adequately supported. Draftstopping shall be installed parallel to the floor framing members unless otherwise approved by the building official. The integrity of the draftstops shall be maintained.

**R302.13 Fire protection of floors.** Deleted.
Floor assemblies that are not required elsewhere in this code to be fire-resistance rated, shall be provided with a $\frac{1}{2}$-inch (12.7 mm) gypsum wallboard membrane, $\frac{5}{8}$-inch (16 mm) wood structural panel membrane, or equivalent on the underside of the floor framing member. Penetrations or openings for ducts, vents, electrical outlets, lighting, devices, luminaires, wires, speakers, drainage, piping and similar openings or penetrations shall be permitted.

**Exceptions:**

1. Floor assemblies located directly over a space protected by an automatic sprinkler system in accordance with Section P2904, NFPA 13D, or other approved equivalent sprinkler system.
2. Floor assemblies located directly over a crawl space not intended for storage or fuel-fired appliances.
3. Portions of floor assemblies shall be permitted to be unprotected where complying with the following:
   3.1. The aggregate area of the unprotected portions does not exceed 80 square feet (7.4 m²) per story
   3.2. Fireblocking in accordance with Section R302.11.1 is installed along the perimeter of the unprotected portion to separate the unprotected portion from the remainder of the floor assembly.
4. Wood floor assemblies using dimension lumber or structural composite lumber equal to or greater than 2-inch by 10-inch (50.8 mm by 254 mm) nominal dimension, or other approved floor assemblies demonstrating equivalent fire performance.

**R302.14 Combustible insulation clearance.**
Combustible insulation shall be separated not less than 3 inches (76 mm) from recessed luminaires, fan motors and other heat-producing devices.
Exception: Where heat-producing devices are listed for lesser clearances, combustible insulation complying with the listing requirements shall be separated in accordance with the conditions stipulated in the listing.

Recessed luminaires installed in the building thermal envelope shall meet the requirements of Section N1102.4.5 of this code.

SECTION R303
LIGHT, VENTILATION AND HEATING

R303.1 Habitable rooms.
Habitable rooms shall have an aggregate glazing area of not less than 8 percent of the floor area of such rooms. Natural ventilation shall be through windows, skylights, doors, louvers or other approved openings to the outdoor air. Such openings shall be provided with ready access or shall otherwise be readily controllable by the building occupants. The openable area to the outdoors shall be not less than 4 percent of the floor area being ventilated.

Exceptions:

1. The glazed areas need not be openable where the opening is not required by Section R310 and a whole-house mechanical ventilation system is installed in accordance with Section M1507.

2. The glazed areas need not be installed in rooms where Exception 1 is satisfied and artificial light is provided that is capable of producing an average illumination of 6 footcandles (65 lux) over the area of the room at a height of 30 inches (762 mm) above the floor level.

3. Use of sunroom and patio covers, as defined in Section R202, shall be permitted for natural ventilation if in excess of 40 percent of the exterior sunroom walls are open, or are enclosed only by insect screening.

R303.2 Adjoining rooms.
For the purpose of determining light and ventilation requirements, any room shall be considered to be a portion of an adjoining room where not less than one-half of the area of the common wall is open and unobstructed and provides an opening of not less than one-tenth of the floor area of the interior room and not less than 25 square feet (2.3 m²).

Exception: Openings required for light or ventilation shall be permitted to open into a sunroom with thermal isolation or a patio cover, provided that there is an openable area between the adjoining room and the sunroom or patio cover of not less than one-tenth of the floor area of the interior room and not less than 20 square feet (2 m²). The minimum openable area to the outdoors shall be based upon the total floor area being ventilated.

R303.2.1 Sunroom additions.
Required glazed openings shall be permitted to open into sunroom additions or patio covers that abut a street, yard or court if in excess of 40 percent of the exterior sunroom walls are
open, or are enclosed only by insect screening, and the ceiling height of the sunroom is not less than 7 feet (2134 mm).

R303.3 Bathrooms.

Bathrooms, water closet compartments and other similar rooms shall be provided with aggregate glazing area in windows of not less than 3 square feet (0.3 m\(^2\)), one-half of which must be openable.

Exception: The glazed areas shall not be required where artificial light and a local exhaust system are provided. The minimum local exhaust rates shall be determined in accordance with Section M1507. Exhaust air from the space shall be exhausted directly to the outdoors.

R303.4 Mechanical ventilation. Deleted.

R303.5 Opening location.

Outdoor intake and exhaust openings shall be located in accordance with Sections R303.5.1 and R303.5.2.

R303.5.1 Intake openings.

Mechanical and gravity outdoor air intake openings shall be located not less than 10 feet (3048 mm) from any hazardous or noxious contaminant, such as vents, chimneys, plumbing vents, streets, alleys, parking lots and loading docks.

For the purpose of this section, the exhaust from dwelling unit toilet rooms, bathrooms and kitchens shall not be considered as hazardous or noxious.

Exceptions:

1. The 10-foot (3048 mm) separation is not required where the intake opening is located 3 feet (914 mm) or greater below the contaminant source.

2. Vents and chimneys serving fuel-burning appliances shall be terminated in accordance with the applicable provisions of Chapters 18 and 24.

3. Clothes dryer exhaust ducts shall be terminated in accordance with Section M1502.3.

R303.5.2 Exhaust openings.

Exhaust air shall not be directed onto walkways.

R303.6 Outside opening protection.

Air exhaust and intake openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles having an opening size of not less than \(\frac{1}{4}\) inch (6 mm) and a maximum opening size of \(\frac{1}{2}\) inch (13 mm), in any dimension. Openings shall be protected.
against local weather conditions. Outdoor air exhaust and intake openings shall meet the provisions for exterior wall opening protectives in accordance with this code.

R303.7 Interior stairway illumination.
Interior stairways shall be provided with an artificial light source to illuminate the landings and treads. The light source shall be capable of illuminating treads and landings to levels of not less than 1 foot-candle (11 lux) as measured at the center of treads and landings. There shall be a wall switch at each floor level to control the light source where the stairway has six or more risers.

Exception: A switch is not required where remote, central or automatic control of lighting is provided.

R303.7.1 Light activation.
Where lighting outlets are installed in interior stairways, there shall be a wall switch at each floor level to control the lighting outlet where the stairway has six or more risers. The illumination of exterior stairways shall be controlled from inside the dwelling unit.

Exception: Lights that are continuously illuminated or automatically controlled.

R303.8 Exterior stairway illumination.
Exterior stairways shall be provided with an artificial light source located at the top landing of the stairway. Exterior stairways providing access to a basement from the outdoor grade level shall be provided with an artificial light source located at the bottom landing of the stairway.

R303.8.1 Sunroom additions. Deleted.
Required glazed openings shall be permitted to open into sunroom additions or patio covers that abut a street, yard or court if in excess of 40 percent of the exterior sunroom walls are open, or are enclosed only by insect screening, and the ceiling height of the sunroom is not less than 7 feet (2134 mm).

R303.9 Required heating.
Where the winter design temperature in Table R301.2(1) is below 60°F (16°C), every dwelling unit shall be provided with heating facilities capable of maintaining a room temperature of not less than 68°F (20°C) at a point 3 feet (914 mm) above the floor and 2 feet (610 mm) from exterior walls in habitable rooms at the design temperature. The installation of one or more portable space heaters shall not be used to achieve compliance with this section.

Exception: Unconditioned sunrooms that are thermally isolated from the dwelling.

SECTION R304
MINIMUM ROOM AREAS

R304.1 Minimum area.
Habitable rooms shall have a floor area of not less than 70 square feet (6.5 m²).

Exception: Kitchens.

R304.2 Minimum dimensions.
Habitable rooms shall be not less than 7 feet (2134 mm) in any horizontal dimension.

2018 North Carolina Residential Code
Exception: Kitchens.

R304.3 Height effect on room area.
Portions of a room with a sloping ceiling measuring less than 5 feet (1524 mm) or a furred ceiling measuring less than 7 feet (2134 mm) from the finished floor to the finished ceiling shall not be considered as contributing to the minimum required habitable area for that room.

SECTION R305
CEILING HEIGHT

R305.1 Minimum height.
Habitable space, hallways and portions of basements containing these spaces shall have a ceiling height of not less than 7 feet (2134 mm). Bathrooms, toilet rooms and laundry rooms shall have a ceiling height of not less than 6 feet 8 inches (2032 mm).

Exceptions:

1. For rooms with sloped ceilings, the required floor area of the room shall have a ceiling height of not less than 5 feet (1524 mm) and not less than 50 percent of the required floor area shall have a ceiling height of not less than 7 feet (2134 mm).

2. The ceiling height above bathroom and toilet room fixtures shall be such that the fixture is capable of being used for its intended purpose. A shower or tub equipped with a showerhead shall have a ceiling height of not less than 6 feet 8 inches (2032 mm) above an area of not less than 30 inches (762 mm) by 30 inches (762 mm) at the showerhead.

3. Beams, girders, ducts or other obstructions in basements containing habitable space shall be permitted to project to within 6 feet 4 inches (1931 mm) of the finished floor.

R305.1.1 Basements.
Portions of basements that do not contain habitable space or hallways shall have a ceiling height of not less than 6 feet 8 inches (2032 mm).

Exception: At beams, girders, ducts or other obstructions, the ceiling height shall be not less than 6 feet 4 inches (1931 mm) from the finished floor.

SECTION R306
SANITATION

R306.1 Toilet facilities.
Every dwelling unit shall be provided with a water closet, lavatory, and a bathtub or shower.

R306.2 Kitchen.
Each dwelling unit shall be provided with a kitchen area and every kitchen area shall be provided with a sink.
R306.3 Sewage disposal.
Plumbing fixtures shall be connected to a sanitary sewer or to an approved private sewage disposal system.

R306.4 Water supply to fixtures.
Plumbing fixtures shall be connected to an approved water supply. Kitchen sinks, lavatories, bathtubs, showers, bidets, laundry tubs and washing machine outlets shall be provided with hot and cold water.

SECTION R307
TOILET, BATH AND SHOWER SPACES

R307.1 Space required.
Fixtures shall be spaced in accordance with Figure R307.1, and in accordance with the requirements of Section P2705.1.

For SI: 1 inch = 25.4 mm.
FIGURE R307.1
MINIMUM FIXTURE CLEARANCES

R307.2 Bathtub and shower spaces.
Bathtub and shower floors and walls above bathtubs with installed shower heads and in shower compartments shall be finished with a nonabsorbent surface. Such wall surfaces shall extend to a height of not less than 6 feet (1829 mm) above the floor.

SECTION R308
GLAZING

R308.1 Identification.
Except as indicated in Section R308.1.1 each pane of glazing installed in hazardous locations as defined in Section R308.4 shall be provided with a manufacturer’s designation specifying who applied the designation, designating the type of glass and the safety glazing standard with which it complies, which is visible in the final installation. The designation shall be acid etched, sandblasted, ceramic-fired, laser etched, embossed, or be of a type that once applied cannot be removed without being destroyed. A label shall be permitted in lieu of the manufacturer’s designation.

Exceptions:

1. For other than tempered glass, manufacturer’s designations are not required provided that the building official approves the use of a certificate, affidavit or other evidence confirming compliance with this code.

2. Tempered spandrel glass is permitted to be identified by the manufacturer with a removable paper designation.

R308.1.1 Identification of multiple assemblies.
Multipane assemblies having individual panes not exceeding 1 square foot (0.09 m²) in exposed area shall have not less than one pane in the assembly identified in accordance with Section R308.1. Other panes in the assembly shall be labeled “CPSC 16 CFR 1201” or “ANSI Z97.1” as appropriate.

R308.2 Louvered windows or jalousies.
Regular, float, wired or patterned glass in jalousies and louvered windows shall be not less than nominal $\frac{3}{16}$ inch (5 mm) thick and not more than 48 inches (1219 mm) in length. Exposed glass edges shall be smooth.

R308.2.1 Wired glass prohibited.
Wired glass with wire exposed on longitudinal edges shall not be used in jalousies or louvered windows.

R308.3 Human impact loads.
Individual glazed areas, including glass mirrors in hazardous locations such as those indicated as defined in Section R308.4, shall pass the test requirements of Section R308.3.1.

2018 North Carolina Residential Code
Exceptions:

1. Louvered windows and jalousies shall comply with Section R308.2.

2. Mirrors and other glass panels mounted or hung on a surface that provides a continuous backing support.

3. Glass unit masonry complying with Section R607.

R308.3.1 Impact test.
Where required by other sections of the code, glazing shall be tested in accordance with CPSC 16 CFR 1201. Glazing shall comply with the test criteria for Category II unless otherwise indicated in Table R308.3.1(1).

Exception: Glazing not in doors or enclosures for hot tubs, whirlpools, saunas, steam rooms, bathtubs and showers shall be permitted to be tested in accordance with ANSI Z97.1. Glazing shall comply with the test criteria for Class A unless indicated in Table R308.3.1(2).

### TABLE R308.3.1(1)
MINIMUM CATEGORY CLASSIFICATION OF GLAZING USING CPSC 16 CFR 1201

<table>
<thead>
<tr>
<th>EXPOSED SURFACE AREA OF ONE SIDE OF ONE LITE</th>
<th>GLAZING IN STORM OR COMBINATION DOORS (Category Class)</th>
<th>GLAZING IN DOORS (Category Class)</th>
<th>GLAZED PANELS REGULATED BY SECTION R308.4.3 (Category Class)</th>
<th>GLAZED PANELS REGULATED BY SECTION R308.4.2 (Category Class)</th>
<th>GLAZING IN DOORS AND ENCLOSURES REGULATED BY SECTION 308.4.5 (Category Class)</th>
<th>SLIDING GLASS DOORS PATIO TYPE (Category Class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 square feet or less</td>
<td>I</td>
<td>I</td>
<td>NR</td>
<td>I</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>More than 9 square feet</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.0929 m
NR = “No Requirement.”

### TABLE R308.3.1(2)
MINIMUM CATEGORY CLASSIFICATION OF GLAZING USING ANSI Z97.1

<table>
<thead>
<tr>
<th>EXPOSED SURFACE AREA OF ONE SIDE OF ONE LITE</th>
<th>GLAZED PANELS REGULATED BY SECTION R308.4.3 (Category Class)</th>
<th>GLAZED PANELS REGULATED BY SECTION R308.4.2 (Category Class)</th>
<th>DOORS AND ENCLOSURES REGULATED BY SECTION R308.4.5 (Category Class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 square feet or less</td>
<td>No requirement</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
R308.4 Hazardous locations.
The locations specified in Sections R308.4.1 through R308.4.7 shall be considered to be specific hazardous locations for the purposes of glazing.

R308.4.1 Glazing in doors.
Glazing in fixed and operable panels of swinging, sliding and bifold doors shall be considered to be a hazardous location.

Exceptions:

1. Glazed openings of a size through which a 3-inch-diameter (76 mm) sphere is unable to pass.

2. Decorative glazing.

R308.4.2 Glazing adjacent to doors.
Glazing in an individual fixed or operable panel adjacent to a door in the same plane as the door shall be considered to be a hazardous location where the bottom exposed edge of the glazing is less than 60 inches (1524 mm) above the floor or walking surface and it meets either of the following conditions:

1. Where the glazing is within 24 inches (610 mm) of either side of the door in the plane of the door in a closed position.

2. Where the glazing is on a wall perpendicular to the plane of the door in a closed position and within 24 inches (610 mm) of the hinge side of an in-swinging door.

Exceptions:

1. Decorative glazing.

2. Where there is an intervening wall or other permanent barrier between the door and the glazing.

3. Where access through the door is to a closet or storage area 3 feet (914 mm) or less in depth. Glazing in this application shall comply with Section R308.4.3.

4. Glazing that is adjacent to the fixed panel of patio doors.

R308.4.3 Glazing in windows.
Glazing in an individual fixed or operable panel that meets all of the following conditions shall be considered to be a hazardous location:
1. The exposed area of an individual pane is larger than 9 square feet (0.836 m$^2$),
2. The bottom edge of the glazing is less than 18 inches (457 mm) above the floor,
3. The top edge of the glazing is more than 36 inches (914 mm) above the floor; and
4. One or more walking surfaces are within 36 inches (914 mm), measured horizontally and in a straight line, of the glazing.

Exceptions:

1. Decorative glazing.
2. Where a horizontal rail is installed on the accessible side(s) of the glazing 34 to 38 inches (864 to 965 mm) above the walking surface. The rail shall be capable of withstanding a horizontal load of 50 pounds per linear foot (730 N/m) without contacting the glass and have a cross-sectional height of not less than $1\frac{1}{2}$ inches (38 mm).
3. Outboard panes in insulating glass units and other multiple glazed panels where the bottom edge of the glass is 25 feet (7620 mm) or more above grade, a roof, walking surfaces or other horizontal [within 45 degrees (0.79 rad) of horizontal] surface adjacent to the glass exterior.

R308.4.4 Glazing in guards and railings.
Glazing in guards and railings, including structural baluster panels and nonstructural in-fill panels, regardless of area or height above a walking surface shall be considered to be a hazardous location.

R308.4.5 Glazing and wet surfaces.
Glazing in walls, enclosures or fences containing or facing hot tubs, spas, whirlpools, saunas, steam rooms, bathtubs, showers and indoor or outdoor swimming pools where the bottom exposed edge of the glazing is less than 60 inches (1524 mm) measured vertically above any standing or walking surface shall be considered to be a hazardous location. This shall apply to single glazing and each pane in multiple glazing.

Exception: Glazing that is more than 60 inches (1524 mm), measured horizontally and in a straight line, from the water's edge of a bathtub, hot tub, spa, whirlpool or swimming pool or from the edge of a shower, sauna or steam room.

R308.4.6 Glazing adjacent to stairs and ramps.
Glazing where the bottom exposed edge of the glazing is less than 36 inches (914 mm) above the plane of the adjacent walking surface of stairways, landings between flights of stairs and ramps shall be considered to be a hazardous location.

Exceptions:
1. Where a rail is installed on the accessible side(s) of the glazing 34 to 38 inches (864 to 965 mm) above the walking surface. The rail shall be capable of withstanding a horizontal load of 50 pounds per linear foot (730 N/m) without contacting the glass and have a cross-sectional height of not less than $1\frac{1}{2}$ inches (38 mm).

2. Glazing 36 inches (914 mm) or more measured horizontally from the walking surface.

3. Where a change in elevation is 8 ¼ inches (210 mm) or less at an exterior door.

**R308.4.7 Glazing adjacent to the bottom stair landing.**
Glazing adjacent to the landing at the bottom of a stairway where the glazing is less than 36 inches (914 mm) above the landing and within a 60-inch (1524 mm) horizontal arc less than 180 degrees from the bottom tread nosing shall be considered to be a hazardous location.

**Exception:** The glazing is protected by a guard complying with Section R312 and the plane of the glass is more than 18 inches (457 mm) from the guard.

![Figure R308.4.7](image-url)

**FIGURE R308.4.7**
PROHIBITED GLAZING LOCATIONS AT BOTTOM STAIR LANDINGS

**R308.5 Site-built windows.**
Site-built windows shall comply with Section 2404 of the *International Building Code.*

**R308.6 Skylights and sloped glazing.**
Skylights and sloped glazing shall comply with the following sections.
R308.6.1 Definitions.
The following terms are defined in Chapter 2:

SKYLIGHT, UNIT.

SKYLIGHTS AND SLOPED GLAZING.

TUBULAR DAYLIGHTING DEVICE (TDD).

R308.6.2 Materials.
The following types of glazing shall be permitted to be used:

1. Laminated glass with not less than a 0.015-inch (0.38 mm) polyvinyl butyral interlayer for glass panes 16 square feet (1.5 m²) or less in area located such that the highest point of the glass is not more than 12 feet (3658 mm) above a walking surface or other accessible area; for higher or larger sizes, the interlayer thickness shall be not less than 0.030 inch (0.76 mm).

2. Fully tempered glass.

3. Heat-strengthened glass.

4. Wired glass.

5. Approved rigid plastics.

R308.6.3 Screens, general.
For fully tempered or heat-strengthened glass, a retaining screen meeting the requirements of Section R308.6.7 shall be installed below the glass, except for fully tempered glass that meets either condition listed in Section R308.6.5.

R308.6.4 Screens with multiple glazing.
Where the inboard pane is fully tempered, heat-strengthened or wired glass, a retaining screen meeting the requirements of Section R308.6.7 shall be installed below the glass, except for either condition listed in Section R308.6.5. Other panes in the multiple glazing shall be of any type listed in Section R308.6.2.

R308.6.5 Screens not required.
Screens shall not be required where fully tempered glass is used as single glazing or the inboard pane in multiple glazing and either of the following conditions are met:

1. Glass area 16 square feet (1.49 m²) or less. Highest point of glass not more than 12 feet (3658 mm) above a walking surface or other accessible area, nominal glass thickness not more than \( \frac{3}{16} \) inch (4.8 mm), and (for multiple glazing only) the other pane or panes fully tempered, laminated or wired glass.
2. Glass area greater than 16 square feet (1.49 m²). Glass sloped 30 degrees (0.52 rad) or less from vertical, and highest point of glass not more than 10 feet (3048 mm) above a walking surface or other accessible area.

R308.6.6 Glass in greenhouses. Any glazing material is permitted to be installed without screening in the sloped areas of greenhouses, provided that the greenhouse height at the ridge does not exceed 20 feet (6096 mm) above grade.

R308.6.7 Screen characteristics. The screen and its fastenings shall be capable of supporting twice the weight of the glazing, be firmly and substantially fastened to the framing members, and have a mesh opening of not more than 1 inch by 1 inch (25 mm by 25 mm).

R308.6.8 Curbs for skylights. Unit skylights installed in a roof with a pitch flatter than three units vertical in 12 units horizontal (25-percent slope) shall be mounted on a curb extending not less than 4 inches (102 mm) above the plane of the roof unless otherwise specified in the manufacturer’s installation instructions.

R308.6.9 Testing and labeling. Unit skylights and tubular daylighting devices shall be tested by an approved independent laboratory, and bear a label identifying manufacturer, performance grade rating and approved inspection agency to indicate compliance with the requirements of AAMA/WDMA/CSA 101/I.S.2/A440.

R308.6.9.1 Comparative analysis for glass-glazed unit skylights. Structural wind load design pressures for glass-glazed unit skylights smaller different than the size tested in accordance with Section R308.6.9 shall be permitted. to be different than the design value of the tested unit where determined in accordance with one of the following comparative analysis methods:

1. Structural wind load design pressures for glass-glazed unit skylights smaller than the size tested in accordance with Section R308.6.9 shall be permitted to be higher than the design value of the tested unit provided that such higher pressures are determined by accepted engineering analysis. Components of the smaller unit shall be the same as those of the tested unit. Such calculated design pressures shall be validated by an additional test of the glass-glazed unit skylight having the highest allowable design pressure.

2. In accordance with WDMA I.S. 11.

SECTION R309
GARAGES AND CARPORTS

R309.1 Floor surface. Garage floor surfaces shall be of approved noncombustible material.

The area of floor used for parking of automobiles or other vehicles shall be sloped to facilitate the movement of liquids to a drain or toward the main vehicle entry doorway.

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R309.2 Carports.
Carports shall be open on not less than two sides. Carport floor surfaces shall be of approved noncombustible material. Carports not open on two or more sides shall be considered to be a garage and shall comply with the provisions of this section for garages.

**Exception:** Asphalt surfaces shall be permitted at ground level in carports.

The area of floor used for parking of automobiles or other vehicles shall be sloped to facilitate the movement of liquids to a drain or toward the main vehicle entry doorway.

R309.3 Flood hazard areas.
For buildings located in flood hazard areas as established by Table R301.2(1), garage floors shall be:

1. Elevated to or above the design flood elevation as determined in accordance with Section R322; or
2. Located below the design flood elevation provided that the floors are at or above grade on not less than one side, are used solely for parking, building access or storage, meet the requirements of Section R322 and are otherwise constructed in accordance with this code.

R309.4 Automatic garage door openers.
Automatic garage door openers, if provided, shall be listed and labeled in accordance with UL 325.

R309.5 Fire sprinklers. Deleted.
Private garages shall be protected by fire sprinklers where the garage wall has been designed based on Table R302.1(2), Footnote a. Sprinklers in garages shall be connected to an automatic sprinkler system that complies with Section P2904. Garage sprinklers shall be residential sprinklers or quick-response sprinklers, designed to provide a density of 0.05 gpm/ft². Garage doors shall not be considered obstructions with respect to sprinkler placement.

SECTION R310
EMERGENCY ESCAPE AND RESCUE OPENINGS

R310.1 Emergency escape and rescue opening required.
Basements, habitable attics and every sleeping room shall have not less than one operable emergency escape and rescue opening. Where basements contain one or more sleeping rooms, an emergency escape and rescue opening shall be required in each sleeping room. Emergency escape and rescue openings shall open directly into a public way, or to a yard or court that opens to a public way.

**Exception:** Storm shelters and basements used only to house mechanical equipment not exceeding a total floor area of 200 square feet (18.58 m²).

R310.1.1 Operational constraints and opening control devices.
Emergency escape and rescue openings shall be operational from the inside of the room.
without the use of keys, tools or special knowledge. Window opening control devices complying with ASTM F 2090 shall be permitted for use on windows serving as a required emergency escape and rescue opening.

R310.2 Emergency escape and rescue openings.
Emergency escape and rescue openings shall have minimum dimensions as specified in this section.

R310.2.1 Minimum opening area.
Emergency and escape rescue openings shall have a net clear opening of not less than 5.7 square feet (0.530 m$^2$). The net clear opening dimensions required by this section shall be obtained by the normal operation of the emergency escape and rescue opening from the inside. The net clear height opening shall be not less than 24 inches (610 mm) and the net clear width shall be not less than 20 inches (508 mm). Minimum net clear openable area of 4 square feet (0.372 m$^2$). The minimum net clear opening height shall be 22 inches (558 mm). The minimum net clear opening width shall be 20 inches (508 mm). Emergency escape and rescue openings must have a minimum total glazing area of not less than 5 square feet (0.465 m$^2$) in the case of a ground floor level window and not less than 5.7 square feet (0.530 m$^2$) in the case of an upper story window.

Exception: Grade floor or below grade openings shall have a net clear opening of not less than 5 square feet (0.465 m$^2$).

R310.2.2 Window sill height.
Where a window is provided as the emergency escape and rescue opening, it shall have a sill height of not more than 44 inches (1118 mm) above the floor; where the sill height is below grade, it shall be provided with a window well in accordance with Section R310.2.3.

R310.2.3 Window wells.
The horizontal area of the window well shall be not less than 9 square feet (0.9 m$^2$), with a horizontal projection and width of not less than 36 inches (914 mm). The area of the window well shall allow the emergency escape and rescue opening to be fully opened.

Exception: The ladder or steps required by Section R310.2.3.1 shall be permitted to encroach not more than 6 inches (152 mm) into the required dimensions of the window well.

R310.2.3.1 Ladder and steps.
Window wells with a vertical depth greater than 44 inches (1118 mm) shall be equipped with a permanently affixed ladder or steps usable with the window in the fully open position. Ladders or steps required by this section shall not be required to comply with Sections R311.7 and R311.8. Ladders or rungs shall have an inside width of not less than 12 inches (305 mm), shall project not less than 3 inches (76 mm) from the wall and shall be spaced not more than 18 inches (457 mm) on center vertically for the full height of the window well.

R310.2.3.2 Drainage. Deleted.
Window wells shall be designed for proper drainage by connecting to the building's
foundation drainage system required by Section R405.1 or by an approved alternative method.

**Exception:** A drainage system for window wells is not required where the foundation is on well-drained soil or sand-gravel mixture soils in accordance with the United Soil Classification System, Group I Soils, as detailed in Table R405.1.

**R310.2.4 Emergency escape and rescue openings under decks and porches.**
Emergency escape and rescue openings shall be permitted to be installed under decks and porches provided that the location of the deck allows the emergency escape and rescue openings to be fully opened and provides a path not less than 36 inches (914 mm) in height to a yard or court.

**R310.3 Emergency escape and rescue doors.**
Where a door is provided as the required emergency escape and rescue opening, it shall be permitted to be a side-hinged door or a slider. Where the opening is below the adjacent ground elevation, it shall be provided with a bulkhead enclosure.

**R310.3.1 Minimum door opening size.**
The minimum net clear height opening for any door that serves as an emergency and escape rescue opening shall be in accordance with Section R310.2.1.

**R310.3.2 Bulkhead enclosures.**
Bulkhead enclosures shall provide direct access from the basement. The bulkhead enclosure shall provide the minimum net clear opening equal to the door in the fully open position.

**R310.3.2.1 Drainage.** Deleted.
Bulkhead enclosures shall be designed for proper drainage by connecting to the building’s foundation drainage system required by Section R405.1 or by an approved alternative method.

**Exception:** A drainage system for bulkhead enclosures is not required where the foundation is on well-drained soil or sand-gravel mixture soils in accordance with the United Soil Classification System, Group I Soils, as detailed in Table R405.1.

**R310.4 Bars, grilles, covers and screens.**
Bars, grilles, covers, screens or similar devices are permitted to be placed over emergency escape and rescue openings, bulkhead enclosures, or window wells that serve such openings, provided that the minimum net clear opening size complies with Sections R310.1.1 to R310.2.3, and such devices shall be releasable or removable from the inside without the use of a key, tool, special knowledge or force greater than that required for the normal operation of the escape and rescue opening.

**R310.5 Dwelling additions.**
Where dwelling additions occur that contain sleeping rooms, an emergency escape and rescue opening shall be provided in each new sleeping room. Where dwelling additions occur that have basements, an emergency escape and rescue opening shall be provided in the new basement.

**Exceptions:**
1. An emergency escape and rescue opening is not required in a new basement that contains a sleeping room with an emergency escape and rescue opening.

2. An emergency escape and rescue opening is not required in a new basement where there is an emergency escape and rescue opening in an existing basement that is accessible from the new basement.

R310.6 Alterations or repairs of existing basements.
An emergency escape and rescue opening is not required where existing basements undergo alterations or repairs.

Exception: New sleeping rooms created in an existing basement shall be provided with emergency escape and rescue openings in accordance with Section R310.1.

SECTION R311
MEANS OF EGRESS

R311.1 Means of egress.
All dwellings shall be provided with a means of egress in accordance with as provided in this section. The means of egress shall provide a continuous and unobstructed path of vertical and horizontal egress travel from all portions of the dwelling to the exterior of the dwelling at the required egress door without requiring travel through a garage. The required egress door shall open directly into a public way or to a yard or court that opens to a public way.

Exception: Equipment service platforms may be served by ladders constructed per Section R310.2.3.1.

R311.2 Egress door.
Not less than one exterior egress door shall be provided for each dwelling unit. The egress door shall be side-hinged, and shall provide a clear width of not less than 32 inches (813 mm) where measured between the face of the door and the stop, with the door open 90 degrees (1.57 rad). The clear height of the door opening shall be not less than 78 inches (1981 mm) in height measured from the top of the threshold to the bottom of the stop. Other exterior doors shall not be required to comply with these minimum dimensions. Egress doors shall be readily openable from inside the dwelling without the use of a key or special knowledge or effort.

R311.3 Floors and landings at exterior doors.
There shall be a landing or floor on each side of each exterior door. The width of each landing shall be not less than the door served. Every landing shall have a dimension of not less than 36 inches (914 mm) measured in the direction of travel. The slope at exterior landings shall not exceed \( \frac{1}{4} \) unit vertical in 12 units horizontal (2 percent).

Exception: Exterior balconies less than 60 square feet (5.6 m\(^2\)) and only accessible from a door are permitted to have a landing less than 36 inches (914 mm) measured in the direction of travel.
R311.3.1 Floor elevations at the required egress doors.
Landings or finished floors at the required egress door shall be not more than $1\frac{1}{2}$ inches (38 mm) lower than the top of the threshold.

**Exception:** The exterior landing or floor on the exterior side shall be not more than $2\frac{3}{4}$ inches (196 210 mm) below the top of the threshold provided the door does not swing over the landing or floor.

Where exterior landings or floors serving the required egress door are not at grade, they shall be provided with access to grade by means of a ramp in accordance with Section R311.8 or a stairway in accordance with Section R311.7.

R311.3.2 Floor elevations for other exterior doors.
Doors other than the required egress door shall be provided with landings or floors not more than $2\frac{3}{4}$ inches (196 210 mm) below the top of the threshold.

**Exception:** A top landing is not required where a stairway of not more than two risers is located on the exterior side of the door, provided that the door does not swing over the stairway.

R311.3.3 Storm and screen doors.
Storm and screen doors shall be permitted to swing over exterior stairs and landings.

R311.4 Vertical egress. Deleted.
Egress from habitable levels including habitable attics and basements not provided with an egress door in accordance with Section R311.2 shall be by a ramp in accordance with Section R311.8 or a stairway in accordance with Section R311.7.

R311.5 Construction.

**R311.5.1 Attachment.** Deleted.
Exterior landings, decks, balconies, stairs and similar facilities shall be positively anchored to the primary structure to resist both vertical and lateral forces or shall be designed to be self-supporting. Attachment shall not be accomplished by use of toenails or nails subject to withdrawal.

R311.6 Hallways.
The width of a hallway shall be not less than 3 feet (914 mm) measured from the finished surface of the walls.

**R311.6.1 Interior egress doors.**
All doors providing egress from habitable rooms shall have nominal minimum dimensions of 2 feet 6 inches (782 mm) width by 6 feet 8 inches (2032 mm) height. Interior egress doors shall be readily openable from the side from which egress is to be made without the use of a key or special knowledge or effort.
R311.7 Stairways.

R311.7.1 Width.
Stairways shall be not less than 36 inches (914 mm) in clear width at all points above the permitted handrail height and below the required headroom height. Handrails shall not project more than $4\frac{1}{2}$ inches (114 mm) on either side of the stairway and the clear width of the stairway at and below the handrail height, including treads and landings, shall be not less than $31\frac{1}{2}$ inches (787 mm) where a handrail is installed on one side and 27 inches (698 mm) where handrails are provided on both sides.

Exceptions:

1. The width of spiral stairways shall be in accordance with Section R311.7.10.1.

2. Stairways not required for egress shall be permitted to be a minimum width of 26 inches (660 mm).

R311.7.2 Headroom.
The headroom in stairways shall be not less than 6 feet 8 inches (2032 mm) measured vertically from the sloped line adjoining the tread nosing or from the floor surface of the landing or platform on that portion of the stairway.

Exceptions:

1. Where the nosings of treads at the side of a flight extend under the edge of a floor opening through which the stair passes, the floor opening shall be allowed to project horizontally into the required headroom not more than $4\frac{3}{4}$ inches (121 mm).

2. The headroom for spiral stairways shall be in accordance with Section R311.7.10.1.

R311.7.3 Vertical rise.
A flight of stairs shall not have a vertical rise larger than 147 inches (3734 mm) between floor levels or landings.

R311.7.4 Walkline. Deleted.

R311.7.5 Stair treads and risers.
Stair treads and risers shall meet the requirements of this section. For the purposes of this
section, dimensions and dimensioned surfaces shall be exclusive of carpets, rugs or runners.

R311.7.5.1 Risers.
The riser height shall be not more than $\frac{7}{8}$ inches (196 mm). The riser shall be measured vertically between leading edges of the adjacent treads. The greatest riser height within any flight of stairs shall not exceed the smallest by more than $\frac{3}{8}$ inch (9.5 mm). Risers shall be vertical or sloped from the underside of the nosing of the tread above at an angle not more than 30 degrees (0.51 rad) from the vertical. Open risers are permitted provided that the openings located more than 30 inches (762 mm), as measured vertically, to the floor or grade below do not permit the passage of a 4-inch-diameter (102 mm) sphere. The top and bottom riser of interior stairs shall not exceed the smallest riser within that stair run by more than 3/4 inch (19 mm). The height of the top and bottom riser of the interior stairs shall be measured from the permanent finished surface (carpet excluded). Where the bottom riser of an exterior stair adjoins an exterior walk, porch, driveway, patio, garage floor, or finish grade, the height of the riser may be less than the height of the adjacent risers.

Exceptions:
1. The opening between adjacent treads is not limited on spiral stairways.
2. The riser height of spiral stairways shall be in accordance with Section R311.7.10.1.

R311.7.5.2 Treads.
The minimum tread depth shall be not less than 10 $\frac{9}{16}$ inches (254 mm). The tread depth shall be measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the tread’s leading edge. The greatest tread depth within any flight of stairs shall not exceed the smallest by more than $\frac{3}{8}$ inch (9.5 mm).

R311.7.5.2.1 Winder treads.
Winder treads shall have a tread depth of not less than 10 $\frac{9}{16}$ inches (254 mm) measured between the vertical planes of the foremost projection of adjacent treads at the intersections with the walkline. Winder treads shall have a tread depth of not less than 6 $\frac{4}{16}$ inches (152 mm) at any point within the clear width of the stair. Within any flight of stairs, the largest winder tread depth at the walkline shall not exceed the smallest winder tread by more than $\frac{3}{8}$ inch (9.5 mm). Consistently shaped winders at the walkline shall be allowed within the same flight of stairs as rectangular treads and do not have to be within $\frac{3}{8}$ inch (9.5 mm) of the rectangular tread depth.

Exception: The tread depth at spiral stairways shall be in accordance with Section R311.7.10.1.
R311.7.5.3 Nosings.
The radius of curvature at the nosing shall be not greater than $\frac{9}{16}$ inch (14 mm). A nosing projection not less than $\frac{3}{4}$ inch (19 mm) and not more than $1\frac{1}{4}$ inches (32 mm) shall be provided on stairways with solid risers. The greatest nosing projection shall not exceed the smallest nosing projection by more than $\frac{3}{8}$ inch (9.5 mm) between two stories, including the nosing at the level of floors and landings. Beveling of nosings shall not exceed $\frac{1}{2}$ inch (12.7 mm).

Exceptions:
1. A nosing projection is not required where the tread depth is not less than 11 inches (279 mm).
2. The opening between adjacent treads is not limited on stairs with a total rise of 30 inches (762 mm) or less.

R311.7.5.4 Exterior plastic composite stair treads.
Plastic composite exterior stair treads shall comply with the provisions of this section and Section R507.3 the requirements of ASTM D 7032.

R311.7.6 Landings for stairways.
The shall be a floor or landing at the top and bottom of each stairway. The width perpendicular to the direction of travel shall be not less than the width of the flight served. Landings of shapes other than square or rectangular shall be permitted provided that the depth at the walk line and the total area is not less than that of a quarter circle with a radius equal to the required landing width. Where the stairway has a straight run, the depth in the direction of travel shall be not less than 36 inches (914 mm).

There shall be a floor or landing at the top and bottom of each stairway. A flight of stairs shall not have a vertical rise larger than 12 feet 3 inches (3734 mm) between floor levels or landings. The width of each landing shall not be less than the width of the stairway served. Every landing shall have a minimum dimension of 36 inches (914 mm) measured in the direction of travel.

Exception: A floor or landing is not required at the top of an interior flight of stairs, including stairs in an enclosed garage, provided that a door does not swing over the stairs.

R311.7.7 Stairway walking surface.
The walking surface of treads and landings of stairways shall be sloped not steeper than one unit vertical in 48 inches horizontal (2-percent slope).

R311.7.8 Handrails.
Handrails shall be provided on not less than one side of each continuous run of treads or flight with four or more risers.

R311.7.8.1 Height.
Handrail height, measured vertically from the sloped plane adjoining the tread nosing, or
finish surface of ramp slope, shall be not less than 34 inches (864 mm) and not more than 38 inches (965 mm).

Exceptions:

1. The use of a volute, turnout or starting easing shall be allowed over the lowest tread.

2. Where handrail fittings or bendings are used to provide continuous transition between flights, transitions at winder treads, the transition from handrail to guard, or used at the start of a flight, the handrail height at the fittings or bendings shall be permitted to exceed 38 inches (956 mm).

R311.7.8.2 Continuity.
Handrails for stairways shall be continuous for the full length of the flight, from a point directly above the top riser of the flight to a point directly above the lowest riser of the flight. Handrail ends shall be returned or shall terminate in newel posts or safety terminals. Handrails adjacent to a wall shall have a space of not less than 1 1/2 inches (38 mm) between the wall and the handrails.

Exceptions:

1. Handrails shall be permitted to be interrupted by a newel post at the turn.

2. The use of a volute, turnout, starting easing or starting newel shall be allowed over the lowest tread.

3. Two or more separate rails shall be considered continuous if the termination of the rails occurs within 6 inches (152 mm) of each other. If transitioning between a wall-mounted handrail and a guardrail/handrail, the wall-mounted rail shall return into the wall.

R311.7.8.3 Grip-size.
Required handrails shall be of one of the following types or provide equivalent graspalbility.

1. Type I. Handrails with a circular cross section shall have an outside diameter of not less than 1 1/4 inches (32 mm) and not greater than 2 inches (51 mm). If the handrail is not circular, it shall have a perimeter dimension of not less than 4 inches (102 mm) and not greater than 6 1/4 inches (160 mm) with a cross section of dimension of not more than 2 1/4 inches (57 mm). Edges shall have a radius of not less than 0.01 inch (0.25 mm).

2. Type II. Handrails with a perimeter greater than 6 1/4 inches (160 mm) shall have a graspable finger recess area on both sides of the profile. The finger recess
shall begin within a distance of \( \frac{3}{4} \) inch (19 mm) measured vertically from the tallest portion of the profile and achieve a depth of not less than \( \frac{5}{16} \) inch (8 mm) within \( \frac{7}{8} \) inch (22 mm) below the widest portion of the profile. This required depth shall continue for not less than \( \frac{3}{8} \) inch (10 mm) to a level that is not less than \( 1\frac{3}{4} \) inches (45 mm) below the tallest portion of the profile. The width of the handrail above the recess shall be not less than \( 1\frac{1}{4} \) inches (32 mm) and not more than \( 2\frac{3}{4} \) inches (70 mm). Edges shall have a radius of not less than 0.01 inch (0.25 mm).

**Exception:** Exterior handrails (garages and areas exposed to the weather) shall not be more than \( 3\frac{1}{2} \) inches (89 mm) in cross-section dimension.

**R311.7.8.4 Exterior plastic composite handrails.**
Plastic composite exterior handrails shall comply with the requirements of Section R507.3 ASTM D 7032.

**R311.7.9 Illumination.**
Stairways shall be provided with illumination in accordance with Section R303.7.

**R311.7.10 Special stairways.**
Spiral stairways, and bulkhead enclosure stairways and bowed tread stairways shall comply with the requirements of Section R311.7 except as specified in Sections R311.7.10.1 and through R311.7.10.23.

**R311.7.10.1 Spiral stairways.**
Spiral stairways are permitted, provided that the clear width at and below the handrail is not less than 26 inches (660 mm) and the walkline radius is not greater than \( 24\frac{1}{2} \) inches (622 mm). Each tread shall have a depth of not less than \( 6\frac{3}{4} \) inches (171 mm) at the walkline. All treads shall be identical, and the rise shall be not more than \( 9\frac{1}{2} \) inches (241 mm). Headroom shall be not less than 6 feet 6 inches (1982 mm).

**R311.7.10.2 Bulkhead enclosure stairways.**
Stairways serving bulkhead enclosures, not part of the required building egress, providing access from the outside grade level to the basement shall be exempt from the requirements of Sections R311.3 and R311.7 where the height from the basement finished floor level to grade adjacent to the stairway is not more than 8 feet (2438 mm) and the grade level opening to the stairway is covered by a bulkhead enclosure with hinged doors or other approved means.

**R311.7.10.3 Bowed tread stairways.**
Bowed tread stairways are permitted provided they are uniform in bowed tread depth along the entire width of the tread with not more than $\frac{3}{8}$ inch (9.5 mm) variance from greatest to smallest tread in the stairway flight. At no point shall the tread be less than 9 inches (229 mm) with a nosing as listed in Sections R311.7.5.2 and R311.7.5.3 respectively.

**R311.7.10.3.1 Standard stairway application.**
The bottom 3 treads in a standard straight run stairway application as listed under Section R311.7.5.2 are permitted to bow provided at no point along the width of the tread they are less than 9 inches (229 mm) as measured under Section R311.7.5.2 and each bowed tread is uniform with other bowed treads with no more than $\frac{3}{8}$ inch (9.5 mm) variance from greatest to least. Nosing is required as listed in Section R311.7.5.3.

**R311.7.10.3.2 Bowed tread circular stairways.**
Bowed treads in a circular stairway are permitted provided they are uniformed as per winder treads as listed in Section R311.7.5.2 measured at a point 12 inches (305 mm) from the side where the treads are narrower. At this walk line, bowed treads must be uniform with other circular stairway treads with the greatest tread not to exceed the smallest by more than $\frac{3}{8}$ inch (9.5 mm). Nosing is required as listed in Section R311.7.5.3.

**R311.7.11 Alternating tread devices.** Deleted. Alternating tread devices shall not be used as an element of a means of egress. Alternating tread devices shall be permitted provided that the required means of egress stairway or ramp serves the same space at each adjoining level or where a means of egress is not required. The clear width at and below the handrails shall be not less than 20 inches (508 mm).

**R311.7.11.1 Treads of alternating tread devices.**
Alternating tread devices shall have a tread depth of not less than 5 inches (127 mm), a projected tread depth of not less than $8\frac{1}{2}$ inches (216 mm), a tread width of not less than 7 inches (178 mm) and a riser height of not more than $9\frac{1}{2}$ inches (241 mm). The tread depth shall be measured horizontally between the vertical planes of the foremost projections of adjacent treads. The riser height shall be measured vertically between the leading edges of adjacent treads. The riser height and tread depth provided shall result in an angle of ascent from the horizontal of between 50 and 70 degrees (0.87 and 1.22 rad). The initial tread of the device shall begin at the same elevation as the platform, landing or floor surface.

**R311.7.11.2 Handrails of alternating tread devices.**
Handrails shall be provided on both sides of alternating tread devices and shall comply with Sections R311.7.8.2 to R311.7.8.4. Handrail height shall be uniform, not less than 30 inches (762 mm) and not more than 34 inches (864 mm).
**R311.7.12 Ships ladders.**
Ships ladders shall not be used as an element of a means of egress. Ships ladders shall be permitted provided that a required means of egress stairway or ramp serves the same space at each adjoining level or where a means of egress is not required. The clear width at and below the handrails shall be not less than 20 inches.

**R311.7.12.1 Treads of ships ladders.**
Treads shall have a depth of not less than 5 inches (127 mm). The tread shall be projected such that the total of the tread depth plus the nosing projection is not less than $8\frac{1}{2}$ inches (216 mm). The riser height shall be not more than $9\frac{1}{2}$ inches (241 mm).

**R311.7.12.2 Handrails of ships ladders.**
Handrails shall be provided on both sides of ships ladders and shall comply with Sections R311.7.8.2 to R311.7.8.4. Handrail height shall be uniform, not less than 30 inches (762 mm) and not more than 34 inches (864 mm).

**R311.8 Ramps.**

**R311.8.1 Maximum slope.**
Ramps serving the egress door required by Section R311.2 shall have a slope of not more than 1 unit vertical in 12 units horizontal (8.3-percent slope). All other ramps shall have a maximum slope of 1 unit vertical in 8 units horizontal (12.5 percent).

**Exception:** Where it is technically infeasible to comply because of site constraints, ramps shall have a slope of not more than 1 unit vertical in 8 units horizontal (12.5 percent).

**R311.8.2 Landings required.**
There shall be a floor or landing at the top and bottom of each ramp, where doors open onto ramps, and where ramps change directions. The width of the landing perpendicular to the ramp slope shall be not less than 36 inches (914 mm).

**R311.8.3 Handrails required.**
Handrails shall be provided on not less than one side of ramps exceeding a slope of one unit vertical in 12 units horizontal (8.33-percent slope).

**R311.8.3.1 Height.**
Handrail height, measured above the finished surface of the ramp slope, shall be not less than 34 inches (864 mm) and not more than 38 inches (965 mm).

**R311.8.3.2 Grip size.**
Handrails on ramps shall comply with Section R311.7.8.3.

**R311.8.3.3 Continuity.**
Handrails where required on ramps shall be continuous for the full length of the ramp. Handrail ends shall be returned or shall terminate in newel posts or safety terminals. Handrails adjacent to a wall shall have a space of not less than $1\frac{1}{2}$ inches (38 mm) between the wall and the handrails.
R312.1 Guards.

Guards shall be provided in accordance with Sections R312.1.1 through R312.1.4.

R312.1.1 Where required.

Guards shall be located along open-sided walking surfaces, including stairs, ramps and landings, that are located more than 30 inches (762 mm) measured vertically to the floor or grade below at any point within 36 inches (914 mm) horizontally to the edge of the open side. Insect screening shall not be considered as a guard.

R312.1.2 Height.

Required guards at open-sided walking surfaces, including stairs, porches, balconies or landings, shall be not less than 36 inches (914 mm) in height as measured vertically above the adjacent walking surface or the line connecting the leading edges of the treads.

Exceptions:

1. Guards on the open sides of stairs shall have a height not less than 34 inches (864 mm) measured vertically from a line connecting the leading edges of the treads.

2. Where the top of the guard serves as a handrail on the open sides of stairs, the top of the guard shall be not less than 34 inches (864 mm) and not more than 38 inches (965 mm) as measured vertically from a line connecting the leading edges of the treads.

R312.1.3 Opening limitations.

Required guards shall not have openings from the walking surface to the required guard height that allow passage of a sphere 4 inches (102 mm) in diameter.

Exceptions:

1. The triangular openings at the open side of stair, formed by the riser, tread and bottom rail of a guard, shall not allow passage of a sphere 6 inches (153 mm) in diameter.

2. Guards on the open side of stairs shall not have openings that allow passage of a sphere \(\frac{3}{8}\) inches (111 mm) in diameter.

R312.1.4 Exterior plastic composite guards.

Plastic composite exterior guards shall comply with the requirements of Section R317.4.

R312.2 Window fall protection.

Window fall protection shall be provided in accordance with Sections R312.2.1 and R312.2.2.

R312.2.1 Window sills.

In dwelling units, where the top of the sill of an operable window opening is located less than
24 inches (610 mm) above the finished floor and greater than 72 inches (1829 mm) above the finished grade or other surface below on the exterior of the building, the operable window shall comply with one of the following:

1. Operable windows with openings that will not allow a 4-inch-diameter (102 mm) sphere to pass through the opening where the opening is in its largest opened position.

2. Operable windows that are provided with window fall prevention devices that comply with ASTM F 2090.

3. Operable windows that are provided with window opening control devices that comply with Section R312.2.2.

**R312.2.2 Window opening control devices.**

Window opening control devices shall comply with ASTM F 2090. The window opening control device, after operation to release the control device allowing the window to fully open, shall not reduce the net clear opening area of the window unit to less than the area required by Section R310.2.1.

**SECTION R313**

**AUTOMATIC FIRE SPRINKLER SYSTEMS**

**R313.1 Townhouse automatic fire sprinkler systems.**

An automatic residential fire sprinkler system shall be installed in townhouses.

**Exceptions:**

1. Townhouses constructed with a common 2-hour fire-resistance-rated wall assembly tested in accordance with ASTM E 119 or UL 263 provided such walls do not contain plumbing or mechanical equipment, ducts or vents in the cavity of the common wall. The wall shall be rated for fire exposure from both sides and shall extend to and be tight against exterior wall sheathing and the underside of the roof sheathing. Electrical installations shall be installed in accordance with Chapters 34 through 43. Penetrations for electrical outlet boxes shall be in accordance with Section R302.4.

2. An automatic residential fire sprinkler system shall not be required where additions or alterations are made to existing townhouses that do not have an automatic residential fire sprinkler system installed.

**R313.1.1 Design and installation.**

Automatic residential fire sprinkler systems for townhouses shall be designed and installed in accordance with Section P2904 or NFPA 13D.

**R313.2 One- and two-family dwellings automatic fire systems.** Deleted.

An automatic residential fire sprinkler system shall be installed in one- and two-family dwellings.
Exception: An automatic residential fire sprinkler system shall not be required for additions or alterations to existing buildings that are not already provided with an automatic residential sprinkler system.

R313.2.1 Design and installation.
Automatic residential fire sprinkler systems shall be designed and installed in accordance with Section P2904 or NFPA 13D.

SECTION R314
SMOKE ALARMS

R314.1 General.
Smoke alarms shall comply with NFPA 72 and Section R314.

R314.1.1 Listings.
Smoke alarms shall be listed in accordance with UL 217. Combination smoke and carbon monoxide alarms shall be listed in accordance with UL 217 and UL 2034.

R314.2 Where required.
Smoke alarms shall be provided in accordance with this section.

R314.2.1 New construction.
Smoke alarms shall be provided in dwelling units.

R314.2.2 Alterations, repairs and additions.
Where alterations, repairs or additions requiring a building permit occur, or where one or more sleeping rooms are added or created in existing dwellings, the individual dwelling unit shall be equipped with smoke alarms located as required for new dwellings.

Exceptions:

1. Work involving the exterior surfaces of dwellings, such as the replacement of roofing or siding, the addition or replacement of windows or doors, or the addition of a porch or deck, are exempt from the requirements of this section.

2. Installation, alteration or repairs of plumbing or mechanical systems are exempt from the requirements of this section.

R314.3 Location.
Smoke alarms shall be installed in the following locations:

1. In each sleeping room.

2. Outside each separate sleeping area in the immediate vicinity of the bedrooms.

3. On each additional story of the dwelling, including basements and habitable attics and not including crawl spaces and uninhabitable attics. In dwellings or dwelling units with split levels and without an intervening door between the adjacent levels, a smoke alarm installed on the upper level shall suffice for the adjacent lower level provided that the lower level is less than one full story below the upper level.
4. Smoke alarms shall be installed not less than 3 feet (914 mm) horizontally from the door or opening of a bathroom that contains a bathtub or shower unless this would prevent placement of a smoke alarm required by Section R314.3.

**R314.3.1 Installation near cooking appliances.**
Smoke alarms shall not be installed in the following locations unless this would prevent placement of a smoke alarm in a location required by Section R314.3.

1. Ionization smoke alarms shall not be installed less than 20 feet (6096 mm) horizontally from a permanently installed cooking appliance.

2. Ionization smoke alarms with an alarm-silencing switch shall not be installed less than 10 feet (3048 mm) horizontally from a permanently installed cooking appliance.

3. Photoelectric smoke alarms shall not be installed less than 6 feet (1828 mm) horizontally from a permanently installed cooking appliance.

**R314.4 Interconnection.**
Where more than one smoke alarm is required to be installed within an individual dwelling unit in accordance with Section R314.3, the alarm devices shall be interconnected in such a manner that the actuation of one alarm will activate all of the alarms in the individual dwelling unit. Physical interconnection of smoke alarms shall not be required where listed wireless alarms are installed and all alarms sound upon activation of one alarm.

**Exception:** Interconnection of smoke alarms in existing areas shall not be required where alterations or repairs do not result in removal of interior wall or ceiling finishes exposing the structure, unless there is an attic, crawl space or basement available that could provide access for interconnection without the removal of interior finishes.

**R314.5 Combination alarms.**
Combination smoke and carbon monoxide alarms shall be permitted to be used in lieu of smoke alarms.

**R314.6 Power source.**
Smoke alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source and, where primary power is interrupted, shall receive power from a battery. Wiring shall be permanent and without a disconnecting switch other than those required for overcurrent protection.

**Exceptions:**

1. Smoke alarms shall be permitted to be battery operated where installed in buildings without commercial power.

2. Smoke alarms installed in accordance with Section R314.2.2 shall be permitted to be battery powered.
R314.7 Fire alarm systems.
Fire alarm systems shall be permitted to be used in lieu of smoke alarms and shall comply with Sections R314.7.1 through R314.7.4.

R314.7.1 General.
Fire alarm systems shall comply with the provisions of this code and the household fire warning equipment provisions of NFPA 72. Smoke detectors shall be listed in accordance with UL 268.

R314.7.2 Location.
Smoke detectors shall be installed in the locations specified in Section R314.3.

R314.7.3 Permanent fixture.
Where a household fire alarm system is installed, it shall become a permanent fixture of the occupancy, owned by the homeowner.

R314.7.4 Combination detectors.
Combination smoke and carbon monoxide detectors shall be permitted to be installed in fire alarm systems in lieu of smoke detectors, provided that they are listed in accordance with UL 268 and UL 2075.

SECTION R315
CARBON MONOXIDE ALARMS

R315.1 General.
Carbon monoxide alarms shall comply with Section R315.

R315.1.1 Listings.
Carbon monoxide alarms shall be listed in accordance with UL 2034. Combination carbon monoxide and smoke alarms shall be listed in accordance with UL 2034 and UL 217.

R315.2 Where required.
Carbon monoxide alarms shall be provided in accordance with Sections R315.2.1 and R315.2.2.

R315.2.1 New construction.
For new construction, carbon monoxide alarms shall be provided in dwelling units where either or both of the following conditions exist.

1. The dwelling unit contains a fuel-fired appliance or fireplace.

2. The dwelling unit has an attached garage with an opening that communicates with the dwelling unit.

R315.2.2 Alterations, repairs and additions.
Where alterations, repairs or additions requiring a building permit occur, or where one or more sleeping rooms are added or created in existing dwellings, or where fuel-fired appliances or fireplaces are added or replaced, the individual dwelling unit shall be equipped with carbon monoxide alarms located as required for new dwellings.
Exceptions:

1. Work involving the exterior surfaces of *dwellings*, such as the replacement of roofing or siding, or the addition or replacement of windows or doors, or the addition of a porch or deck, or the installation of a fuel fired appliance that cannot introduce carbon monoxide to the interior of the dwelling, is exempt from the requirements of this section.

2. Installation, alteration or repairs of plumbing or mechanical systems are exempt from the requirements of this section. Deleted.

R315.3 Location.
Carbon monoxide alarms in *dwelling units* shall be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms. Where a fuel-burning *appliance* is located within a bedroom or its attached bathroom, a carbon monoxide alarm shall be installed within the bedroom.

R315.4 Combination alarms.
Combination carbon monoxide and smoke alarms shall be permitted to be used in lieu of carbon monoxide alarms.

R315.5 Power source.
Carbon monoxide alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source and, where primary power is interrupted, shall receive power from a battery. Wiring shall be permanent and without a disconnecting switch other than those required for overcurrent protection.

Exceptions:

1. Carbon monoxide alarms shall be permitted to be battery operated where installed in buildings without commercial power.

2. Carbon monoxide alarms installed in accordance with Section R315.2.2 shall be permitted to be battery powered.

R315.6 Carbon monoxide detection systems.
Carbon monoxide detection systems shall be permitted to be used in lieu of carbon monoxide alarms and shall comply with Sections R315.6.1 through R315.6.4.

R315.6.1 General.
Household carbon monoxide detection systems shall comply with NFPA 720. Carbon monoxide detectors shall be *listed* in accordance with UL 2075.

R315.6.2 Location.
Carbon monoxide detectors shall be installed in the locations specified in Section R315.3. These locations supersede the locations specified in NFPA 720.

R315.6.3 Permanent fixture.
Where a household carbon monoxide detection system is installed, it shall become a permanent fixture of the occupancy and owned by the homeowner.
R315.6.4 Combination detectors.
Combination carbon monoxide and smoke detectors shall be permitted to be installed in carbon monoxide detection systems in lieu of carbon monoxide detectors, provided that they are listed in accordance with UL 2075 and UL 268.

SECTION R316
FOAM PLASTIC

R316.1 General.
The provisions of this section shall govern the materials, design, application, construction and installation of foam plastic materials.

R316.2 Labeling and identification.
Packages and containers of foam plastic insulation and foam plastic insulation components delivered to the job site shall bear the label of an approved agency showing the manufacturer's name, the product listing, product identification and information sufficient to determine that the end use will comply with the requirements.

R316.3 Surface burning characteristics.
Unless otherwise allowed in Section R316.5, foam plastic or foam plastic cores used as a component in manufactured assemblies used in building construction shall have a flame spread index of not more than 75 and shall have a smoke-developed index of not more than 450 when tested in the maximum thickness and density intended for use in accordance with ASTM E 84 or UL 723. Loose-fill-type foam plastic insulation shall be tested as board stock for the flame spread index and smoke-developed index.

Exception: Foam plastic insulation more than 4 inches (102 mm) thick shall have a flame spread index of not more than 75 and a smoke-developed index of not more than 450 where tested at a thickness of not more than 4 inches (102 mm), provided that the end use is approved in accordance with Section R316.6 using the thickness and density intended for use.

R316.4 Thermal barrier.
Unless otherwise allowed in Section R316.5, foam plastic shall be separated from the interior of a building by an approved thermal barrier of not less than $1/2$-inch (12.7 mm) gypsum wallboard, $23/32$-inch (18.2 mm) wood structural panel or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

R316.5 Specific requirements.
The following requirements shall apply to these uses of foam plastic unless specifically approved in accordance with Section R316.6 or by other sections of the code or the requirements of Sections R316.2 through R316.4 have been met.

R316.5.1 Masonry or concrete construction.
The thermal barrier specified in Section R316.4 is not required in a masonry or concrete
wall, floor or roof when the foam plastic insulation is separated from the interior of the building by not less than a 1-inch (25 mm) thickness of masonry or concrete.

**R316.5.2 Roofing.**
The thermal barrier specified in Section R316.4 is not required where the foam plastic in a roof assembly or under a roof covering is installed in accordance with the code and the manufacturer’s instructions and is separated from the interior of the building by tongue-and-groove wood planks or wood structural panel sheathing, in accordance with Section R803, that is not less than \( \frac{15}{32} \) inch (11.9 mm) thick bonded with exterior glue, identified as Exposure 1 and with edges supported by blocking or tongue-and-groove joints or an equivalent material. The smoke-developed index for roof applications shall not be limited.

**R316.5.3 Attics.**
The thermal barrier specified in Section R316.4 is not required where all of the following apply:

1. **Attic** access is required by Section R807.1.
2. The space is entered only for purposes of repairs or maintenance.
3. The foam plastic insulation has been tested in accordance with Section R316.6 or the foam plastic insulation is protected against ignition using one of the following ignition barrier materials:
   3.1. \( \frac{1}{2} \)-inch-thick (38 mm) mineral fiber insulation.
   3.2. \( \frac{1}{4} \)-inch-thick (6.4 mm) wood structural panels.
   3.3. \( \frac{3}{8} \)-inch (9.5 mm) particleboard.
   3.4. \( \frac{1}{4} \)-inch (6.4 mm) hardboard.
   3.5. \( \frac{3}{8} \)-inch (9.5 mm) gypsum board.
   3.6. Corrosion-resistant steel having a base metal thickness of 0.016 inch (0.406 mm).
   3.7. \( \frac{1}{2} \)-inch-thick (38 mm) cellulose insulation; or
   3.8. \( \frac{1}{4} \)-inch (6.4 mm) fiber-cement panel, soffit or backer board.
The ignition barrier is not required where the foam plastic insulation has been tested in accordance with Section R316.6.

R316.5.4 Crawl spaces. The thermal barrier specified in Section R316.4 is not required where all of the following apply:

1. Crawl space access is required by Section R408.48.
2. Entry is made only for purposes of repairs or maintenance.
3. The foam plastic insulation has been tested in accordance with Section R316.6 or the foam plastic insulation is protected against ignition using one of the following ignition barrier materials:
   3.1. 1/2-inch-thick (38 mm) mineral fiber insulation;
   3.2. 1/4-inch-thick (6.4 mm) wood structural panels;
   3.3. 3/8-inch (9.5 mm) particleboard;
   3.4. 1/4-inch (6.4 mm) hardboard;
   3.5. 3/8-inch (9.5 mm) gypsum board; or
   3.6. Corrosion-resistant steel having a base metal thickness of 0.016 inch (0.406 mm).

R316.5.5 Foam-filled exterior doors. Foam-filled exterior doors are exempt from the requirements of Sections R316.3 and R316.4.

R316.5.6 Foam-filled garage doors. Foam-filled garage doors in attached or detached garages are exempt from the requirements of Sections R316.3 and R316.4.

R316.5.7 Foam backer board. The thermal barrier specified in Section R316.4 is not required where siding backer board foam plastic insulation has a thickness of not more than 0.5 inch (12.7 mm) and a potential heat of not more than 2000 Btu per square foot (22 720 kJ/m²) when tested in accordance with NFPA 259 provided that:

1. The foam plastic insulation is separated from the interior of the building by not less than 2 inches (51 mm) of mineral fiber insulation;
2. The foam plastic insulation is installed over existing exterior wall finish in conjunction with re-siding; or

3. The foam plastic insulation has been tested in accordance with Section R316.6.

R316.5.8 Re-siding.
The thermal barrier specified in Section R316.4 is not required where the foam plastic insulation is installed over existing exterior wall finish in conjunction with re-siding provided that the foam plastic has a thickness of not more than 0.5 inch (12.7 mm) and a potential heat of not more than 2000 Btu per square foot (22 720 kJ/m²) when tested in accordance with NFPA 259.

R316.5.9 Interior trim.
The thermal barrier specified in Section R316.4 is not required for exposed foam plastic interior trim, provided that all of the following are met:

1. The density is not less than 20 pounds per cubic foot (320 kg/m³).

2. The thickness of the trim is not more than 0.5 inch (12.7 mm) and the width is not more than 8 inches (204 mm).

3. The interior trim shall not constitute more than 10 percent of the aggregate wall and ceiling area of any room or space.

4. The flame spread index does not exceed 75 when tested per ASTM E 84 or UL 723. The smoke-developed index is not limited.

R316.5.10 Interior finish.
Foam plastics shall be permitted as interior finish where approved in accordance with Section R316.6. Foam plastics that are used as an interior finish shall meet the flame spread index and smoke-developed index requirements of Sections R302.9.1 and R302.9.2.

R316.5.11 Sill plates and headers.
Foam plastic shall be permitted to be spray applied to sill plates and headers or installed in the perimeter joist space without the thermal barrier specified in Section R316.4 subject to all of the following:

1. The thickness of the foam plastic shall be not more than 3 1/4 inches (83 mm).

2. The density of the foam plastic shall be in the range of 0.5 to 2.0 pounds per cubic foot (8 to 32 kg/m³).

3. The foam plastic shall have a flame spread index of 25 or less and an accompanying smoke-developed index of 450 or less when tested in accordance with ASTM E 84 or UL 723.
R316.5.12 Sheathing.
Foam plastic insulation used as sheathing shall comply with Section R316.3 and Section R316.4. Where the foam plastic sheathing is exposed to the attic space at a gable or kneewall, the provisions of Section R316.5.3 shall apply. Where foam plastic insulation is used as exterior wall sheathing on framed wall assemblies, it shall comply with Section R316.8.

R316.5.13 Floors.
The thermal barrier specified in Section R316.4 is not required to be installed on the walking surface of a structural floor system that contains foam plastic insulation when the foam plastic is covered by not more than a nominal 1/2-inch-thick (12.7 mm) wood structural panel or equivalent. The thermal barrier specified in Section R316.4 is required on the underside of the structural floor system that contains foam plastic insulation when the underside of the structural floor system is exposed to the interior of the building.

R316.6 Specific approval.
Foam plastic not meeting the requirements of Sections R316.3 through R316.5 shall be specifically approved on the basis of one of the following approved tests: NFPA 286 with the acceptance criteria of Section R302.9.4, FM 4880, UL 1040 or UL 1715, or fire tests related to actual end-use configurations. Approval shall be based on the actual end-use configuration and shall be performed on the finished foam plastic assembly in the maximum thickness intended for use. Assemblies tested shall include seams, joints and other typical details used in the installation of the assembly and shall be tested in the manner intended for use.

R316.7 Termite damage.
The use of foam plastics in areas of “very-moderate-heavy” termite infestation probability shall be in accordance with Section R318.4.

R316.8 Wind resistance.
Foam plastic insulation complying with ASTM C 578 and ASTM C 1289 and used as exterior wall sheathing on framed wall assemblies shall comply with SBCA FS 100 for wind pressure resistance unless installed directly over a sheathing material that is separately capable of resisting the wind load or otherwise exempted from the scope of SBCA FS 100.

SECTION R317
PROTECTION OF WOOD AND WOOD-BASED PRODUCTS AGAINST DECAY

R317.1 Location required.
Protection of wood and wood-based products from decay shall be provided in the following locations by the use of naturally durable wood or wood that is preservative-treated in accordance with AWPA U1 for the species, product, preservative and end use. Preservatives shall be listed in Section 4 of AWPA U1.

1. Wood joists or the bottom of a wood structural floor when closer than 18 inches (457 mm) or wood girders when closer than 12 inches (305 mm) to the exposed ground in crawl spaces or unexcavated area located within the periphery of the building foundation.
2. Wood framing members that rest on concrete or masonry exterior foundation walls and are less than 8 inches (203 mm) from the exposed ground.

3. Sills and sleepers on a concrete or masonry unless the slab that is in direct contact with the ground is separated from the ground unless separated from such slab by an impervious moisture barrier.

4. The ends of wood girders entering exterior masonry or concrete walls having clearances of less than \( \frac{1}{2} \) inch (12.7 mm) on tops, sides and ends.

5. Wood siding, and sheathing and wall framing on the exterior of a building having a clearance of less than 6 inches (152 mm) from the ground or less than 2 inches (51 mm) measured vertically from concrete steps, porch slabs, patio slabs and similar horizontal surfaces exposed to the weather.

6. Wood structural members supporting moisture-permeable floors or roofs that are exposed to the weather, such as concrete or masonry slabs, unless separated from such floors or roofs by an impervious moisture barrier.

7. Wood furring strips or other wood framing members attached directly to the interior of exterior masonry walls or concrete walls below grade except where an approved vapor retarder is applied between the wall and the furring strips or framing members.

8. All portions of a porch, screen porch or deck from the bottom of the header down, including posts, guardrails, pickets, steps, and floor structure. Coverings that would prevent moisture or water accumulation on the surface or at joints between members are allowed.

**Exception:** Columns complying with Section R317.1.4 Exception #3.

**R317.1.1 Field treatment.** Deleted.

Field-cut ends, notches and drilled holes of preservative-treated wood shall be treated in the field in accordance with AWPA M4.

**R317.1.2 Ground contact.**

All wood in contact with the ground, embedded in concrete in direct contact with the ground or embedded in concrete exposed to the weather that supports permanent structures intended for human occupancy shall be approved pressure-preservative-treated wood suitable for ground contact use, except that untreated wood used entirely below groundwater level or continuously submerged in fresh water shall not be required to be pressure-preservative treated.

**R317.1.3 Geographical areas.** Deleted.

In geographical areas where experience has demonstrated a specific need, approved naturally durable or pressure-preservative-treated wood shall be used for those portions of wood members that form the structural supports of buildings, balconies, porches or similar permanent building appurtenances when those members are exposed to the weather without adequate protection from a roof, eave, overhang or other covering that would
prevent moisture or water accumulation on the surface or at joints between members. Depending on local experience, such members may include:

1. Horizontal members such as girders, joists and decking.
2. Vertical members such as posts, poles and columns.
3. Both horizontal and vertical members.

R317.1.4 Wood columns.
Wood columns shall be approved wood of natural decay resistance or approved pressure-preservative-treated wood.

Exceptions:

1. Columns exposed to the weather or in basements where supported by concrete piers or metal pedestals projecting 1 inch (25 mm) above a concrete floor or 6 inches (152 mm) above exposed earth and the earth is covered by an approved impervious moisture barrier.

2. Columns in enclosed crawl spaces or unexcavated areas located within the periphery of the building when supported by a concrete pier or metal pedestal at a height more than 8 inches (203 mm) from exposed earth and the earth is covered by an impervious moisture barrier.

3. Deck posts supported by concrete piers or metal pedestals projecting not less than 1 inch (25 mm) above a concrete floor or 6 inches (152 mm) above exposed earth.

1. Columns in basements when supported by a concrete floor with an approved impervious moisture barrier installed between the slab and earth.

2. Columns exposed to the weather when all of the following conditions are met:
   a. The column is supported by piers or metal pedestals projecting 1 inch (25.4 mm) above a concrete floor or 6 inches (152 mm) above exposed earth and the earth is covered by an approved impervious moisture barrier; and
   b. There are no joints in or between structural members (from the header to the base of the column); and
   c. The column is protected from exposure to surface moisture at the top by a roof, eave, or overhang; and
   d. The exterior surface of the column is fully sealed (paint, sealer, etc.) against moisture intrusion.

3. Columns in enclosed crawl spaces or unexcavated areas located within the periphery of the building when supported by a concrete pier or metal pedestal at a
height more than 8 inches (203 mm) from exposed earth and the earth is covered by an impervious moisture barrier.

**R317.1.5 Exposed glued-laminated timbers.**
The portions of glued-laminated timbers that form the structural supports of a building or other structure and are exposed to weather and not properly protected by a roof, eave or similar covering shall be pressure treated with preservative, or be manufactured from naturally durable or preservative-treated wood.

**R317.2 Quality mark.**
Lumber and plywood required to be pressure-preservative treated in accordance with Section R318.1 shall bear the quality mark of an approved inspection agency that maintains continuing supervision, testing and inspection over the quality of the product and that has been approved by an accreditation body that complies with the requirements of the American Lumber Standard Committee treated wood program.

**R317.2.1 Required information.**
The required quality mark on each piece of pressure-preservative-treated lumber or plywood shall contain the following information:

1. Identification of the treating plant.
2. Type of preservative.
3. The minimum preservative retention.
4. End use for which the product was treated.
5. Standard to which the product was treated.
6. Identity of the approved inspection agency.
7. The designation “Dry,” if applicable.

**Exception:** Quality marks on lumber less than 1 inch (25 mm) nominal thickness, or lumber less than nominal 1 inch by 5 inches (25 mm by 127 mm) or 2 inches by 4 inches (51 mm by 102 mm) or lumber 36 inches (914 mm) or less in length shall be applied by stamping the faces of exterior pieces or by end labeling not less than 25 percent of the pieces of a bundled unit.

**R317.3 Fasteners and connectors in contact with preservative-treated and fire-retardant-treated wood.**
Fasteners, including nuts and washers, and connectors in contact with preservative-treated wood and fire-retardant-treated wood shall be in accordance with this section. The coating weights for zinc-coated fasteners shall be in accordance with ASTM A 153. Stainless steel driven fasteners shall be in accordance with the material requirements of ASTM F 1667.

**R317.3.1 Fasteners for preservative-treated wood.**
Fasteners, including nuts and washers, for preservative-treated wood shall be of hot-dipped, zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Coating types and
weights for connectors in contact with preservative-treated wood shall be in accordance with the connector manufacturer's recommendations. In the absence of manufacturer’s recommendations, a minimum of ASTM A 653 type G185 zinc-coated galvanized steel, or equivalent, shall be used.

Exceptions:

1. \( \frac{1}{2} \)-inch-diameter (12.7 mm) or greater steel bolts.

2. Fasteners other than nails and timber rivets shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B 695, Class 55 minimum.

3. Plain carbon steel fasteners in SBX/DOT and zinc borate preservative-treated wood in an interior, dry environment shall be permitted.

R317.3.2 Fastenings for wood foundations.
Fastenings, including nuts and washers, for wood foundations shall be as required in AF&PA PWF.

R317.3.3 Fasteners for fire-retardant-treated wood used in exterior applications or wet or damp locations.
Fasteners, including nuts and washers, for fire-retardant-treated wood used in exterior applications or wet or damp locations shall be of hot-dipped, zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Fasteners other than nails and timber rivets shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B 695, Class 55 minimum.

R317.3.4 Fasteners for fire-retardant-treated wood used in interior applications.
Fasteners, including nuts and washers, for fire-retardant-treated wood used in interior locations shall be in accordance with the manufacturer’s recommendations. In the absence of the manufacturer’s recommendations, Section R317.3.3 shall apply.

R317.4 Plastic composites.
Plastic composite exterior deck boards, stair treads, guards and handrails containing wood, cellulosic or other biodegradable materials shall comply with the requirements of Section R602.11 ASTM D 7032.

SECTION R318
PROTECTION AGAINST SUBTERRANEAN TERMITES

R318.1 Subterranean termite control methods.
In areas subject to damage from termites as indicated by Table R301.2(1), methods of protection shall be one, or a combination, of the following methods:

1. Chemical termiticide treatment in accordance with Section R318.2.

2. Termite baiting system installed and maintained in accordance with the label.
3. Pressure-preservative-treated wood in accordance with the provisions of Section R317.1.


5. Physical barriers in accordance with Section R318.3 and used in locations as specified in Section R317.1.

6. Cold-formed steel framing in accordance with Sections R505.2.1 and R603.2.1—Deleted.

**R318.1.1 Quality mark.**
Lumber and plywood required to be pressure-preservative treated in accordance with Section R318.1 shall bear the quality mark of an approved inspection agency that maintains continuing supervision, testing and inspection over the quality of the product and that has been approved by an accreditation body that complies with the requirements of the American Lumber Standard Committee treated wood program.

**R318.1.2 Field treatment.** Deleted.
Field-cut ends, notches and drilled holes of pressure-preservative treated wood shall be retreated in the field in accordance with AWPA M4.

**R318.2 Chemical termiticide soil treatment.**
Chemical termiticide treatment shall include soil treatment or field-applied wood treatment. The concentration, rate of application and method of treatment of the chemical termiticide shall be in strict accordance with the termiticide label and applied according to the standards of the North Carolina Department of Agriculture.

**R318.3 Barriers.**
Approved physical barriers, such as metal or plastic sheeting or collars specifically designed for termite prevention, shall be installed in a manner to prevent termites from entering the structure. Shields placed on top of an exterior foundation wall are permitted to be used only if in combination with another method of protection.

**R318.4 Foam plastic protection.**
This section shall apply to both treated and untreated foam plastic. In areas where the probability of termite infestation is “very heavy” as indicated in Figure R301.2(6), extruded and expanded polystyrene, polyisocyanurate and other foam plastics shall not be installed on the exterior face or under interior or exterior foundation walls or slab foundations located below grade. The clearance between foam plastics installed above grade and exposed earth shall be not less than 6 inches (152 mm).

**Exceptions:**

1. Buildings where the structural members of walls, floors, ceilings and roofs are entirely of noncombustible materials or pressure-preservative-treated wood.

2. Where in addition to the requirements of Section R318.1, an approved method of protecting the foam plastic and structure from subterranean termite damage is used.

3. On the interior side of basement walls.
R318.4.1 Foundation walls.
All foam plastic shall be a minimum of 8 inches (203 mm) above grade. See Appendix O.

Exception: Foam plastic less than 8 inches (203 mm) above or in contact with grade shall be installed in accordance with Section 318.4.5 and Appendix O.

R318.4.2 Termite control.
When foam plastic is in contact with the ground, subterranean termite control shall be in accordance with Section 318.1.

R318.4.3 Slab on grade (non-structural).
Foam plastic shall be installed along the vertical edge and underneath the slab as specified in Section R318.4.5.

R318.4.4 Slab on grade (structural).
All slabs which distribute the wall loads to the foundation shall be insulated as specified in this section. Foam plastic shall be installed along the vertical edge and underneath grade as specified in Appendix O, Figure O-3.

R318.4.5 Foam plastic in contact with ground.
Foam plastic in contact with the ground shall comply with Sections R318.4.5.1 through R318.4.5.4.

R318.4.5.1 Inspection and treatment gaps.
Foam plastic in contact with the ground shall not be continuous to the bottom of the weather-resistant siding. A clear and unobstructed 2-inch (51 mm) minimum inspection gap shall be maintained from the bottom of the weather-resistant siding to the top of any foam plastic. A minimum 4-inch (102 mm) treatment gap shall be provided beginning not more than 6 inches (152 mm) below grade. The top and bottom edges of the foam plastic installed between the inspection gap and the treatment gap shall be cut at a 45-degree (0.79 rad) angle. See Appendix O. For additional requirements for ICF foundations see Section R404.1.3.3.6.1.

R318.4.5.2 Protection of exposed foam plastic.
Exposed foam plastic shall be protected from physical damage. The required inspection gap foam plastic and treatment gap shall be on the exterior with a cementitious coating that extends at least 2 inches (51 mm) below the foam plastic onto the surface of the foundation wall. See Appendix O.

R318.4.5.3 Waterproofing foam plastic between inspection gap and treatment gap.
Waterproofing shall be installed over the required cementitious coating from 6 inches (152 mm) above grade to the treatment gap per manufacturer’s installation instructions.

R318.4.5.4 Dampproofing of below grade walls.
Any foam plastic applied below the treatment gap shall be installed after required foundation wall dampproofing is in place. See Section R406 and Appendix O.

SECTION R319
SITE ADDRESS
R319.1 Address identification.
Buildings shall be provided with approved address identification. The address identification shall be legible and placed in a position that is visible from the street or road fronting the property. Address identification characters shall contrast with their background. Address numbers shall be Arabic numbers or alphabetical letters. Numbers shall not be spelled out. Each character shall be not less than 4 inches (102 mm) in height with a stroke width of not less than 0.5 inch (12.7 mm). Where required by the fire code official, address identification shall be provided in additional approved locations to facilitate emergency response. Where access is by means of a private road and the building address cannot be viewed from the public way, a monument, pole or other sign or means shall be used to identify the structure. Address identification shall be maintained.

SECTION R320
ACCESSIBILITY

R320.1 Scope.
Where there are four or more dwelling units or sleeping units in a single structure, the provisions of Chapter 11 of the International Building Code for Group R-3 shall apply.

R320.1.1 Guestrooms. Deleted.
A dwelling with guestrooms shall comply with the provisions of Chapter 11 of the International Building Code for Group R-3. For the purpose of applying the requirements of Chapter 11 of the International Building Code, guestrooms shall be considered to be sleeping units.

Exception: Owner-occupied lodging houses with five or fewer guestrooms constructed in accordance with the International Residential Code are not required to be accessible.

SECTION R321
ELEVATORS AND PLATFORM LIFTS

R321.1 Elevators.
Where provided, passenger elevators, limited-use and limited-application elevators or private residence elevators shall comply with ASME A17.1/CSA B44.

R321.2 Platform lifts.
Where provided, platform lifts shall comply with ASME A18.1.

R321.3 Accessibility. Deleted.
Elevators or platform lifts that are part of an accessible route required by Chapter 11 of the International Building Code, shall comply with ICC A117.1.

R321.4 Certification.
The installer shall certify that the following conditions have been met:

1. The elevator or platform lift has been installed in accordance with the manufacturer’s installation instructions.

2. The elevator meets the requirements of ASME A17.1, Part 5, Section 5.3 and other applicable parts.
3. The elevator or platform lift meets the requirements of the North Carolina Electrical Code. Before a Certificate of Occupancy is issued, the permit holder shall provide the code enforcement official a letter of certification from the installer, evidencing compliance with the above conditions. Any maintenance requirements required by the manufacturer shall be stated and affixed to the component. When an elevator or platform lift or its components has been serviced, the service provider shall certify to the owner that the elevator continues to meet the above conditions.

SECTION R322
FLOOD-RESISTANT CONSTRUCTION

R322.1 General.
Buildings and structures constructed in whole or in part in flood hazard areas, including A or V Zones and Coastal A Zones, as established in Table R301.2(1), and substantial improvement and restoration of substantial damage of buildings and structures in flood hazard areas, shall be designed and constructed in accordance with the provisions contained in this section. Buildings and structures that are located in more than one flood hazard area shall comply with the provisions associated with the most restrictive flood hazard area. Buildings and structures located in whole or in part in identified floodways shall be designed and constructed in accordance with ASCE 24. See additional provisions in Chapter 46.

R322.1.1 Alternative provisions.
As an alternative to the requirements in Section R322, ASCE 24 is permitted subject to the limitations of this code and the limitations therein.

R322.1.2 Structural systems.
Structural systems of buildings and structures shall be designed, connected and anchored to resist flotation, collapse or permanent lateral movement due to structural loads and stresses from flooding equal to the design flood elevation.

R322.1.3 Flood-resistant construction.
Buildings and structures erected in areas prone to flooding shall be constructed by methods and practices that minimize flood damage.

R322.1.4 Establishing the design flood elevation.
The design flood elevation shall be used to define flood hazard areas. At a minimum, the design flood elevation shall be the higher of the following:

1. The base flood elevation at the depth of peak elevation of flooding, including wave height, that has a 1 percent (100-year flood) or greater chance of being equaled or exceeded in any given year; or

2. The elevation of the design flood associated with the area designated on a flood hazard map adopted by the community, or otherwise legally designated.

R322.1.4.1 Determination of design flood elevations.
If design flood elevations are not specified, the building official is authorized to require the applicant to comply with either of the following:
1. Obtain and reasonably use data available from a federal, state or other source; or

2. Determine the design flood elevation in accordance with accepted hydrologic and hydraulic engineering practices used to define special flood hazard areas. Determinations shall be undertaken by a registered design professional who shall document that the technical methods used reflect currently accepted engineering practice. Studies, analyses and computations shall be submitted in sufficient detail to allow thorough review and approval.

R322.1.4.2 Determination of impacts.
In riverine flood hazard areas where design flood elevations are specified but floodways have not been designated, the applicant shall demonstrate that the effect of the proposed buildings and structures on design flood elevations, including fill, when combined with other existing and anticipated flood hazard area encroachments, will not increase the design flood elevation more than 1 foot (305 mm) at any point within the jurisdiction.

R322.1.5 Lowest floor.
The lowest floor shall be the lowest floor of the lowest enclosed area, including basement, and excluding any unfinished flood-resistant enclosure that is useable solely for vehicle parking, building access or limited storage provided that such enclosure is not built so as to render the building or structure in violation of this section.

R322.1.6 Protection of mechanical, plumbing and electrical systems.
Electrical systems, equipment and components; heating, ventilating, air conditioning; plumbing appliances and plumbing fixtures; duct systems; and other service equipment shall be located at or above the elevation required in Section R322.2 or R322.3. If replaced as part of a substantial improvement, electrical systems, equipment and components; heating, ventilating, air conditioning and plumbing appliances and plumbing fixtures; duct systems; and other service equipment shall meet the requirements of this section. Systems, fixtures, and equipment and components shall not be mounted on or penetrate through walls intended to break away under flood loads.

Exception: Locating electrical systems, equipment and components; heating, ventilating, air conditioning; plumbing appliances and plumbing fixtures; duct systems; and other service equipment is permitted below the elevation required in Section R322.2 or R322.3 provided that they are designed and installed to prevent water from entering or accumulating within the components and to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the design flood elevation in accordance with ASCE 24. Electrical wiring systems are permitted to be located below the required elevation provided that they conform to the provisions of the electrical part of this code for wet locations.

R322.1.7 Protection of water supply and sanitary sewage systems.
New and replacement water supply systems shall be designed to minimize or eliminate infiltration of flood waters into the systems in accordance with the plumbing provisions of this code. New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of floodwaters into systems and discharges from systems into
floodwaters in accordance with the plumbing provisions of this code and Chapter 3 of the International Private Sewage Disposal Code.

R322.1.8 Flood-resistant materials.
Building materials and installation methods used for flooring and interior and exterior walls and wall coverings below the elevation required in Section R322.2 or R322.3 shall be flood damage-resistant materials that conform to the provisions of FEMA TB-2.

R322.1.9 Manufactured homes.
The bottom of the frame of new and replacement manufactured homes on foundations that conform to the requirements of Section R322.2 or R322.3, as applicable, shall be elevated to or above the elevations specified in Section R322.2 (flood hazard areas including A Zones) or R322.3 in coastal high-hazard areas (V Zones and Coastal A Zones). The anchor and tie-down requirements of the applicable state or federal requirements shall apply. The foundation and anchorage of manufactured homes to be located in identified floodways shall be designed and constructed in accordance with ASCE 24.

R322.1.10 As-built elevation documentation.
A registered design professional shall prepare and seal documentation of the elevations specified in Section R322.2 or R322.3.

R322.2 Flood hazard areas (including A Zones).
Areas that have been determined to be prone to flooding and that are not subject to high-velocity wave action shall be designated as flood hazard areas. Flood hazard areas that have been delineated as subject to wave heights between \(1 \frac{1}{2}\) feet (457 mm) and 3 feet (914 mm) or otherwise designated by the jurisdiction shall be designated as Coastal A Zones and are subject to the requirements of Section R322.3. Buildings and structures constructed in whole or in part in flood hazard areas shall be designed and constructed in accordance with Sections R322.2.1 through R322.2.3.

R322.2.1 Elevation requirements.

1. Buildings and structures in flood hazard areas, including flood hazard areas designated as Coastal A Zones, shall have the lowest floors elevated to or above the base flood elevation plus 1 foot (305 mm), or the design flood elevation.

2. In areas of shallow flooding (AO Zones), buildings and structures shall have the lowest floor (including basement) elevated to a height of not less than the highest adjacent grade as the depth number specified in feet (mm) on the FIRM plus 1 foot (305 mm), or not less than 3 feet (15 mm) if a depth number is not specified.

3. Basement floors that are below grade on all sides shall be elevated to or above base flood elevation plus 1 foot (305 mm), or the design flood elevation, whichever is higher.

Exception: Enclosed areas below the design flood elevation, including basements with floors that are not below grade on all sides, shall meet the requirements of Section R322.2.2.
R322.2.2 Enclosed area below design flood elevation.
Enclosed areas, including crawl spaces, that are below the design flood elevation shall:

1. Be used solely for parking of vehicles, building access or storage.

2. Be provided with flood openings that meet the following criteria and are installed in accordance with Section R322.2.2.1:
   
   2.1. The total net area of openings shall be not less than 1 square inch (645 mm²) for each square foot (0.093 m²) of enclosed area where the enclosed area is measured on the exterior of the enclosure walls, or the openings shall be designed as engineered openings and the construction documents shall include a statement by a registered design professional that the design of the openings will provide for equalization of hydrostatic flood forces on exterior walls by allowing for the automatic entry and exit of floodwaters as specified in Section 2.6.2.2 of ASCE 24.

   2.2. Openings shall be no less than 3 inches (76 mm) in any direction in the plane of the wall.

R322.2.2.1 Installation of openings.
The walls of enclosed areas shall have openings installed such that:

1. There shall be not less than two openings on different sides of each enclosed area; if a building has more than one enclosed area below the design flood elevation, each area shall have openings on exterior walls.

2. The bottom of each opening shall be not more than 1 foot (305 mm) above the higher of the final interior grade or floor and the finished exterior grade immediately under each opening.

3. Openings shall be permitted to be installed in doors and windows; doors and windows without installed openings do not meet the requirements of this section.

R322.2.3 Foundation design and construction.
Foundation walls for buildings and structures erected in flood hazard areas shall meet the requirements of Chapter 4.

Exception: Unless designed in accordance with Section R404:

1. The unsupported height of 6-inch (152 mm) plain masonry walls shall be not more than 3 feet (914 mm).

2. The unsupported height of 8-inch (203 mm) plain masonry walls shall be not more than 4 feet (1219 mm).

3. The unsupported height of 8-inch (203 mm) reinforced masonry walls shall be not more than 8 feet (2438 mm).
For the purpose of this exception, unsupported height is the distance from the finished grade of the under-floor space to the top of the wall.

R322.2.4 Tanks. Deleted.
Underground tanks shall be anchored to prevent flotation, collapse and lateral movement under conditions of the base flood. Above-ground tanks shall be installed at or above the elevation required in Section R322.2.1 or shall be anchored to prevent flotation, collapse and lateral movement under conditions of the base flood.

R322.3 Coastal high-hazard areas (including V Zones and Coastal A Zones, where designated).
Areas that have been determined to be subject to wave heights in excess of 3 feet (914 mm) or subject to high-velocity wave action or wave-induced erosion shall be designated as coastal high-hazard areas. Flood hazard areas that have been designated as subject to wave heights between $1 \frac{1}{2}$ feet (457 mm) and 3 feet (914 mm) or otherwise designated by the jurisdiction shall be designated as Coastal A Zones. Buildings and structures constructed in whole or in part in coastal high-hazard areas and coastal A Zones, where designated, shall be designed and constructed in accordance with Sections R322.3.1 through R322.3.7.

R322.3.1 Location and site preparation. Deleted.

1. New buildings and buildings that are determined to be substantially improved pursuant to Section R105.3.1.1 shall be located landward of the reach of mean high tide.

2. For any alteration of sand dunes and mangrove stands, the building official shall require submission of an engineering analysis that demonstrates that the proposed alteration will not increase the potential for flood damage.

R322.3.2 Elevation requirements.

1. Buildings and structures erected within coastal high-hazard areas and Coastal A Zones, shall be elevated so that the bottom of the lowest portion of horizontal structural members supporting the lowest floor, with the exception of piling, pile caps, columns, grade beams and bracing, is elevated to or above the base flood elevation plus 1 foot (305 mm) or the design flood elevation, whichever is higher.

2. Basement floors that are below grade on all sides are prohibited.

3. The use of fill for structural support is prohibited.

4. Minor grading, and the placement of minor quantities of fill, shall be permitted for landscaping and for drainage purposes under and around buildings and for support of parking slabs, pool decks, patios and walkways.

5. Walls and partitions enclosing areas below the design flood elevation shall meet the requirements of Sections R322.3.4 and R322.3.5.

R322.3.3 Foundations.
Buildings and structures erected in coastal high-hazard areas and Coastal A Zones shall be
supported on pilings or columns and shall be adequately anchored to such pilings or columns. The space below the elevated building shall be either free of obstruction or, if enclosed with walls, the walls shall meet the requirements of Section R322.3.4. Pilings shall have adequate soil penetrations to resist the combined wave and wind loads (lateral and uplift). Water-loading values used shall be those associated with the design flood. Wind-loading values shall be those required by this code. Pile embedment shall include consideration of decreased resistance capacity caused by scour of soil strata surrounding the piling. Pile systems design and installation shall be certified in accordance with Section R322.3.6. Spread footing, mat, raft or other foundations that support columns shall not be permitted where soil investigations that are required in accordance with Section R401.4 indicate that soil material under the spread footing, mat, raft or other foundation is subject to scour or erosion from wave-velocity flow conditions. If permitted, spread footing, mat, raft or other foundations that support columns shall be designed in accordance with ASCE 24. Slabs, pools, pool decks and walkways shall be located and constructed to be structurally independent of buildings and structures and their foundations to prevent transfer of flood loads to the buildings and structures during conditions of flooding, scour or erosion from wave-velocity flow conditions, unless the buildings and structures and their foundations are designed to resist the additional flood load.

**Exception:** In Coastal A Zones, stem wall foundations supporting a floor system above and backfilled with soil or gravel to the underside of the floor system shall be permitted provided the foundations are designed to account for wave action, debris impact, erosion and local scour. Where soils are susceptible to erosion and local scour, stem wall foundations shall have deep footings to account for the loss of soil.

R322.3.4 Walls below design flood elevation.
Walls and partitions are permitted below the elevated floor, provided that such walls and partitions are not part of the structural support of the building or structure and:

1. Electrical, mechanical and plumbing system components are not to be mounted on or penetrate through walls that are designed to break away under flood loads; and

2. Are constructed with insect screening or open lattice; or

3. Are designed to break away or collapse without causing collapse, displacement or other structural damage to the elevated portion of the building or supporting foundation system. Such walls, framing and connections shall have a resistance of not less than 10 (479 Pa) and not more than 20 pounds per square foot (958 Pa) as determined using allowable stress design; or

4. Where wind loading values of this code exceed 20 pounds per square foot (958 Pa), the construction documents shall include documentation prepared and sealed by a registered design professional that:

   4.1. The walls and partitions below the design flood elevation have been designed to collapse from a water load less than that which would occur during the base flood.

   4.2. The elevated portion of the building and supporting foundation system have been designed to withstand the effects of wind and flood loads acting
simultaneously on structural and nonstructural building components. Water-loading values used shall be those associated with the design flood. Wind-loading values shall be those required by this code.

5. Walls intended to break away under flood loads as specified in Item 3 or 4 have flood openings that meet the criteria in Section R322.2.2, Item 2.

6. In Coastal A Zones, walls shall be provided with flood openings that meet the criteria of Section R322.2.2.

R322.3.5 Enclosed areas below design flood elevation.
Enclosed areas below the design flood elevation shall be used solely for parking of vehicles, building access or storage.

R322.3.5.1 Protection of building envelope. Deleted.
An exterior door that meets the requirements of Section R609 shall be installed at the top of stairs that provide access to the building and that are enclosed with walls designed to break away in accordance with Section R322.3.4.

R322.3.6 Construction documents.
The construction documents shall include documentation that is prepared and sealed by a registered design professional that the design and methods of construction to be used meet the applicable criteria of this section.

Exception: Piers and docks meeting the requirements of Section R327.

R322.3.7 Tanks. Deleted.
Underground tanks shall be anchored to prevent flotation, collapse and lateral movement under conditions of the base flood. Above-ground tanks shall be installed at or above the elevation required in Section R322.3.2. Where elevated on platforms, the platforms shall be cantilevered from or knee braced to the building or shall be supported on foundations that conform to the requirements of Section R322.3.

SECTION R323
STORM SHELTERS

R323.1 General.
This section applies to storm shelters where constructed as separate detached buildings or where constructed as safe rooms within buildings for the purpose of providing refuge from storms that produce high winds, such as tornados and hurricanes. In addition to other applicable requirements in this code, storm shelters shall be constructed in accordance with ICC/NSSA-500.

SECTION 324
SOLAR ENERGY SYSTEMS

R324.1 General.
Solar energy systems shall comply with the provisions of this section.
R324.2 Solar thermal systems.
Solar thermal systems shall be designed and installed in accordance with Chapter 23 and the International Fire Code.

R324.3 Photovoltaic systems.
Photovoltaic systems shall be designed and installed in accordance with Sections R324.3.1 through R324.7.2.5 and NFPA 70. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

R324.3.1 Equipment listings.
Photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703.

R324.4 Rooftop-mounted photovoltaic systems. Deleted.
Rooftop-mounted photovoltaic panel systems installed on or above the roof covering shall be designed and installed in accordance with Section R907.

R324.4.1 Roof live load.
Roof structures that provide support for photovoltaic panel systems shall be designed for applicable roof live load. The design of roof structures need not include roof live load in the areas covered by photovoltaic panel systems. Portions of roof structures not covered by photovoltaic panels shall be designed for roof live load. Roof structures that provide support for photovoltaic panel systems shall be designed for live load, $L_{R}$, for the load case where the photovoltaic panel system is not present.

R324.5 Building-integrated photovoltaic systems. Deleted.
Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Section R905.

R324.5.1 Photovoltaic shingles.
Photovoltaic shingles shall comply with Section R905.16.

R324.6 Ground-mounted photovoltaic systems.
Ground-mounted photovoltaic systems shall be designed and installed in accordance with Section R301.

R324.6.1 Fire separation distances.
Ground-mounted photovoltaic systems shall be subject to the fire separation distance requirements determined by the local jurisdiction.

R324.7 Access and pathways.
Roof access, pathways and spacing requirements shall be provided in accordance with Sections R324.7.1 through R324.7.2.5.

Exceptions:

1. Detached garages and accessory structures to one-and two-family dwellings and townhouses, such as parking shade structures, carports, solar trellises and similar structures.
2. Roof access, pathways and spacing requirements need not be provided where an alternative ventilation method approved by the code official has been provided or where the code official has determined that vertical ventilation techniques will not be employed.

R324.7.1 Roof access points.
Roof access points shall be located in areas that do not require the placement of ground ladders over openings such as windows or doors, and located at strong points of building construction in locations where the access point does not conflict with overhead obstructions such as tree limbs, wires or signs.

R324.7.2 Solar photovoltaic systems.
Solar photovoltaic systems shall comply with Sections R324.7.2.1 through R324.7.2.5.

R324.7.2.1 Size of solar photovoltaic array.
Each photovoltaic array shall be limited to 150 feet by 150 feet (45 720 by 45 720 mm). Multiple arrays shall be separated by a clear access pathway not less than 3 feet (914 mm) in width.

R324.7.2.2 Hip roof layouts.
Panels and modules installed on dwellings with hip roof layouts shall be located in a manner that provides a clear access pathway not less than 3 feet (914 mm) in width from the eave to the ridge on each roof slope where panels and modules are located. The access pathway shall be located at a structurally strong location on the building capable of supporting the live load of fire fighters accessing the roof.

Exception: These requirements shall not apply to roofs with slopes of 2 units vertical in 12 units horizontal (16.6 percent) and less.

R324.7.2.3 Single ridge roofs.
Panels and modules installed on dwellings with a single ridge shall be located in a manner that provides two, 3-foot-wide (914 mm) access pathways from the eave to the ridge on each roof slope where panels or modules are located.

Exception: This requirement shall not apply to roofs with slopes of 2 units vertical in 12 units horizontal (16.6 percent) and less.

R324.7.2.4 Roofs with hips and valleys.
Panels and modules installed on dwellings with roof hips or valleys shall not be located less than 18 inches (457 mm) from a hip or valley where panels or modules are to be placed on both sides of a hip or valley. Where panels are to be located on one side only of a hip or valley that is of equal length, the 18-inch (457 mm) clearance does not apply.

Exception: These requirements shall not apply to roofs with slopes of 2 units vertical in 12 units horizontal (16.6 percent) and less.

R324.7.2.5 Allowance for smoke ventilation operations.
Panels and modules installed on dwellings shall not be located less than 3 feet (914 mm) below the roof ridge to allow for fire department smoke ventilation operations.
Exception: Where an alternative ventilation method approved by the code official has been provided or where the code official has determined that vertical ventilation techniques will not be employed, clearance from the roof ridge is not required.

SECTION R325
MEZZANINES

R325.1 General.
Mezzanines shall comply with Section R325.

R325.2 Mezzanines.
The clear height above and below mezzanine floor construction shall be not less than 7 feet (2134 mm).

R325.3 Area limitation.
The aggregate area of a mezzanine or mezzanines shall be not greater than one-third of the floor area of the room or space in which they are located. The enclosed portion of a room shall not be included in a determination of the floor area of the room in which the mezzanine is located.

R325.4 Means of egress.
The means of egress for mezzanines shall comply with the applicable provisions of Section R311.

R325.5 Openness.
Mezzanines shall be open and unobstructed to the room in which they are located except for walls not more than 42 inches (1067 mm) in height, columns and posts.

Exceptions:

1. Mezzanines or portions thereof are not required to be open to the room in which they are located, provided that the aggregate floor area of the enclosed space is not greater than 10 percent of the mezzanine area.

2. In buildings that are not more than two stories above grade plane and equipped throughout with an automatic sprinkler system in accordance with NFPA 13R or NFPA 13D, a mezzanine having two or more means of egress shall not be required to be open to the room in which the mezzanine is located.

SECTION R326
SWIMMING POOLS, SPAS AND HOT TUBS

R326.1 General.
The design and construction of pools and spas shall comply with Appendix V, the International Swimming Pool and Spa Code.

SECTION R327
DOCKS, PIERS, BULKHEADS AND WATERWAY STRUCTURES

R327.1 General.
Docks, piers, bulkheads and waterway structures shall be constructed in accordance with Chapter 36 of the North Carolina Building Code.

Exception: Structures complying with the following are not required to meet the provisions of Chapter 36 of the North Carolina Building Code or this code.

1. Fixed piers associated with a one- or two-family dwelling meeting all of the following:
   1.1 A maximum of four boat slips for a single owner of a one- or two-family dwelling or two adjacent, riparian owners.
   1.2 A maximum height of 15 feet (4572 mm) measured from deck to mud line at any location along the pier.
   1.3 A maximum normal pool depth of 13 feet (3962 mm) on lakes and ponds and a maximum mean low water depth of 7 feet (2134 mm) in other locations.
   1.4 A maximum walkway width of 6 feet (1829 mm).
   1.5 A maximum pile spacing of 8 feet (2438 mm), in both directions.
   1.6 A maximum of 576 sq. ft. (53.5 m²) for non-walkways areas.
   1.7 A maximum boat slip length of 40 feet (12.2 m).
   1.8 A maximum roofed area of 576 sq. ft. (53.5 m²) with an additional maximum 2 foot (610 mm) overhang.
   1.9 Constructed with no enclosed or multilevel structures.
   1.10 Supports a boatlift with a maximum design capacity no greater than 16,000 pounds (71.2 kN).

2. Floating docks associated with a one- or two-family dwelling meeting all of the following:
   2.1 A maximum of four boat slips for a single owner of a one- or two-family dwelling or two adjacent, riparian owners.
   2.2 A maximum normal pool depth of 20 feet (6096 mm) for docks with guide piles on lakes and ponds and a maximum mean low water of 10 feet (3048 mm) for docks with guide piles in other locations.
   2.3 A maximum boat slip length of 40 feet (12.2 m).
   2.4 Finger piers, crosswalks or other floating surfaces having a minimum width of 3 feet (914 mm) wide to a maximum of 6 feet (1829 mm) wide, except for a single 8 foot x 16 foot (2438 mm x 4877 mm) section.
   2.5 When constructed with a roof the following conditions exist:
      i. Ultimate design wind speed is 115 mph (51 m/s) or less;
ii. Roof load is 20 psf (0.96 kPa) or less;
iii. A maximum eave height of 10 feet (3048 mm);
iv. A maximum roof slope of 4:12;
v. A maximum roofed area of 576 sq. ft. (53.5 m²) with an additional maximum 2 foot (610 mm) overhang;
vi. A minimum boat slip width of 12 feet (3658 mm);

vii. A minimum floating dock width of 4 feet (1219 mm) along both sides of the boat slip;
viii. A maximum dead load of 12 psf (0.57 kPa);
ix. Floating structures supporting roof structures are balanced or anchored to reduce the possibility of tipping.

2.6 Constructed with no enclosed or multilevel structures.

2.7 Supports a boat lift with a maximum design capacity no greater than 16,000 pounds (71.2 kN).
R401.1 Application.
The provisions of this chapter shall control the design and construction of the foundation and foundation spaces for buildings. In addition to the provisions of this chapter, the design and construction of foundations in flood hazard areas as established by Table R301.2(1) shall meet the provisions of Section R322. Wood foundations shall be designed and installed in accordance with AWC PWF.

Exception: The provisions of this chapter shall be permitted to be used for wood foundations only in the following situations:

1. In buildings that have no more than two floors and a roof.

2. When interior basement and foundation walls are constructed at intervals not exceeding 50 feet (15240 mm).

Wood foundations in Seismic Design Category D_0, D_1 or D_2 shall be designed in accordance with accepted engineering practice.

R401.2 Requirements.
Foundation construction shall be capable of accommodating all loads in accordance with Section R301 and of transmitting the resulting loads to the supporting soil. Fill soils that support footings and foundations shall be designed, installed and tested in accordance with accepted engineering practice. Gravel fill used as footings for wood and precast concrete foundations shall comply with Section R403.

R401.3 Drainage.
Surface drainage shall be diverted to a storm sewer conveyance or other approved point of collection that does not create a hazard. Lots shall be graded to drain surface water away from foundation walls. The grade shall fall a minimum of 6 inches (152 mm) within the first 10 feet (3048 mm).

Exception: Where lot lines, walls, slopes or other physical barriers prohibit 6 inches (152 mm) of fall within 10 feet (3048 mm), drains or swales shall be constructed to ensure
drainage away from the structure. Impervious surfaces within 10 feet (3048 mm) of the building foundation shall be sloped a minimum of 2 percent away from the building.

R401.4 Soil tests.
Where quantifiable data created by accepted soil science methodologies indicate expansive, compressible, shifting or other questionable soil characteristics are likely to be present, the building official shall determine whether to require a soil test to determine the soil’s characteristics at a particular location. This test shall be done by an approved agency using an approved method.

R401.4.1 Geotechnical evaluation.
In lieu of a complete geotechnical evaluation, the load-bearing values in Table R401.4.1 shall be assumed. The load bearing values greater than 2000 psf (95.8 kPa) in Table R401.4.1 require an engineering evaluation.

<table>
<thead>
<tr>
<th>CLASS OF MATERIAL</th>
<th>LOAD-BEARING PRESSURE (pounds per square foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalline bedrock</td>
<td>12,000</td>
</tr>
<tr>
<td>Sedimentary and foliated rock</td>
<td>4,000  6,000</td>
</tr>
<tr>
<td>Sandy gravel and/or gravel (GW and GP)</td>
<td>3,000  5,000</td>
</tr>
<tr>
<td>Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)</td>
<td>2,000  3,000</td>
</tr>
<tr>
<td>Clay, sandy, silty clay, clayey silt, silt and sandy silty clay (CL, ML, MH and CH)</td>
<td>1,500  2,000  b</td>
</tr>
</tbody>
</table>

For SI: 1 pound per square foot = 0.0479 kPa.

a. Where soil tests are required by Section R401.4, the allowable bearing capacities of the soil shall be part of the recommendations.

b. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 2,000 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

R401.4.2 Compressible or shifting soil.
Instead of a complete geotechnical evaluation, where top or subsoils are compressible or shifting, they shall be removed to a depth and width sufficient to ensure stable moisture content in each active zone and shall not be used as fill or stabilized within each active zone by chemical, dewatering or presaturation.

SECTION R402 MATERIALS

R402.1 Wood foundations.
Wood foundation systems shall be designed and installed in accordance with the provisions of this code.
R402.1.1 Fasteners.
Fasteners used below grade to attach plywood to the exterior side of exterior basement or crawlspace wall studs, or fasteners used in knee wall construction, shall be of Type 304 or 316 stainless steel. Fasteners used above grade to attach plywood and all lumber-to-lumber fasteners except those used in knee wall construction shall be of Type 304 or 316 stainless steel, silicon bronze, copper, hot-dipped galvanized (zinc coated) steel nails, or hot-tumbled galvanized (zinc coated) steel nails. Electro-galvanized steel nails and galvanized (zinc coated) steel staples shall not be permitted.

R402.1.2 Wood treatment.
All lumber and plywood shall be pressure-preservative treated and dried after treatment in accordance with AWPA U1 (Commodity Specification A, Use Category 4B and Section 5.2), and shall bear the label of an accredited agency. Where lumber and/or plywood is cut or drilled after treatment, the treated surface shall be field treated with copper naphthenate, the concentration of which shall contain a minimum of 2-percent copper metal, by repeated brushing, dipping or soaking until the wood absorbs no more preservative.

R402.2 Concrete.
Concrete shall have a minimum specified compressive strength of $f'_c$, as shown in Table R402.2. Concrete subject to moderate or severe weathering as indicated in Table R301.2(1) shall be air entrained as specified in Table R402.2. The maximum weight of fly ash, other pozzolans, silica fume, slag or blended cements that is included in concrete mixtures for garage floor slabs and for exterior porches, carport slabs and steps that will be exposed to deicing chemicals shall not exceed the percentages of the total weight of cementitious materials specified in Section 19.3.3.4 of ACI 318. Materials used to produce concrete and testing thereof shall comply with the applicable standards listed in Chapters 19 and 20 of ACI 318 or ACI 332.

**TABLE R402.2**

<table>
<thead>
<tr>
<th>TYPE OR LOCATION OF CONCRETE CONSTRUCTION</th>
<th>MINIMUM SPECIFIED COMPRESSIVE STRENGTH$^a$ ($f'_c$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weathering Potential$^b$</td>
</tr>
<tr>
<td></td>
<td>Negligible</td>
</tr>
<tr>
<td>Basement walls, foundations and other concrete not exposed to the weather</td>
<td>2,500</td>
</tr>
<tr>
<td>Basement slabs and interior slabs on grade, except garage floor slabs</td>
<td>2,500</td>
</tr>
<tr>
<td>Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather</td>
<td>2,500</td>
</tr>
<tr>
<td>Porches, carport slabs and steps exposed to the weather, and garage floor slabs</td>
<td>2,500</td>
</tr>
</tbody>
</table>

For SI: 1 pound per square inch = 6.895 kPa.

a. Strength at 28 days psi.

b. See Table R301.2(1) for weathering potential.

c. Concrete in these locations that is subject to freezing and thawing during construction shall be air-entrained concrete in accordance with Footnote d.

d. Concrete shall be air-entrained. Total air content (percent by volume of concrete) shall be not less than 5 percent or more than 7 percent.
e. See Section R402.2 for maximum cementitious materials content.

f. For garage floors with a steel-troweled finish, reduction of the total air content (percent by volume of concrete) to not less than 3 percent is permitted if the specified compressive strength of the concrete is increased to not less than 4,000 psi.

**R402.2.1 Materials for concrete.**

Materials for concrete shall comply with the requirements of Section R608.5.1.

**R402.3 Precast concrete.**

Precast concrete foundations shall be designed in accordance with Section R404.5 and shall be installed in accordance with the provisions of this code and the manufacturer’s instructions.

**R402.3.1 Precast concrete foundation materials.**

Materials used to produce precast concrete foundations shall meet the following requirements.

1. All concrete used in the manufacture of precast concrete foundations shall have a minimum compressive strength of 5,000 psi (34 470 kPa) at 28 days. Concrete exposed to a freezing and thawing environment shall be air entrained with a minimum total air content of 5 percent.

2. Structural reinforcing steel shall meet the requirements of ASTM A 615, A 706 or A 996. The minimum yield strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa). Steel reinforcement for precast concrete foundation walls shall have a minimum concrete cover of $$\frac{3}{4}$$ inch (19.1 mm).

3. Panel-to-panel connections shall be made with Grade II steel fasteners.

4. The use of nonstructural fibers shall conform to ASTM C 1116.

5. Grout used for bedding precast foundations placed upon concrete footings shall meet ASTM C 1107.

**R402.4 Masonry.**

Masonry systems shall be designed and installed in accordance with this chapter and shall have a minimum specified compressive strength of 1,500 psi (10.3 MPa).

**SECTION R403 FOOTINGS**

**R403.1 General.**

All exterior walls shall be supported on continuous solid or fully grouted masonry or concrete footings, crushed stone footings, wood foundations, or other approved structural systems which shall be of sufficient design to accommodate all loads according to Section R301 and to transmit the resulting loads to the soil within the limitations as determined from the character of the soil. Footings shall be supported on undisturbed natural soils or engineered fill. Concrete footing shall be designed and constructed in accordance with the provisions of Section R403 or in accordance with ACI 332. Discontinuous footings shall be permitted to be constructed in accordance with ACI 332 for concrete foundation walls and Appendix Q for masonry foundation walls.

2018 North Carolina Residential Code
**TABLE R403.1(1)**

**MINIMUM WIDTH OF CONCRETE, PRECAST OR MASONRY FOOTINGS (inches)**

<table>
<thead>
<tr>
<th>LOAD-BEARING VALUE OF SOIL (psf)</th>
<th>1,500</th>
<th>2,000</th>
<th>3,000</th>
<th>4,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional light-frame construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-story</td>
<td>12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>2-story</td>
<td>15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>3-story</td>
<td>23</td>
<td>17</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>4-inch brick veneer over light frame or 8-inch hollow concrete masonry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-story</td>
<td>12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>2-story</td>
<td>15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>3-story</td>
<td>32</td>
<td>24</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>5-inch solid or fully grouted masonry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-story</td>
<td>16</td>
<td>12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>2-story</td>
<td>29</td>
<td>21</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>3-story</td>
<td>42</td>
<td>32</td>
<td>21</td>
<td>16</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Where minimum footing width is 12 inches, use of a single wythe of solid or fully grouted 12-inch nominal concrete masonry units is permitted.

b. A minimum footing width of 12 inches is acceptable for monolithic slab foundations.

**TABLE R403.1(2)**

**PIER<sup>a</sup> AND FOOTING<sup>b</sup> SIZES FOR SUPPORT OF GIRDER**

<table>
<thead>
<tr>
<th>Area&lt;sup&gt;e&lt;/sup&gt;</th>
<th>1 (ONE) STORY</th>
<th>2 (TWO) STORY</th>
<th>2- ½ (TWO &amp; ONE HALF) STORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pier&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>Footing</td>
<td>Pier&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>50</td>
<td>8” x 16”</td>
<td>1’-4” x 2’-0” x 8”</td>
<td>8” x 16”</td>
</tr>
<tr>
<td>100</td>
<td>8” x 16”</td>
<td>1’-4” x 2’-0” x 8”</td>
<td>8” x 16”</td>
</tr>
<tr>
<td>150</td>
<td>8” x 16”</td>
<td>2’-0” x 2’-0” x 8”</td>
<td>16” x 16”</td>
</tr>
<tr>
<td>200</td>
<td>8” x 16”</td>
<td>2’-4” x 2’-4” x 10”</td>
<td>16” x 16”</td>
</tr>
<tr>
<td>250</td>
<td>-</td>
<td>-</td>
<td>16” x 16”</td>
</tr>
<tr>
<td>300</td>
<td>-</td>
<td>-</td>
<td>16” x 16”</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Pier sizes are based on hollow CMU capped with 4 inches of solid masonry or concrete for 1 (one) story and 8 inches of solid masonry or concrete for 2 (two), 2 ½ (two and one half) or 3 (three) story houses or shall have cavities of the top course filled with concrete or grout or other approved methods. Mortar shall be Type S.A minimum footing width of 12 inches is acceptable for monolithic slab foundations.

b. Footing sizes are based on 2000 psf allowable soil bearing and 2500 psi concrete. This table is based upon the limitations of a tributary area using dimensional framing lumber only.
c. Centers of piers shall bear in the middle one-third of the footings. Girders must have full bearing on piers. Footings shall be full thickness over the entire area of the footing.
d. Pier sizes given are minimum. For height/thickness limitations see Section R606.7.
e. Area at first level supported by pier and footing in square feet.

### TABLE R403.1(1)
**MINIMUM WIDTH AND THICKNESS FOR CONCRETE FOOTINGS FOR LIGHT-FRAME CONSTRUCTION (inches)\(^{a,b}\)**

<table>
<thead>
<tr>
<th>Snow Load or Roof Live Load</th>
<th>Story and Type of Structure with Light Frame</th>
<th>Load-Bearing Value of Soil (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1500</td>
</tr>
<tr>
<td>20-psf</td>
<td>1-story—slab-on-grade</td>
<td>12 x 6</td>
</tr>
<tr>
<td></td>
<td>1-story—with crawl space</td>
<td>12 x 6</td>
</tr>
<tr>
<td></td>
<td>1-story—plus basement</td>
<td>18 x 6</td>
</tr>
<tr>
<td></td>
<td>2-story—slab-on-grade</td>
<td>12 x 6</td>
</tr>
<tr>
<td></td>
<td>2-story—with crawl space</td>
<td>16 x 6</td>
</tr>
<tr>
<td></td>
<td>2-story—plus basement</td>
<td>22 x 6</td>
</tr>
<tr>
<td></td>
<td>3-story—slab-on-grade</td>
<td>14 x 6</td>
</tr>
<tr>
<td></td>
<td>3-story—with crawl space</td>
<td>19 x 6</td>
</tr>
<tr>
<td></td>
<td>3-story—plus basement</td>
<td>25 x 6</td>
</tr>
</tbody>
</table>

| 30-psf                      | 1-story—slab-on-grade                      | 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 1-story—with crawl space                   | 13 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 1-story—plus basement                       | 19 x 6| 14 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 2-story—slab-on-grade                       | 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 2-story—with crawl space                   | 17 x 6| 13 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 2-story—plus basement                       | 23 x 6| 17 x 6| 14 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 3-story—slab-on-grade                       | 15 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 3-story—with crawl space                   | 20 x 6| 15 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 3-story—plus basement                       | 26 x 6| 20 x 6| 16 x 6| 13 x 6| 12 x 6| 12 x 6|

| 50-psf                      | 1-story—slab-on-grade                      | 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|
|                             | 1-story—with crawl space                   | 16 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6| 12 x 6|

---

\(^a\) Bearing value of soil based on the Code.
\(^b\) Values in the table are minimum values. Actual values may vary based on the specific conditions and design requirements.
<table>
<thead>
<tr>
<th>Snow Load or Roof Live Load</th>
<th>Story and Type of Structure with Brick Veneer</th>
<th>Load-Bearing Value of Soil (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1500</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>2500</td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>3500</td>
</tr>
<tr>
<td></td>
<td>3500</td>
<td>4000</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 plf = 14.6 N/m, 1 pound per square foot = 47.9 N/m².

a. Interpolation allowed. Extrapolation is not allowed.

b. Based on 32-foot wide house with load-bearing center wall that carries half of the tributary attic, and floor framing. For every 2 feet of adjustment to the width of the house, add or subtract 2 inches of footing width and 1 inch of footing thickness (but not less than 6 inches thick).

---

**TABLE R403.1(2)**

**MINIMUM WIDTH AND THICKNESS FOR CONCRETE FOOTINGS FOR LIGHT-FRAME CONSTRUCTION WITH BRICK VENEER (inches)\(^{a,b}\)**

<table>
<thead>
<tr>
<th>Story and Type of Structure</th>
<th>Minimum Width (inches)</th>
<th>Minimum Thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-story—plus basement</td>
<td>21 × 6</td>
<td>16 × 6</td>
</tr>
<tr>
<td>2-story—slab-on-grade</td>
<td>14 × 6</td>
<td>12 × 6</td>
</tr>
<tr>
<td>2-story—with crawl space</td>
<td>19 × 6</td>
<td>14 × 6</td>
</tr>
<tr>
<td>2-story—plus basement</td>
<td>25 × 7</td>
<td>19 × 6</td>
</tr>
<tr>
<td>3-story—slab-on-grade</td>
<td>17 × 6</td>
<td>13 × 6</td>
</tr>
<tr>
<td>3-story—with crawl space</td>
<td>22 × 6</td>
<td>17 × 6</td>
</tr>
<tr>
<td>3-story—plus basement</td>
<td>28 × 9</td>
<td>21 × 6</td>
</tr>
<tr>
<td>2-story—slab-on-grade</td>
<td>12 × 6</td>
<td>12 × 6</td>
</tr>
<tr>
<td>1-story—with crawl space</td>
<td>18 × 6</td>
<td>13 × 6</td>
</tr>
<tr>
<td>1-story—plus basement</td>
<td>24 × 7</td>
<td>18 × 6</td>
</tr>
<tr>
<td>2-story—slab-on-grade</td>
<td>16 × 6</td>
<td>12 × 6</td>
</tr>
<tr>
<td>2-story—with crawl space</td>
<td>21 × 6</td>
<td>16 × 6</td>
</tr>
<tr>
<td>2-story—plus basement</td>
<td>27 × 9</td>
<td>20 × 6</td>
</tr>
<tr>
<td>3-story—slab-on-grade</td>
<td>19 × 6</td>
<td>14 × 6</td>
</tr>
<tr>
<td>3-story—with crawl space</td>
<td>25 × 7</td>
<td>18 × 6</td>
</tr>
<tr>
<td>3-story—plus basement</td>
<td>30 × 10</td>
<td>23 × 6</td>
</tr>
</tbody>
</table>

---

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<table>
<thead>
<tr>
<th></th>
<th>1 story—slab-on-grade</th>
<th>1 story—slab-on-grade</th>
<th>1 story—slab-on-grade</th>
<th>1 story—slab-on-grade</th>
<th>1 story—slab-on-grade</th>
<th>1 story—slab-on-grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 psf</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
</tr>
<tr>
<td>30 psf</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
</tr>
<tr>
<td>50 psf</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
</tr>
<tr>
<td>70 psf</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
<td>12 x 6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 psf = 14.6 N/m, 1 pound per square foot = 47.9 N/m².
a—Interpolation allowed. Extrapolation is not allowed.

2018 North Carolina Residential Code
b. Based on 32-foot-wide house with load-bearing center wall that carries half of the tributary attic, and floor framing. For every 2 feet of adjustment to the width of the house, add or subtract 2 inches of footing width and 1 inch of footing thickness (but not less than 6 inches thick).

![Diagram of house types: slab on grade, crawl space, basement.]

**TABLE R403.1(3)**

**MINIMUM WIDTH AND THICKNESS FOR CONCRETE FOOTINGS WITH CAST-IN-PLACE CONCRETE OR FULLY GROUTED MASONRY WALL CONSTRUCTION (inches) **

<table>
<thead>
<tr>
<th>Snow Load or Roof-Live Load</th>
<th>Story and Type of Structure With CMU</th>
<th>Load-Bearing Value of Soil (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1500</td>
</tr>
<tr>
<td>20 psf</td>
<td>1-story—slab-on-grade</td>
<td>14 × 6</td>
</tr>
<tr>
<td></td>
<td>1-story—with crawl space</td>
<td>19 × 6</td>
</tr>
<tr>
<td></td>
<td>1-story—plus basement</td>
<td>25 × 8</td>
</tr>
<tr>
<td></td>
<td>2-story—slab-on-grade</td>
<td>23 × 7</td>
</tr>
<tr>
<td></td>
<td>2-story—with crawl space</td>
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<tr>
<td></td>
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### Table

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<thead>
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<td>21 x 6</td>
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<tr>
<td>3-story—plus basement</td>
<td>18 x 6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 plf = 14.6 N/m, 1 pound per square foot = 47.9 N/m².

**a.** Interpolation allowed. Extrapolation is not allowed.

**b.** Based on 32-foot-wide house with load-bearing center wall that carries half of the tributary attic, and floor framing. For every 2 feet of adjustment to the width of the house add or subtract 2 inches of footing width and 1 inch of footing thickness (but not less than 6 inches thick).

---

**NOTES:**

- See Section R404.3 for sill requirements.
b. See Section R403.1.6 for sill attachment.

c. See Section R506.2.3 for vapor barrier requirements.

d. See Section R403.1 for base.

e. See Figure R403.1.3 for additional footing requirements for structures in SDC D₀, D₁, and D₂, and townhouses in SDC C.

f. See Section R408 for under-floor ventilation and access requirements.

FIGURE R403.1(1)
PLAIN CONCRETE FOOTINGS WITH MASONRY AND CONCRETE STEM WALLS IN SDC A, B AND C

For SI: 1 inch = 25.4 mm.

W = Width of footing, T = Thickness of footing and P = Projection per Section R403.1.1

NOTES:
1. Foundations shall extend not less than 12 inches below finished grade and in no case less than the frost line depth.
2. Footing sizes are based on soil with an allowable soil pressure of 2,000 pounds per square foot. Footings on soil with a lower allowable soil pressure shall be designed in accordance with accepted engineering practice.
3. Footing projections shall not exceed the footing thickness.
4. For minimum footing width (W) see Table R403.1(1).
5. Minimum footing thickness (T) is .6" for 1 story, 8" for 2 story and 10" for 3 story.
6. Install anchor bolts per Section R403.1.6.

FIGURE R403.1(1)
CONCRETE AND MASONRY FOUNDATION DETAILS

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254.

FIGURE R403.1(2)
R403.1.1 Minimum size. The minimum width, W, and thickness, T, for concrete footings shall be in accordance with Tables R403.1(1) through R403.1(3) and Figure R403.1(1) or R403.1.3, as applicable. Minimum sizes for concrete and masonry footings shall be as set forth in Table R403.1(1) and Figure R403.1(1). The footing width shall be based on the load-bearing value of the soil in accordance with Table R401.4.1. Spread footings shall be at least 6 inches (152 mm) in thickness, T. Footing projections, P, shall be not less than 2 inches (51 mm) and shall not exceed the thickness of the footing. Footing thickness and projection for fireplaces shall be in accordance with Section R1001.2. The size of footings supporting piers and columns shall be based on the tributary load in accordance with Table R403.1(2) and allowable soil pressure in accordance with Table R401.4.1. Footings for wood foundations shall be in accordance with the details set forth in Section R403.2, and Figures R403.1(2) and R403.1(3).

R403.1.2 Continuous footing in Seismic Design Categories D0, D1 and D2. Deleted. Exterior walls of buildings located in Seismic Design Categories D, D, and D shall be supported by continuous solid or fully grouted masonry or concrete footings. Other footing materials or systems shall be designed in accordance with accepted engineering practice. All required interior braced wall panels in buildings located in Seismic Design Categories D, D, and D, with plan dimensions greater than 50 feet (15240 mm) shall be supported by continuous solid or fully grouted masonry or concrete footings in accordance with Section...
R403.1.3.4, except for two-story buildings in Seismic Design Category D2, in which all braced wall panels, interior and exterior, shall be supported on continuous foundations.

**Exception:** Two-story buildings shall be permitted to have interior braced wall panels supported on continuous foundations at intervals not exceeding 50 feet (15 240 mm) provided that:

1. The height of cripple walls does not exceed 4 feet (1219 mm).
2. First-floor braced wall panels are supported on doubled floor joists, continuous blocking or floor beams.
3. The distance between bracing lines does not exceed twice the building width measured parallel to the braced wall line.

R403.1.3 Footing and stem wall reinforcing in Seismic Design Categories D0, D1, and D2. Deleted. Concrete footings located in Seismic Design Categories D0, D1, and D2, as established in Table R301.2(1), shall have minimum reinforcement in accordance with this section and Figure R403.1.3. Reinforcement shall be installed with support and cover in accordance with Section R403.1.3.5.
W = Width of footing, T = Thickness of footing and P = Projection per Section R403.1.1

NOTES:

a. See Section R404.3 for sill requirements.
b. See Section R403.1.6 for sill attachment.
c. See Section R506.2.3 for vapor barrier requirements.
d. See Section R403.1 for base.
e. See Section R408 for under-floor ventilation and access requirements.
f. See Section R403.1.3.5 for reinforcement requirements.

**FIGURE R403.1.3**
REINFORCED CONCRETE FOOTINGS AND MASONRY AND CONCRETE STEM WALLS IN SDC D₀, D₁, AND D₂

R403.1.3.1 Concrete stem walls with concrete footings.
In Seismic Design Categories D₀, D₁, and D₂, where a construction joint is created between a concrete footing and a concrete stem wall, a minimum of one No. 4 vertical bar shall be installed at not more than 4 feet (1219 mm) on center. The vertical bar shall have a standard hook and extend to the bottom of the footing and shall have support and cover as specified in Section R403.1.3.5.3 and extend a minimum of 14 inches (357
mm) into the stem wall. Standard hooks shall comply with Section R608.5.4.5. A minimum of one No. 4 horizontal bar shall be installed within 12 inches (305 mm) of the top of the stem wall and one No. 4 horizontal bar shall be located 3 to 4 inches (76 mm to 102 mm) from the bottom of the footing.

**R403.1.3.2 Masonry stem walls with concrete footings.**
In Seismic Design Categories D₀, D₁, and D₂, where a masonry stem wall is supported on a concrete footing, a minimum of one No. 4 vertical bar shall be installed at not more than 4 feet (1219 mm) on center. The vertical bar shall have a standard hook and extend to the bottom of the footing and shall have support and cover as specified in Section R403.1.3.5.3 and extend a minimum of 14 inches (357 mm) into the stem wall. Standard hooks shall comply with Section R608.5.4.5. A minimum of one No. 4 horizontal bar shall be installed within 12 inches (305 mm) of the top of the wall and one No. 4 horizontal bar shall be located 3 to 4 inches (76 mm to 102 mm) from the bottom of the footing. Masonry stem walls shall be solid grouted.

**R403.1.3.3 Slabs-on-ground with turned-down footings.**
In Seismic Design Categories D₀, D₁, and D₂, slabs on ground cast monolithically with turned-down footings shall have a minimum of one No. 4 bar at the top and the bottom of the footing or one No. 5 bar or two No. 4 bars in the middle third of the footing depth.

Where the slab is not cast monolithically with the footing, No. 3 or larger vertical dowels with standard hooks on each end shall be installed at not more than 4 feet (1219 mm) on center in accordance with Figure R403.1.3, Detail 2. Standard hooks shall comply with Section R608.5.4.5.

**R403.1.3.4 Interior bearing and braced wall panel footings in Seismic Design Categories D₀, D₁ and D₂.**
In Seismic Design Categories D₀, D₁, and D₂, interior footings supporting bearing walls or braced wall panels, and cast monolithically with a slab on grade, shall extend to a depth of not less than 12 inches (305 mm) below the top of the slab.

**R403.1.3.5 Reinforcement.**
Footing and stem wall reinforcement shall comply with Sections R403.1.3.5.1 through R403.1.3.5.4.

**R403.1.3.5.1 Steel reinforcement.**
Steel reinforcement shall comply with the requirements of ASTM A 615, A 706 or A 996. ASTM A 996 bars produced from rail steel shall be Type R. The minimum yield strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa).

**R403.1.3.5.2 Location of reinforcement in wall.**
The center of vertical reinforcement in stem walls shall be located at the centerline of the wall. Horizontal and vertical reinforcement shall be located in footings and stem walls to provide the minimum cover required by Section R403.1.3.5.3.

**R403.1.3.5.3 Support and cover.**
Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system to prevent displacement during the concrete placement.
Steel reinforcement in concrete cast against the earth shall have a minimum cover of 3 inches (75 mm). Minimum cover for reinforcement in concrete cast in removable forms that will be exposed to the earth or weather shall be \(1 \frac{1}{2}\) inches (38 mm) for No. 5 bars and smaller, and 2 inches (50 mm) for No. 6 bars and larger. For concrete cast in removable forms that will not be exposed to the earth or weather, and for concrete cast in stay-in-place forms, minimum cover shall be \(\frac{3}{4}\) inch (19 mm).

**R403.1.3.5.4 Lap splices.**
Vertical and horizontal reinforcement shall be the longest lengths practical. Where splices are necessary in reinforcement, the length of lap splice shall be in accordance with Table R608.5.4. (1) and Figure R608.5.4(1). The maximum gap between noncontact parallel bars at a lap splice shall not exceed the smaller of one-fifth the required lap length and 6 inches (152 mm) [see Figure R608.5.4(1)].

**R403.1.3.6 Isolated concrete footings.**
In detached one- and two-family dwellings that are three stories or less in height and constructed with stud bearing walls, isolated plain concrete footings supporting columns or pedestals are permitted.

**R403.1.4 Minimum depth.**
Exterior footings shall be placed not less than 12 inches (305 mm) below the undisturbed ground surface. Where applicable, the depth of footings shall also conform to Sections R403.1.4.1 through R403.1.4.2.

All exterior footings and foundation systems shall extend below the frost line specified in Table R301.2(1). In no case shall the bottom of the exterior footings be less than 12 inches (305 mm) below the finished grade.

**Exception:** Footings and foundations erected on solid rock shall not be required to extend below the frost line.

**R403.1.4.1 Frost protection.** Deleted.
Except where otherwise protected from frost, foundation walls, piers and other permanent supports of buildings and structures shall be protected from frost by one or more of the following methods:

1. Extended below the frost line specified in Table R301.2. (1).
2. Constructed in accordance with Section R403.3.
3. Constructed in accordance with ASCE 32.
4. Erected on solid rock.

**Exceptions:**
1. Protection of freestanding accessory structures with an area of 600 square feet (56 m²) or less, of light-frame construction, with an eave height of 10 feet (3048 mm) or less shall not be required.

2. Protection of freestanding accessory structures with an area of 400 square feet (37 m²) or less, of other than light-frame construction, with an eave height of 10 feet (3048 mm) or less shall not be required.

3. Decks not supported by a dwelling need not be provided with footings that extend below the frost line.

Footings shall not bear on frozen soil unless the frozen condition is permanent.

R403.1.5 Slope.
The top surface of footings shall be level (1/2 inch in 10 feet) or shall be brought level, under the width of the wall, with masonry units with full mortar joints. The bottom surface of footings shall not have a slope exceeding one unit vertical in 10 units horizontal (10-percent slope). Footings shall be stepped where it is necessary to change the elevation of the top surface of the footings or where the slope of the bottom surface of the footings will exceed one unit vertical in 10 units horizontal (10-percent slope).

R403.1.6 Foundation anchorage.
Wood sill plates and wood walls supported directly on continuous foundations shall be anchored to the foundation in accordance with this section.

Cold-formed steel framing shall be anchored directly to the foundation or fastened to wood sill plates anchored to the foundation. Anchorage of cold-formed steel framing and sill plates supporting cold-formed steel framing shall be in accordance with this section and Section R505.3.1 or R603.3.1.

Wood sole plates at all exterior walls on monolithic slabs, wood sole plates of braced wall panels at building interiors on monolithic slabs and all wood sill plates shall be anchored to the foundation with minimum \( \frac{1}{2} \)-inch-diameter (12.7 mm) anchor bolts spaced a maximum of 6 feet (1829 mm) on center or approved anchors or anchor straps spaced as required to provide equivalent anchorage to \( \frac{1}{2} \)-inch-diameter (12.7 mm) anchor bolts. Bolts shall extend a minimum of 7 inches (178 mm) into concrete or grouted cells of concrete masonry units. The bolts shall be located in the middle third of the width of the plate. A nut and washer shall be tightened on each anchor bolt. There shall be a minimum of two bolts per plate section with one bolt located not more than 12 inches (305 mm) from the corner or less than seven bolt diameters from each end of the plate section. Interior bearing wall sole plates on monolithic slab foundation that are not part of a braced wall panel shall be positively anchored with approved fasteners. Sill plates and sole plates shall be protected against decay and termites where required by Sections R317 and R318.

Exceptions:
1. Walls 24 inches (610 mm) total length or shorter connecting offset braced wall panels shall be anchored to the foundation with a minimum of one anchor bolt located in the center third of the plate section and shall be attached to adjacent braced wall panels at corners as shown in Item 9 of Table R602.3(1).

2. Connection of walls 12 inches (305 mm) total length or shorter connecting offset braced wall panels to the foundation without anchor bolts shall be permitted. The wall shall be attached to adjacent braced wall panels at corners as shown in Item 9 of Table R602.3(1).

R403.1.6.1 Foundation anchorage in Seismic Design Categories C, D0, D1 and D2.
In addition to the requirements of Section R403.1.6, the following requirements shall apply to wood light-frame structures in Seismic Design Categories D0, D1 and D2 and wood light-frame townhouses in Seismic Design Category C.

1. Plate washers conforming to Section R602.11.1 shall be used on each bolt, provided for all anchor bolts over the full length of required braced wall lines except where approved anchor straps are used. Properly sized cut washers shall be permitted for anchor bolts in wall lines not containing braced wall panels.

2. Interior braced wall plates shall have anchor bolts spaced at not more than 6 feet (1829 mm) on center and not more than located within 12 inches (305 mm) from the corner of the ends of each plate section when supported on a continuous foundation.

3. Interior bearing wall sole plates shall have anchor bolts spaced at not more than 6 feet (1829 mm) on center and not more than located within 12 inches (305 mm) from the corner of the ends of each plate section when supported on a continuous foundation.

4. The maximum anchor bolt spacing shall be 4 feet (1219 mm) for buildings over two stories in height.

5. Stepped-cripple walls shall conform to Section R602.11.2. Deleted.

6. Where continuous wood foundations in accordance with Section R404.2 are used, the force transfer shall have a capacity equal to or greater than the connections required by Section R602.11.1 or the braced wall panel shall be connected to the wood foundations in accordance with the braced wall panel-to-floor fastening requirements of Table R602.3(1).

R403.1.7 Footings on or adjacent to slopes. Deleted.
The placement of buildings and structures on or adjacent to slopes steeper than one unit vertical in three units horizontal (33.3-percent slope) shall conform to Sections R403.1.7.1 through R403.1.7.4.

R403.1.7.1 Building clearances from ascending slopes.
In general, buildings below slopes shall be set a sufficient distance from the slope to
provide protection from slope drainage, erosion and shallow failures. Except as provided in Section R403.1.7.4 and Figure R403.1.7.1, the following criteria will be assumed to provide this protection. Where the existing slope is steeper than one unit vertical in one unit horizontal (100-percent slope), the toe of the slope shall be assumed to be at the intersection of a horizontal plane drawn from the top of the foundation and a plane drawn tangent to the slope at an angle of 45 degrees (0.79 rad) to the horizontal. Where a retaining wall is constructed at the toe of the slope, the height of the slope shall be measured from the top of the wall to the top of the slope.

For SI: 1 foot = 304.8 mm.

FIGURE R403.1.7.1
FOUNDATION CLEARANCE FROM SLOPES

R403.1.7.2 Footing setback from descending slope surfaces.
Footings on or adjacent to slope surfaces shall be founded in material with an embedment and setback from the slope surface sufficient to provide vertical and lateral support for the footing without detrimental settlement. Except as provided for in Section R403.1.7.4 and Figure R403.1.7.1, the following setback is deemed adequate to meet the criteria. Where the slope is steeper than one unit vertical in one unit horizontal (100-percent slope), the required setback shall be measured from an imaginary plane 45 degrees (0.79 rad) to the horizontal, projected upward from the toe of the slope.

R403.1.7.3 Foundation elevation.
On graded sites, the top of any exterior foundation shall extend above the elevation of the street gutter at point of discharge or the inlet of an approved drainage device a minimum of 12 inches (305 mm) plus 2 percent. Alternate elevations are permitted subject to the approval of the building official, provided it can be demonstrated that required drainage to the point of discharge and away from the structure is provided at all locations on the site.

R403.1.7.4 Alternate setbacks and clearances.
Alternate setbacks and clearances are permitted, subject to the approval of the building official. The building official is permitted to require an investigation and recommendation of a qualified engineer to demonstrate that the intent of this section has been satisfied. Such an investigation shall include consideration of material, height of slope, slope gradient, load intensity and erosion characteristics of slope material.
R403.1.8 Foundations on expansive soils. Deleted.
Foundation and floor slabs for buildings located on expansive soils shall be designed in accordance with Section 1808.6 of the International Building Code.

Exception: Slab-on-ground and other foundation systems which have performed adequately in soil conditions similar to those encountered at the building site are permitted subject to the approval of the building official.

R403.1.8.1 Expansive soils classifications.
Soils meeting all four of the following provisions shall be considered expansive, except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:

1. Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D 4318.

2. More than 10 percent of the soil particles pass a No. 200 sieve (75 µm), determined in accordance with ASTM D 422.

3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D 422.

4. Expansion Index greater than 20, determined in accordance with ASTM D 4829.

R403.1.9 Excavations near footings or foundations.
Excavations shall not remove lateral support from any footing or foundation without first shoring, underpinning or protecting the footing or foundation against settlement or lateral translation. Where footings of adjacent buildings or structures are undercut by excavations measured from the bottom of the adjacent existing footing at a 45 degree angle (0.79 rad) within 10 feet (3048 mm) as shown in Figure R403.1.9, the footings shall require evaluation by a registered design professional.

Exception: Accessory buildings not exceeding 400 square feet (37 m²) exempt from providing a masonry or concrete foundation in accordance with Section R101.2.1.
FIGURE R403.1.9
EXCAVATIONS NEAR FOOTINGS OR FOUNDATIONS

R403.2 Footings for wood foundations.
Footings for wood foundations shall be in accordance with Figures R403.1(2) and R403.1(3). Gravel shall be washed and well graded. The maximum size stone shall not exceed \( \frac{3}{4} \) inch (19.1 mm). Gravel shall be free from organic, clayey or silty soils. Sand shall be coarse, not smaller than \( \frac{1}{16} \)-inch (1.6 mm) grains and shall be free from organic, clayey or silty soils. Crushed stone shall have a maximum size of \( \frac{1}{2} \) inch (12.7 mm).

R403.3 Frost-protected shallow foundations. Deleted.
For buildings where the monthly mean temperature of the building is maintained at a minimum of 64°F (18°C), footings are not required to extend below the frost line when protected from frost by insulation in accordance with Figure R403.3(1) and Table R403.3(1). Foundations protected from frost in accordance with Figure R403.3(1) and Table R403.3(1) shall not be used for unheated spaces such as porches, utility rooms, garages and carports, and shall not be attached to basements or crawl spaces that are not maintained at a minimum monthly mean temperature of 64°F (18°C).

Materials used below grade for the purpose of insulating footings against frost shall be labeled as complying with ASTM C 578.
For SI: 1 inch = 25.4 mm.

a—See Table R403.3(1) for required dimensions and R-values for vertical and horizontal insulation and minimum footing depth.

**FIGURE R403.3(1)**
INSULATION PLACEMENT FOR FROST-PROTECTED FOOTINGS IN HEATED BUILDINGS

**TABLE R403.3(1)**
MINIMUM FOOTING DEPTH AND INSULATION REQUIREMENTS FOR FROST-PROTECTED FOOTINGS IN HEATED BUILDINGS

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<th>AIR FREEZING INDEX b (°F-days)</th>
<th>MINIMUM FOOTING DEPTH, D (inches)</th>
<th>VERTICAL INSULATION R-VALUE d</th>
<th>HORIZONTAL INSULATION R-VALUE c,e</th>
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<td>13.1</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm, °C = [(°F) - 32]/1.8.

a. Insulation requirements are for protection against frost damage in heated buildings. Greater values may be required to meet energy conservation standards.
b. See Figure R403.3(2) or Table R403.3(2) for Air Freezing Index values.
c. Insulation materials shall provide the stated minimum R-values under long-term exposure to moist, below-ground conditions in freezing climates. The following R-values shall be used to determine insulation thicknesses required for this application: Type II expanded polystyrene-2.4 R per inch; Type IV extruded polystyrene-4.5 R per inch; Type VI extruded polystyrene-4.5 R per inch; Type IX expanded polystyrene-3.2 R per inch; Type X extruded polystyrene-4.5 R per inch.
d. Vertical insulation shall be expanded polystyrene insulation or extruded polystyrene insulation.
e. Horizontal insulation shall be expanded polystyrene insulation or extruded polystyrene insulation.

Note: The air-freezing index is defined as cumulative degree days below 32°F. It is used as a measure of the combined magnitude and duration of air temperature below freezing. The index was computed over a 12-month period (July-June) for each of the 3,044 stations used in the above analysis. Dates from the 1951-80 period were fitted to a Weibull probability distribution to produce an estimate of the 100-year return period.

**FIGURE R403.3(2)**
AIR-FREEZING INDEX AN ESTIMATE OF THE 100-YEAR RETURN PERIOD

**TABLE R403.3(2)**
AIR-FREEZING INDEX FOR U.S. LOCATIONS BY COUNTY

<table>
<thead>
<tr>
<th>STATE</th>
<th>AIR-FREEZING INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1500 or less</td>
</tr>
<tr>
<td>Alabama</td>
<td>All counties</td>
</tr>
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</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>State</th>
<th>Counties Listed</th>
<th>Counties Not Listed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>Ketchikan Gateway, Prince-of-Wales-Outer Ketchikan (CA), Sitka, Wrangell-Petersburg (CA)</td>
<td>Aleutians West (CA), Haines, Juneau, Skagway-Hoonah-Anagoon (CA), Yakutat</td>
</tr>
<tr>
<td>Arizona</td>
<td>All counties</td>
<td>All counties not listed</td>
</tr>
<tr>
<td>Arkansas</td>
<td>All counties</td>
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</tr>
<tr>
<td>California</td>
<td>All counties not listed</td>
<td>Nevada, Sierra</td>
</tr>
<tr>
<td>Connecticut</td>
<td>All counties not listed</td>
<td>Hartford, Litchfield</td>
</tr>
<tr>
<td>Delaware</td>
<td>All counties</td>
<td>All counties not listed</td>
</tr>
<tr>
<td>District of Columbia</td>
<td>All counties</td>
<td>All counties not listed</td>
</tr>
<tr>
<td>Florida</td>
<td>All counties</td>
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<tr>
<td>Georgia</td>
<td>All counties</td>
<td>All counties not listed</td>
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<tr>
<td>Hawaii</td>
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<td>Idaho</td>
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<tr>
<td>STATE</td>
<td>All counties not listed</td>
<td>1500 or less</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>Carroll, Ogle, Stephenson, Winnebago</td>
<td></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

(continued)

TABLE R403.3(2)—continued
AIR-FREEZING INDEX FOR U.S. LOCATIONS BY COUNTY

<table>
<thead>
<tr>
<th>STATE</th>
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2018 North Carolina Residential Code
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<th>Counties Not Listed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
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<tr>
<td>Kansas</td>
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<td></td>
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<tr>
<td>Kentucky</td>
<td>All counties</td>
<td></td>
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<tr>
<td>Louisiana</td>
<td>All counties</td>
<td></td>
</tr>
<tr>
<td>Maine</td>
<td>York, Knox, Lincoln, Sagadahoc</td>
<td>Androscoggin, Cumberland, Hancock, Kennebec, Waldo, Washington</td>
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<tr>
<td>Maryland</td>
<td>All counties</td>
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</tr>
<tr>
<td>Massachusetts</td>
<td>All counties not listed</td>
<td>Berkshire, Franklin, Hampden, Worcester</td>
</tr>
<tr>
<td>Michigan</td>
<td>Berrien, Branch, Cass, Kalamazoo, Macomb, Ottawa, St. Clair, St. Joseph</td>
<td>All counties not listed</td>
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</tbody>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>STATE</th>
<th>AIR-FREEZING INDEX</th>
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</thead>
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<td>1500 or less</td>
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<td>Mississippi</td>
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</tr>
<tr>
<td>Missouri</td>
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</tr>
<tr>
<td>Montana</td>
<td>Mineral</td>
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(continued)
<table>
<thead>
<tr>
<th>State</th>
<th>Counties Listed</th>
<th>Counties Not Listed</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nebraska</td>
<td>Adams, Banner, Chase, Cheyenne, Clay, Deuel, Dundyl</td>
<td>All counties not listed</td>
<td>Boyd, Burt, Cedar, Cuming, Dakota, Dixon, Dodge, Knox, Thurston</td>
</tr>
<tr>
<td>Nevada</td>
<td>All counties not listed</td>
<td>Elko, Eureka, Nye, Washoe, White Pine</td>
<td>—</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>All counties not listed</td>
<td>All counties not listed</td>
<td>—</td>
</tr>
<tr>
<td>New Jersey</td>
<td>All counties</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>New Mexico</td>
<td>All counties not listed</td>
<td>Rio Arriba</td>
<td>Colfax, Mora, Taos</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
### TABLE R403.3(2)—continued
AIR-FREEZING INDEX FOR U.S. LOCATIONS BY COUNTY

<table>
<thead>
<tr>
<th>STATE</th>
<th>AIR-FREEZING INDEX</th>
<th>1500 or less</th>
<th>2000</th>
<th>2500</th>
<th>3000</th>
<th>3500</th>
<th>4000</th>
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</thead>
<tbody>
<tr>
<td>North Dakota</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Billings, Bowman</td>
<td>Adams, Dickey, Golden Valley, Hettinger, LaMoure, Oliver, Ransom, Sargent, Sioux, Slope, Stark</td>
</tr>
<tr>
<td>Ohio</td>
<td>All counties not-listed</td>
<td>Ashland, Crawford, Defiance, Holmes, Huron, Knox, Licking, Morrow, Paulding, Putnam, Richland, Seneca, Williams</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>All counties</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Oregon</td>
<td>All counties not-listed</td>
<td>Baker, Crook, Grant, Harney</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>STATE</th>
<th>AIR-FREEZING INDEX FOR U.S. LOCATIONS BY COUNTY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AIR-FREEZING INDEX</td>
</tr>
<tr>
<td></td>
<td>1500-or-less</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>All counties</td>
</tr>
<tr>
<td>South Carolina</td>
<td>All counties</td>
</tr>
<tr>
<td>South Dakota</td>
<td>Bennett, Custer, Fall River, Lawrence, Mellette, Shannon, Todd, Tripp</td>
</tr>
<tr>
<td>Tennessee</td>
<td>All counties</td>
</tr>
<tr>
<td>Texas</td>
<td>All counties</td>
</tr>
<tr>
<td>Utah</td>
<td>All counties, not listed</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>State</th>
<th>Counties Listed</th>
<th>Counties Not Listed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermont</td>
<td>Bennington, Grand Isle, Rutland, Windham</td>
<td>Addison, Chittenden, Franklin, Orange, Washington, Windsor, Caledonia, Essex, Lamoille, Orleans</td>
</tr>
<tr>
<td>Virginia</td>
<td>All counties</td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td>All counties not-listed</td>
<td>Chelan, Douglas, Ferry, Okanogan</td>
</tr>
<tr>
<td>West Virginia</td>
<td>All counties</td>
<td></td>
</tr>
<tr>
<td>Wisconsin</td>
<td>Kenosha, Kewaunee, Racine, Sheboygan, Walworth</td>
<td>All counties not-listed</td>
</tr>
<tr>
<td>Wyoming</td>
<td>Goshen, Platte</td>
<td>Campell, Carbon, Hot Springs, Johnson, Natrona, Sheridan, Uinta, Weston</td>
</tr>
<tr>
<td></td>
<td>Converse, Crook, Laramie, Niobrara</td>
<td>Campbell, Carbon, Hot Springs, Johnson, Natrona, Sheridan, Uinta, Weston</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Albany, Big Horn, Park, Washakie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fremont, Teton</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lincoln, Sublette, Sweetwater</td>
</tr>
</tbody>
</table>
a. See Table R403.3(1) for required dimensions and R-values for vertical and horizontal insulation.

FIGURE R403.3(3)
INSULATION PLACEMENT FOR FROST-PROTECTED FOOTINGS ADJACENT TO UNHEATED SLAB-ON-GROUND STRUCTURE
R403.3.1 Foundations adjoining frost-protected shallow foundations.
Foundations that adjoin frost-protected shallow foundations shall be protected from frost in accordance with Section R403.1.4.

R403.3.1.1 Attachment to unheated slab-on-ground structure.
Vertical wall insulation and horizontal insulation of frost-protected shallow foundations that adjoin a slab-on-ground foundation that does not have a monthly mean temperature maintained at a minimum of 64°F (18°C) shall be in accordance with Figure R403.3(3) and Table R403.3(1). Vertical wall insulation shall extend between the frost-protected shallow foundation and the adjoining slab foundation. Required horizontal insulation shall be continuous under the adjoining slab foundation and through any foundation walls adjoining the frost-protected shallow foundation. Where insulation passes through a foundation wall, it shall be either of a type complying with this section and having bearing capacity equal to or greater than the structural loads imposed by the building, or the building shall be designed and constructed using beams, lintels, cantilevers or other means of transferring building loads such that the structural loads of the building do not bear on the insulation.

R403.3.1.2 Attachment to heated structure.
Where a frost-protected shallow foundation abuts a structure that has a monthly mean temperature maintained at a minimum of 64°F (18°C), horizontal insulation and vertical wall insulation shall not be required between the frost-protected shallow foundation and the adjoining structure. Where the frost-protected shallow foundation abuts the heated structure, the horizontal insulation and vertical wall insulation shall extend along the adjoining foundation in accordance with Figure R403.3(4) a distance of not less than Dimension A in Table R403.3(1).

Exception: Where the frost-protected shallow foundation abuts the heated structure to form an inside corner, vertical insulation extending along the adjoining foundation is not required.

R403.3.2 Protection of horizontal insulation below ground.
Horizontal insulation placed less than 12 inches (305 mm) below the ground surface or that portion of horizontal insulation extending outward more than 24 inches (610 mm) from the foundation edge shall be protected against damage by use of a concrete slab or asphalt paving on the ground surface directly above the insulation or by cementitious board, plywood rated for below-ground use, or other approved materials placed below ground, directly above the top surface of the insulation.

R403.3.3 Drainage.
Final grade shall be sloped in accordance with Section R401.3. In other than Group I Soils, as detailed in Table R405.1, gravel or crushed stone beneath horizontal insulation below ground shall drain to daylight or into an approved sewer system.
R403.3.4 Termite protection.
The use of foam plastic in areas of "very heavy" termite infestation probability shall be in accordance with Section R318.4.

R403.4 Footings for precast concrete foundations.
Footings for precast concrete foundations shall comply with Section R403.4.

### TABLE R403.4
MINIMUM DEPTH OF CRUSHED STONE FOOTINGS\(^a\) (D), (inches)

<table>
<thead>
<tr>
<th>NUMBER OF STORIES</th>
<th>UNIFORM WALL LOAD</th>
<th>LOAD-BEARING VALUE OF SOIL (psf)</th>
<th>1500</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SC, GC, SM, GM, SP, SW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall width (inches)</td>
<td>Wall width (inches)</td>
<td>GP, GW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>6</td>
<td>8</td>
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<td>6</td>
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<td>12</td>
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<td>10</td>
<td>12</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

**Conventional light-frame construction**

<table>
<thead>
<tr>
<th>NUMBER OF STORIES</th>
<th>UNIFORM WALL LOAD</th>
<th>LOAD-BEARING VALUE OF SOIL (psf)</th>
<th>1500</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-story</td>
<td>1100 plf</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2-story</td>
<td>1800 plf</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3-story</td>
<td>2900 plf</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

**4-inch brick veneer over light-frame or 8-inch hollow concrete masonry**

<table>
<thead>
<tr>
<th>NUMBER OF STORIES</th>
<th>UNIFORM WALL LOAD</th>
<th>LOAD-BEARING VALUE OF SOIL (psf)</th>
<th>1500</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-story</td>
<td>1500 plf</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2-story</td>
<td>2700 plf</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>3-story</td>
<td>4000 plf</td>
<td>22</td>
<td>22</td>
<td>20</td>
<td>18</td>
<td>16</td>
</tr>
</tbody>
</table>

**8-inch solid or fully grouted masonry**

<table>
<thead>
<tr>
<th>NUMBER OF STORIES</th>
<th>UNIFORM WALL LOAD</th>
<th>LOAD-BEARING VALUE OF SOIL (psf)</th>
<th>1500</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-story</td>
<td>2000 plf</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2-story</td>
<td>3600 plf</td>
<td>20</td>
<td>18</td>
<td>16</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>3-story</td>
<td>5300 plf</td>
<td>32</td>
<td>30</td>
<td>28</td>
<td>26</td>
<td>22</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 plf = 14.6 N/m, 1 pound per square foot = 47.9 N/m².
\(a\). Linear interpolation of stone depth between wall widths is permitted within each Load-Bearing Value of Soil (psf).
FIGURE R403.4(1)
BASEMENT OR CRAWL SPACE WITH PRECAST FOUNDATION WALL BEARING ON CRUSHED STONE
FIGURE R403.4(2)
BASEMENT OR CRAWL SPACE WITH PRECAST FOUNDATION WALL ON SPREAD FOOTING

R403.4.1 Crushed stone footings.
Clean crushed stone shall be free from organic, clayey or silty soils. Crushed stone shall be angular in nature and meet ASTM C 33, with the maximum size stone not to exceed $\frac{1}{2}$ inch (12.7 mm) and the minimum stone size not to be smaller than $\frac{1}{16}$ inch (1.6 mm). Crushed stone footings for precast foundations shall be installed in accordance with Figure R403.4(1) and Table R403.4. Crushed stone footings shall be consolidated using a vibratory plate in a maximum of 8-inch (203 mm) lifts. Crushed stone footings shall be limited to Seismic Design Categories A, B and C.

R403.4.2 Concrete footings.
Concrete footings shall be installed in accordance with Section R403.1 and Figure R403.4(2).

SECTION R404
FOUNDATION AND RETAINING WALLS
R404.1 Concrete and masonry foundation walls.
Concrete foundation walls shall be selected and constructed in accordance with the provisions of Section R404.1.3. Masonry foundation walls shall be selected and constructed in accordance with the provisions of Section R404.1.2.

R404.1.1 Design required.
Concrete or masonry foundation walls shall be designed in accordance with accepted engineering practice where either of the following conditions exists:

1. Walls are subject to hydrostatic pressure from ground water.
2. Walls supporting more than 48 inches (1219 mm) of unbalanced backfill that do not have permanent lateral support at the top or bottom.

R404.1.2 Design of masonry foundation walls. Masonry foundation walls shall be designed and constructed in accordance with the provisions of this section or in accordance with the provisions of TMS 402/ACI 530/ASCE 5. When TMS 402/ACI 530/ASCE 5, or the provisions of this section are used to design masonry foundation walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the jurisdiction having authority.

**TABLE R404.1.1(1)**
**PLAIN MASONRY FOUNDATION WALLS**

<table>
<thead>
<tr>
<th>MAXIMUM WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (feet)</th>
<th>PLAIN MASONRY MINIMUM NOMINAL WALL THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW and SP</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>6 solid₃ or 8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>6 solid₃ or 8</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>6 solid₃ or 8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>6 solid₃ or 8</td>
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<tr>
<td>7</td>
<td>4</td>
<td>8</td>
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<tr>
<td></td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

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GW, GP, SW and SP: Gamma weight, Gamma permeability, Saturated weight, Saturated permeability
GM, GC, SM, SM-SC and ML: Gamma weight, Gamma permeability, Saturated weight, Saturated permeability
SC, MH, ML-CL and inorganic CL: Saturated coefficient, Moisture weight, Moisture coefficient, Inorganic CL
Footnote e

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 Pa.

a. Mortar shall be Type M or S and masonry shall be laid in running bond. Ungrouted hollow masonry units are permitted except where otherwise indicated.

b. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

c. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.

d. Solid indicates solid masonry unit; grout indicates grouted hollow units.

e. Wall construction shall be in accordance with either Table R404.1.1(2), Table R404.1.1(3), Table R404.1.1(4), or a design shall be provided.

f. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.1(2)
8-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE d \( \geq \) 5 INCHES

<table>
<thead>
<tr>
<th>WALL HEIGHT</th>
<th>HEIGHT OF UNBALANCED BACKFILL</th>
<th>MINIMUM VERTICAL REINFORCEMENT AND SPACING (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soil classes and lateral soil load ( d ) (psf per foot below grade)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW and SP soils 30</td>
</tr>
<tr>
<td>6 feet 8 inches</td>
<td>4 feet (or less) 5 feet 6 feet 8 inches</td>
<td>#4 at 48</td>
</tr>
<tr>
<td>7 feet 4 inches</td>
<td>4 feet (or less) 5 feet 6 feet 7 feet 4 inches</td>
<td>#4 at 48</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/mm.

a. Mortar shall be Type M or S and masonry shall be laid in running bond.

b. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of the reinforcement does not exceed 72 inches in Seismic Design Categories A, B and C, and 48 inches in Seismic Design Categories D, D₁ and D₂.

c. Vertical reinforcement shall be Grade 60 minimum. The distance, \( d \), from the face of the soil side of the wall to the center of vertical reinforcement shall be not less than 5 inches.

d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure. Refer to Table R405.1.

e. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.

f. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.1(3)

10-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE \( d \geq 6.75 \) INCHES

<table>
<thead>
<tr>
<th>WALL HEIGHT</th>
<th>HEIGHT OF UNBALANCED BACKFILL</th>
<th>MINIMUM VERTICAL REINFORCEMENT AND SPACING (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Soil classes and later soil load</strong> (psf per foot below grade)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>GW, GP, SW and SP soils</strong> 30</td>
</tr>
<tr>
<td>6 feet 8 inches</td>
<td>4 feet (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>6 feet 8 inches</td>
<td>#4 at 56</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/mm.
a. Mortar shall be Type M or S and masonry shall be laid in running bond.
b. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of the reinforcement does not exceed 72 inches in Seismic Design Categories A, B and C, and 48 inches in Seismic Design Categories D0, D1 and D2.
c. Vertical reinforcement shall be Grade 60 minimum. The distance, \(d\), from the face of the soil side of the wall to the center of vertical reinforcement shall be not less than 6.75 inches.
d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure. Refer to Table R405.1.
e. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab-on-grade is provided and is in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height from the exterior finish ground level to the top of the interior concrete slab is permitted.
f. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.1(4)
12-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE \(d \geq 8.75\) INCHES\(^{a,c,f}\)

<table>
<thead>
<tr>
<th>WALL HEIGHT</th>
<th>HEIGHT OF UNBALANCED BACKFILL</th>
<th>MINIMUM VERTICAL REINFORCEMENT AND SPACING (INCHES) (^{b,c})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soil classes and lateral soil load (d) (psf per foot below grade)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW and SP soils 30</td>
</tr>
<tr>
<td>7 feet 4 inches</td>
<td>4 feet (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>6 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>7 feet 4 inches</td>
<td>#4 at 56</td>
</tr>
<tr>
<td>8 feet</td>
<td>4 feet (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>6 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>7 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>8 feet 8 inches</td>
<td>#5 at 56</td>
</tr>
<tr>
<td>8 feet 8 inches</td>
<td>4 feet (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>6 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>7 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>8 feet 8 inches</td>
<td>#5 at 56</td>
</tr>
<tr>
<td>9 feet 4 inches</td>
<td>4 feet (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>6 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>7 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>8 feet 4 inches</td>
<td>#5 at 56</td>
</tr>
<tr>
<td></td>
<td>9 feet 4 inches</td>
<td>#6 at 56</td>
</tr>
<tr>
<td>10 feet</td>
<td>4 feet (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>6 feet</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>7 feet</td>
<td>#5 at 56</td>
</tr>
<tr>
<td></td>
<td>8 feet</td>
<td>#5 at 56</td>
</tr>
<tr>
<td></td>
<td>9 feet</td>
<td>#5 at 56</td>
</tr>
<tr>
<td></td>
<td>10 feet</td>
<td>#6 at 60</td>
</tr>
<tr>
<td>Height (feet)</td>
<td>Mortar &amp; Masonry</td>
<td>Reinforcement Size &amp; Spacing</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>6 feet 8 inches</td>
<td>Type M or S</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>5 feet</td>
<td>#4 at 72</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>6 feet 8 inches</td>
<td>#4 at 72</td>
<td>#5 at 72</td>
</tr>
<tr>
<td>7 feet 4 inches</td>
<td>#4 at 72</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>4 feet (or less)</td>
<td>#4 at 72</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>5 feet</td>
<td>#4 at 72</td>
<td>#5 at 72</td>
</tr>
<tr>
<td>6 feet</td>
<td>#4 at 72</td>
<td>#6 at 72</td>
</tr>
<tr>
<td>7 feet</td>
<td>#5 at 72</td>
<td>#6 at 72</td>
</tr>
<tr>
<td>8 feet</td>
<td>#6 at 72</td>
<td>#6 at 72</td>
</tr>
<tr>
<td>8 feet 8 inches</td>
<td>#4 at 72</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>5 feet</td>
<td>#4 at 72</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>6 feet</td>
<td>#4 at 72</td>
<td>#5 at 72</td>
</tr>
<tr>
<td>7 feet</td>
<td>#5 at 72</td>
<td>#6 at 72</td>
</tr>
<tr>
<td>8 feet</td>
<td>#6 at 72</td>
<td>#6 at 48</td>
</tr>
<tr>
<td>9 feet 4 inches</td>
<td>#4 at 72</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>5 feet</td>
<td>#4 at 72</td>
<td>#4 at 72</td>
</tr>
<tr>
<td>6 feet</td>
<td>#5 at 72</td>
<td>#5 at 72</td>
</tr>
<tr>
<td>7 feet</td>
<td>#5 at 72</td>
<td>#6 at 72</td>
</tr>
<tr>
<td>8 feet</td>
<td>#6 at 72</td>
<td>#6 at 56</td>
</tr>
<tr>
<td>9 feet 4 inches</td>
<td>#6 at 72</td>
<td>#6 at 40</td>
</tr>
<tr>
<td>10 feet</td>
<td>#6 at 72</td>
<td>#6 at 40</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/mm.

a. Mortar shall be Type M or S and masonry shall be laid in running bond.

b. Alternative reinforcing bar sizes and spacings having an equivalent cross-sectional area of reinforcement per lineal foot of wall shall be permitted provided the spacing of the reinforcement does not exceed 72 inches in Seismic Design Categories A, B, and C, and 48 inches in Seismic Design Categories D₁ and D₂.

c. Vertical reinforcement shall be Grade 60 minimum. The distance, \( d \), from the face of the soil side of the wall to the center of vertical reinforcement shall be not less than 8.75 inches.

d. Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist conditions without hydrostatic pressure. Refer to Table R405.1.

e. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground levels. Where an interior concrete slab-on-grade is provided and in contact with the interior surface of the foundation wall, measurement of the unbalanced backfill height is permitted to be measured from the exterior finish ground level to the top of the interior concrete slab is permitted.

f. The use of this table shall be prohibited for soil classifications not shown.
### TABLE R404.1.2(1)
MINIMUM HORIZONTAL REINFORCEMENT FOR CONCRETE BASEMENT WALLS\(^{a, b}\)

<table>
<thead>
<tr>
<th>MAXIMUM UNSUPPORTED HEIGHT OF BASEMENT WALL (feet)</th>
<th>LOCATION OF HORIZONTAL REINFORCEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 8 )</td>
<td>One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near mid-height of the wall story.</td>
</tr>
<tr>
<td>( &gt; 8 )</td>
<td>One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near third points in the wall story.</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.

\( a \). Horizontal reinforcement requirements are for reinforcing bars with a minimum yield strength of 40,000 psi and concrete with a minimum concrete compressive strength of 2,500 psi.

\( b \). See Section R404.1.2.2 R404.1.3.2 for minimum reinforcement required for foundation walls supporting above-grade concrete walls.

### TABLE R404.1.2(2)
MINIMUM VERTICAL REINFORCEMENT FOR 6-INCH NOMINAL FLAT CONCRETE BASEMENT WALLS\(^{b, c, d, e, g, h, i, j, k}\)

<table>
<thead>
<tr>
<th>MAXIMUM UNSUPPORTED WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (^{f}) (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW, SP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GM, GC, SM, SM-SC and ML</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC, ML-CL and inorganic CL</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6 @ 39</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 @ 48</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6 @ 25</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5 @ 37</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 @ 44</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6 @ 22</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6 @ 17</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5 @ 35</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 @ 41</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6 @ 20</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6 @ 15</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6 @ 19</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.
NR = Not required.
a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.7.2.
c. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.7.6 and Table R404.1.2(95).
d. Deflection criterion is $L/240$, where $L$ is the height of the basement wall in inches.
e. Interpolation is not permitted.
f. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
g. NR indicates no vertical wall reinforcement is required, except for 6-inch-nominal walls formed with stay-in-place forming systems in which case vertical reinforcement shall be No. 4@48 inches on center.
h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
i. See Table R608.3 for tolerance from nominal thickness permitted for flat walls.
j. DR means design is required in accordance with the applicable building code, or where there is no code, in accordance with ACI 318.
k. The use of this table shall be prohibited for soil classifications not shown.

**TABLE R404.1.2(3)**

**MINIMUM VERTICAL REINFORCEMENT FOR 8-INCH (203 mm) NOMINAL FLAT CONCRETE BASEMENT WALLS**

<table>
<thead>
<tr>
<th>MAXIMUM UNSUPPORTED WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soil classes $^a$ and design lateral soil (psf per foot of depth)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW, SP $^{30}$</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td>5</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>6</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>7</td>
<td>NR</td>
<td>6 @ 36</td>
</tr>
<tr>
<td>8</td>
<td>6 @ 41</td>
<td>6 @ 35</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td>5</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>6</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>7</td>
<td>NR</td>
<td>6 @ 35</td>
</tr>
<tr>
<td>8</td>
<td>6 @ 36</td>
<td>6 @ 32</td>
</tr>
<tr>
<td>9</td>
<td>6 @ 35</td>
<td>6 @ 25</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6 @ 35</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6 @ 34</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6 @ 27</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 pound per square foot per foot = 0.1571 kPa /m, 1 pound per square inch = 6.895 kPa.
NR = Not required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi, concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.

c. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).

d. NR indicates no vertical reinforcement is required.

e. Deflection criterion is \( L/240 \), where \( L \) is the height of the basement wall in inches.

f. Interpolation is not permitted.

g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.

h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.

i. See Table R608.3 for tolerance from nominal thickness permitted for flat walls.

j. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.2(4)

**MINIMUM VERTICAL REINFORCEMENT FOR 10-INCH NOMINAL FLAT CONCRETE BASEMENT WALLS**

<table>
<thead>
<tr>
<th>MAXIMUM UNSUPPORTED WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (^g) (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW, GP, SW, SP 30</td>
<td>GM, GC, SM, SM-SC and ML 45</td>
<td>SC, ML-CL and inorganic CL 60</td>
</tr>
<tr>
<td>GWennaBoV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil classes a and design lateral soil (psf per foot of depth)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GW, GP, SW, SP 30</td>
<td>GM, GC, SM, SM-SC and ML 45</td>
<td>SC, ML-CL and inorganic CL 60</td>
</tr>
<tr>
<td>GWennaBoV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>NR</td>
<td>NR</td>
<td>NR</td>
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<td>NR</td>
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<td>NR</td>
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<td>NR</td>
</tr>
<tr>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>6 @ 48</td>
<td>6 @ 35</td>
<td>6 @ 28</td>
</tr>
<tr>
<td>6 @ 48</td>
<td>6 @ 35</td>
<td>6 @ 28</td>
</tr>
<tr>
<td>6 @ 37</td>
<td>6 @ 28</td>
<td>6 @ 24</td>
</tr>
<tr>
<td>6 @ 33</td>
<td>6 @ 28</td>
<td>6 @ 21</td>
</tr>
<tr>
<td>6 @ 28</td>
<td>6 @ 23</td>
<td>6 @ 17</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 pound per square foot per foot = 0.1571 kPa /m, 1 pound per square inch = 6.895 kPa.

NR = Not required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.
c. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).

d. NR indicates no vertical reinforcement is required.

e. Deflection criterion is $L/240$, where $L$ is the height of the basement wall in inches.

f. Interpolation is not permitted.

g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.

h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.

i. See Table R608.3 for tolerance from nominal thickness permitted for flat walls.

j. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.2(5)

**MINIMUM VERTICAL WALL REINFORCEMENT FOR 6-INCH WAFFLE-GRID BASEMENT WALLS**

<table>
<thead>
<tr>
<th>MAXIMUM UNSUPPORTED WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soil classes $a$ and design lateral soil (psf per foot of depth)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW, SP 30</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4 @ 48</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4 @ 45</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5 @ 45</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 @ 44</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6 @ 32</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>4 @ 48</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4 @ 42</td>
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<tr>
<td></td>
<td>6</td>
<td>5 @ 41</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 @ 39</td>
</tr>
<tr>
<td></td>
<td>&gt;8</td>
<td>DR</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>4 @ 48</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4 @ 40</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5 @ 38</td>
</tr>
<tr>
<td></td>
<td>&gt;8</td>
<td>DR</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 pound per square foot per foot = 0.1571 kPa $^2/m$, 1 pound per square inch = 6.895 kPa.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.

c. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole number multiple of 12 inches (i.e., 12, 24, 36 and 48) that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).

d. Deflection criterion is $L/240$, where $L$ is the height of the basement wall in inches.

e. Interpolation is not permitted.

f. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
g. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.

h. See Table R608.3 for thicknesses and dimensions of waffle-grid walls.

i. DR means design is required in accordance with the applicable building code, or where there is no code, in accordance with ACI 318.

j. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.2(6)

**MINIMUM VERTICAL REINFORCEMENT FOR 8-INCH WAFFLE-GRID BASEMENT WALLS**

<table>
<thead>
<tr>
<th>Maximum Unsupported Wall Height (feet)</th>
<th>Maximum Unbalanced Backfill Height (feet)</th>
<th>Minimum Vertical Reinforcement—Bar Size and Spacing (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soil classes and design lateral soil (psf per foot of depth)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW, SP 30</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5 @ 48</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>5 @ 46</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6 @ 48</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5 @ 46</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 @ 44</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6 @ 34</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6 @ 42</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6 @ 44</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>NR</td>
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<tr>
<td></td>
<td>5</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5 @ 46</td>
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<tr>
<td></td>
<td>7</td>
<td>6 @ 44</td>
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<tr>
<td></td>
<td>8</td>
<td>6 @ 34</td>
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<tr>
<td></td>
<td>9</td>
<td>6 @ 42</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6 @ 44</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 pound per square foot per foot = 0.1571 kPa2/m, 1 pound per square inch = 6.895 kPa.

NR = Not required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.

b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.

c. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 (420 MPa) and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches (i.e., 12, 24, 36 and 48) that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).

d. NR indicates no vertical reinforcement is required.

e. Deflection criterion is L/240, where L is the height of the basement wall in inches.

f. Interpolation shall not be permitted.

g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.

h. See Section R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.

i. See Table R608.3 for thicknesses and dimensions of waffle-grid walls.
j. DR means design is required in accordance with the applicable building code, or where there is no code, in accordance with ACI 318.

k. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.2(7)

**MINIMUM VERTICAL REINFORCEMENT FOR 6-INCH (152 mm) SCREEN-GRID BASEMENT WALLS**

<table>
<thead>
<tr>
<th>MAXIMUM UNSUPPORTED WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soil classes and design lateral soil (psf per foot of depth)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GW, GP, SW, SP 30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GM, GC, SM, SC and ML 45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC, ML-CL and inorganic CL 60</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4 @ 48</td>
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<tr>
<td></td>
<td>5</td>
<td>5 @ 48</td>
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<tr>
<td></td>
<td>6</td>
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<tr>
<td></td>
<td>7</td>
<td>6 @ 48 DR</td>
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<tr>
<td></td>
<td>8</td>
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<tr>
<td>9</td>
<td>4</td>
<td>4 @ 48</td>
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<td>5 @ 48</td>
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<td></td>
<td>7</td>
<td>6 @ 43 DR</td>
</tr>
<tr>
<td></td>
<td>&gt;8</td>
<td>DR</td>
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<tr>
<td>10</td>
<td>4</td>
<td>4 @ 48</td>
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<tr>
<td></td>
<td>5</td>
<td>5 @ 44</td>
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<tr>
<td></td>
<td>6</td>
<td>6 @ 42 DR</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6 @ 40 DR</td>
</tr>
<tr>
<td></td>
<td>&gt;8</td>
<td>DR</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 pound per square foot per foot = 0.1571 kPa/m; 1 pound per square inch = 6.895 kPa.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi, concrete with a minimum specified compressive strength of 2,500 psi and vertical reinforcement being located at the centerline of the wall. See Section R404.1.3.3.7.2.
c. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole number multiple of 12 inches (i.e., 12, 24, 36 and 48) that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.3.7.6 and Table R404.1.2(9).
d. Deflection criterion is $L/240$, where $L$ is the height of the basement wall in inches.
e. Interpolation is not permitted.
f. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
g. See Sections R404.1.3.2 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
h. See Table R608.3 for thicknesses and dimensions of screen-grid walls.
i. DR means design is required in accordance with the applicable building code, or where there is no code, in accordance with ACI 318.
j. The use of this table shall be prohibited for soil classifications not shown.

### TABLE R404.1.2(8)
## Minimum Vertical Reinforcement for 6-, 8-, 10- and 12-Inch Nominal Flat Basement Walls

### Soil Classes and Design Lateral Soil (psf per foot of depth)

<table>
<thead>
<tr>
<th>Soil classes</th>
<th>GW, GP, SW, SP</th>
<th>GM, GC, SM, SM-SC</th>
<th>SC, ML, CL and inorganic CL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>45</td>
<td>60</td>
</tr>
</tbody>
</table>

### Minimum Nominal Wall Thickness (inches)

<table>
<thead>
<tr>
<th>MAXIMUM WALL HEIGHT (feet)</th>
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<th>8</th>
<th>10</th>
<th>12</th>
<th>6</th>
<th>8</th>
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<td>8</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Maximum Unbalanced Backfill Height (feet)

- 4
- 5
- 6
- 7
- 8
- 9
- 10

### Minimum Vertical Reinforcement-BAR SIZE AND SPACING (inches)

<table>
<thead>
<tr>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (feet)</th>
<th>4 @ 35</th>
<th>5 @ 47</th>
<th>6 @ 43</th>
<th>6 @ 37</th>
<th>6 @ 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
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<td></td>
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<tr>
<td>7</td>
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<tr>
<td>10</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
TABLE R404.1.2(95)
MINIMUM SPACING FOR ALTERNATE BAR SIZE AND/OR ALTERNATE GRADE OF STEEL $^{a,b,c}$

<table>
<thead>
<tr>
<th>BAR SPACING FROM APPLICABLE TABLE IN SECTION R404.1.3.2 (inches)</th>
<th>BAR SIZE FROM APPLICABLE TABLE IN SECTION R404.1.3.2</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate bar size and/or alternate grade of steel desired</td>
<td>Grade 60</td>
<td>Grade 60</td>
<td>Grade 60</td>
<td>Grade 60</td>
</tr>
<tr>
<td>#5</td>
<td>#6</td>
<td>#4</td>
<td>#5</td>
<td>#6</td>
</tr>
<tr>
<td>Maximum spacing for alternate bar size and/or alternate grade of steel (inches)</td>
<td>8</td>
<td>12</td>
<td>18</td>
<td>5</td>
</tr>
</tbody>
</table>

---

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 pound per square foot per foot = 0.1571 kPa $^2/m$, 1 pound per square inch = 6.895 kPa.

NR = Not required.

a. Soil classes are in accordance with the Unified Soil Classification System. Refer to Table R405.1.
b. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi.
c. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R404.1.3.7.6 and Table R404.1.2(9).
d. NR indicates no vertical wall reinforcement is required, except for 6-inch nominal walls formed with stay-in-place forming systems in which case vertical reinforcement shall be No. 4 @ 48 inches on center.
e. Allowable deflection criterion is $L/240$, where $L$ is the unsupported height of the basement wall in inches.
f. Interpolation is not permitted.
g. Where walls will retain 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
h. Vertical reinforcement shall be located to provide a cover of $1\frac{1}{4}$ inches measured from the inside face of the wall. The center of the steel shall not vary from the specified location by more than the greater of 10 percent of the wall thickness or $\frac{3}{8}$ inch.
i. Concrete cover for reinforcement measured from the inside face of the wall shall be not less than $\frac{3}{4}$ inch. Concrete cover for reinforcement measured from the outside face of the wall shall be not less than $1\frac{1}{2}$ inches for No. 5 bars and smaller, and not less than 2 inches for larger bars.
j. DR means design is required in accordance with the applicable building code, or where there is no code, in accordance with ACI 318.
k. Concrete shall have a specified compressive strength, $f_{c}$, of not less than 2,500 psi at 28 days, unless a higher strength is required by Footnote l or m.
l. The minimum thickness is permitted to be reduced 2 inches, provided the minimum specified compressive strength of concrete, $f^c$, is 4,000 psi.
m. A plain concrete wall with a minimum nominal thickness of 12 inches is permitted, provided minimum specified compressive strength of concrete, $f^c$, is 3,600 psi.

---

TABLE R404.1.2(95)
MINIMUM SPACING FOR ALTERNATE BAR SIZE AND/OR ALTERNATE GRADE OF STEEL $^{a,b,c}$
<table>
<thead>
<tr>
<th>9</th>
<th>14</th>
<th>20</th>
<th>6</th>
<th>9</th>
<th>13</th>
<th>6</th>
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<td>22</td>
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For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa.
a. This table is for use with tables in Section R404.1.3.2 that specify the minimum bar size and maximum spacing of vertical wall reinforcement for foundation walls and above-grade walls. Reinforcement specified in tables in Section R404.1.3.2 is based on Grade 60 steel reinforcement.
b. Bar spacing shall not exceed 48 inches on center and shall be not less than one-half the nominal wall thickness.
c. For Grade 50 steel bars (ASTM A 996, Type R), use spacing for Grade 40 bars or interpolate between Grades 40 and 60.

R404.1.2.1 Masonry foundation walls.
Concrete masonry and clay masonry foundation walls shall be constructed as set forth in Table R404.1.1(1), R404.1.1(2), R404.1.1(3) or R404.1.1(4) and shall also comply with applicable provisions of Section R606.
Categories D₀, D₁ and D₂, concrete masonry and clay masonry foundation walls shall also comply with Section R404.1.4.1. Rubble stone masonry foundation walls shall be constructed in accordance with Sections R404.1.8 and R606.3.2. Rubble stone masonry walls shall not be used in Seismic Design Categories D₀, D₁ and D₂.

R404.1.3 Concrete foundation walls.
Concrete foundation walls that support light-frame walls shall be designed and constructed in accordance with the provisions of this section, ACI 318, ACI 332 or PCA 100. Concrete foundation walls that support above-grade concrete walls that are within the applicability limits of Section R608.2 shall be designed and constructed in accordance with the provisions of this section, ACI 318, ACI 332 or PCA 100. Concrete foundation walls that support above-grade concrete walls that are not within the applicability limits of Section R608.2 shall be designed and constructed in accordance with the provisions of ACI 318, ACI 332, PCA 100 or the provisions of this section are used to design concrete foundation walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the jurisdiction having authority.

R404.1.3.1 Concrete cross-section.
Concrete walls constructed in accordance with this code shall comply with the shapes and minimum concrete cross-sectional dimensions required by Table R608.3. Other types of forming systems resulting in concrete walls not in compliance with this section and Table R608.3 shall be designed in accordance with ACI 318.

R404.1.3.2 Reinforcement for foundation walls.
Concrete foundation walls shall be laterally supported at the top and bottom. Horizontal reinforcement shall be provided in accordance with Table R404.1.2(1). Vertical reinforcement shall be provided in accordance with Table R404.1.2(2), R404.1.2(3), or R404.1.2(4), R404.1.2(5), R404.1.2(6), R404.1.2(7) or R404.1.2(8). Vertical reinforcement for flat basement walls retaining 4 feet (1219 mm) or more of unbalanced backfill is permitted to be determined in accordance with Table R404.1.2(95). For basement walls supporting above-grade concrete walls, vertical reinforcement shall be the greater of that required by Tables R404.1.2(2) through R404.1.2(8), R404.1.2(4) or by Section R608.6 for the above-grade wall. In buildings assigned to Seismic Design Category D₀, D₁ or D₂, concrete foundation walls shall also comply with Section R404.1.4.2.

R404.1.3.2.1 Concrete foundation stem walls supporting above-grade concrete walls.
Foundation stem walls that support above-grade concrete walls shall be designed and constructed in accordance with this section.

1. Stem walls not laterally supported at top. Concrete stem walls that are not monolithic with slabs-on-ground or are not otherwise laterally supported by slabs-on-ground shall comply with this section. Where unbalanced backfill retained by the stem wall is less than or equal to 18 inches (457 mm), the stem wall and above-grade wall it supports shall be provided with vertical reinforcement in accordance with Section R608.6 and Table R608.6(1), R608.6(2) or R608.6(3) for above-grade walls. Where unbalanced backfill
retained by the stem wall is greater than 18 inches (457 mm), the stem wall and above-grade wall it supports shall be provided with vertical reinforcement in accordance with Section R608.6 and Table R608.6(4).

2. Stem walls laterally supported at top. Concrete stem walls that are monolithic with slabs-on-ground or are otherwise laterally supported by slabs-on-ground shall be vertically reinforced in accordance with Section R608.6 and Table R608.6(1), R608.6(2) or R608.6(3) for above-grade walls. Where the unbalanced backfill retained by the stem wall is greater than 18 inches (457 mm), the connection between the stem wall and the slab-on-ground, and the portion of the slab-on-ground providing lateral support for the wall shall be designed in accordance with PCA 100 or with accepted engineering practice. Where the unbalanced backfill retained by the stem wall is greater than 18 inches (457 mm), the minimum nominal thickness of the wall shall be 6 inches (152 mm).

R404.1.3.2.2 Concrete foundation stem walls supporting light-frame above-grade walls.
Concrete foundation stem walls that support light-frame above-grade walls shall be designed and constructed in accordance with this section.

1. Stem walls not laterally supported at top. Concrete stem walls that are not monolithic with slabs-on-ground or are not otherwise laterally supported by slabs-on-ground and retain 48 inches (1219 mm) or less of unbalanced fill, measured from the top of the wall, shall be constructed in accordance with Section R404.1.3. Foundation stem walls that retain more than 48 inches (1219 mm) of unbalanced fill, measured from the top of the wall, shall be designed in accordance with Sections R404.1.4 and R404.4.

2. Stem walls laterally supported at top. Concrete stem walls that are monolithic with slabs-on-ground or are otherwise laterally supported by slabs-on-ground shall be constructed in accordance with Section R404.1.3. Where the unbalanced backfill retained by the stem wall is greater than 48 inches (1219 mm), the connection between the stem wall and the slab-on-ground, and the portion of the slab-on-ground providing lateral support for the wall, shall be designed in accordance with PCA 100 or in accordance with accepted engineering practice.

R404.1.3.3 Concrete, materials for concrete, and forms.
Materials used in concrete, the concrete itself and forms shall conform to requirements of this section or ACI 318.

R404.1.3.3.1 Compressive strength.
The minimum specified compressive strength of concrete, f’c, shall comply with Section R402.2 and shall be not less than 2,500 psi (17.2 MPa) at 28 days in buildings assigned to Seismic Design Category A, B or C and 3000 psi (20.5 MPa) in buildings assigned to Seismic Design Category D, D1 or D2.

R404.1.3.3.2 Concrete mixing and delivery.
Mixing and delivery of concrete shall comply with ASTM C 94 or ASTM C 685.
R404.1.3.3.3 Maximum aggregate size.
The nominal maximum size of coarse aggregate shall not exceed one-fifth the narrowest distance between sides of forms, or three-fourths the clear spacing between reinforcing bars or between a bar and the side of the form.

Exception: When approved, these limitations shall not apply where removable forms are used and workability and methods of consolidation permit concrete to be placed without honeycombs or voids.

R404.1.3.3.4 Proportioning and slump of concrete.
Proportions of materials for concrete shall be established to provide workability and consistency to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding. Slump of concrete placed in removable forms shall not exceed 6 inches (152 mm).

Exception: When approved, the slump is permitted to exceed 6 inches (152 mm) for concrete mixtures that are resistant to segregation, and are in accordance with the form manufacturer’s recommendations.

Slump of concrete placed in stay-in-place forms shall exceed 6 inches (152 mm). Slump of concrete shall be determined in accordance with ASTM C 143.

R404.1.3.3.5 Consolidation of concrete.
Concrete shall be consolidated by suitable means during placement and shall be worked around embedded items and reinforcement and into corners of forms. Where stay-in-place forms are used, concrete shall be consolidated by internal vibration.

Exception: When approved for concrete to be placed in stay-in-place forms, self-consolidating concrete mixtures with slumps equal to or greater than 8 inches (203 mm) that are specifically designed for placement without internal vibration need not be internally vibrated.

R404.1.3.3.6 Form materials and form ties.
Forms shall be made of wood, steel, aluminum, plastic, a composite of cement and foam insulation, a composite of cement and wood chips, or other approved material suitable for supporting and containing concrete. Forms shall provide sufficient strength to contain concrete during the concrete placement operation.

Form ties shall be steel, solid plastic, foam plastic, a composite of cement and wood chips, a composite of cement and foam plastic, or other suitable material capable of resisting the forces created by fluid pressure of fresh concrete.

R404.1.3.3.6.1 Stay-in-place forms.
Stay-in-place concrete forms shall comply with this section.

1. Surface burning characteristics. The flame-spread index and smoke-developed index of forming material, other than foam plastic, left exposed
on the interior shall comply with Section R302. The surface burning characteristics of foam plastic used in insulating concrete forms shall comply with Section R316.3.

2. Interior covering. Stay-in-place forms constructed of rigid foam plastic shall be protected on the interior of the building as required by Section R316. Where gypsum board is used to protect the foam plastic, it shall be installed with a mechanical fastening system. Use of adhesives in addition to mechanical fasteners is permitted.

3. Exterior wall covering. Stay-in-place forms constructed of rigid foam plastics shall be protected from sunlight and physical damage by the application of an approved exterior wall covering complying with this code. Exterior surfaces of other stay-in-place forming systems shall be protected in accordance with this code.

4. Deleted. Termite protection. In areas where the probability of termite infestation is “very heavy” as indicated by Table R301.2(1) or Figure R301.2(6), foam plastic insulation shall be permitted below grade on foundation walls in accordance with Section R318.4.

5. Flat ICF wall system forms shall conform to ASTM E 2634.

**R404.1.3.3.7 Reinforcement.**

**R404.1.3.3.7.1 Steel reinforcement.**
Steel reinforcement shall comply with the requirements of ASTM A 615, A 706, or A 996. ASTM A 996 bars produced from rail steel shall be Type R. In buildings assigned to Seismic Design Category A, B or C, the minimum yield strength of reinforcing steel shall be 40,000 psi (Grade 40) (276 MPa). In buildings assigned to Seismic Design Category D, reinforcing steel shall comply with the requirements of ASTM A 706 for low-alloy steel with a minimum yield strength of 60,000 psi (Grade 60) (414 MPa).

**R404.1.3.3.7.2 Location of reinforcement in wall.**
The center of vertical reinforcement in basement walls determined from Tables R404.1.2(2) through R404.1.2(7) shall be located at the centerline of the wall. Vertical reinforcement in basement walls determined from Table R404.1.2(8) shall be located to provide a maximum cover of 1 1/4 inches (32 mm) measured from the inside face of the wall. Regardless of the table used to determine vertical wall reinforcement, the center of the steel shall not vary from the specified location by more than the greater of 10 percent of the wall thickness and 3/8 inch (10 mm). Horizontal and vertical reinforcement shall be located in foundation walls to provide the minimum cover required by Section R404.1.3.3.7.4.

**R404.1.3.3.7.3 Wall openings.**
Vertical wall reinforcement required by Section R404.1.3.2 that is interrupted
by wall openings shall have additional vertical reinforcement of the same size placed within 12 inches (305 mm) of each side of the opening.

**R404.1.3.3.7.4 Support and cover.**
Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system to prevent displacement during the concrete placement operation. Steel reinforcement in concrete cast against the earth shall have a minimum cover of 3 inches (75 mm). Minimum cover for reinforcement in concrete cast in removable forms that will be exposed to the earth or weather shall be $1\frac{1}{2}$ inches (38 mm) for No. 5 bars and smaller, and 2 inches (50 mm) for No. 6 bars and larger. For concrete cast in removable forms that will not be exposed to the earth or weather, and for concrete cast in stay-in-place forms, minimum cover shall be $\frac{3}{4}$ inch (19 mm). The minus tolerance for cover shall not exceed the smaller of one-third the required cover or $\frac{3}{8}$ inch (10 mm).

**R404.1.3.3.7.5 Lap splices.**
Vertical and horizontal wall reinforcement shall be the longest lengths practical. Where splices are necessary in reinforcement, the length of lap splice shall be in accordance with Table R608.5.4. (1) and Figure R608.5.4(1). The maximum gap between noncontact parallel bars at a lap splice shall not exceed the smaller of one-fifth the required lap length and 6 inches (152 mm) [See Figure R608.5.4(1)].

**R404.1.3.3.7.6 Alternate grade of reinforcement and spacing.**
Where tables in Section R404.1.3.2 specify vertical wall reinforcement based on minimum bar size and maximum spacing, which are based on Grade 60 (414 MPa) steel reinforcement, different size bars or bars made from a different grade of steel are permitted provided an equivalent area of steel per linear foot of wall is provided. Use of Table R404.1.2(95) is permitted to determine the maximum bar spacing for different bar sizes than specified in the tables or bars made from a different grade of steel. Bars shall not be spaced less than one-half the wall thickness, or more than 48 inches (1219 mm) on center.

**R404.1.3.3.7.7 Standard hooks.**
Where reinforcement is required by this code to terminate with a standard hook, the hook shall comply with Section R608.5.4.5 and Figure R608.5.4(3).

**R404.1.3.3.7.8 Construction joint reinforcement.**
Construction joints in foundation walls shall be made and located to not impair the strength of the wall. Construction joints in plain concrete walls, including walls required to have not less than No. 4 bars at 48 inches (1219 mm) on center by Sections R404.1.3.2 and R404.1.4.2, shall be located at points of lateral support, and a minimum of one No. 4 bar shall extend across the construction joint at a spacing not to exceed 24 inches (610 mm) on center. Construction joint reinforcement shall have a minimum of 12 inches
(305 mm) embedment on both sides of the joint. Construction joints in reinforced concrete walls shall be located in the middle third of the span between lateral supports, or located and constructed as required for joints in plain concrete walls.

**Exception:** Use of vertical wall reinforcement required by this code is permitted in lieu of construction joint reinforcement provided the spacing does not exceed 24 inches (610 mm), or the combination of wall reinforcement and No. 4 bars described above does not exceed 24 inches (610 mm).

**R404.1.3.3.8 Exterior wall coverings.**
Requirements for installation of masonry veneer, stucco and other wall coverings on the exterior of concrete walls and other construction details not covered in this section shall comply with the requirements of this code.

**R404.1.3.4 Requirements for Seismic Design Category C.**
Concrete foundation walls supporting above-grade concrete walls in townhouses assigned to Seismic Design Category C shall comply with ACI 318, ACI 332 or PCA 100 (see Section R404.1.3).

**R404.1.4 Seismic Design Category D0, D1 or D2.** Deleted.

**R404.1.4.1 Masonry foundation walls.**
In buildings assigned to Seismic Design Category D₀, D₁ or D₂, as established in Table R301.2(1), masonry foundation walls shall comply with this section. In addition to the requirements of Table R404.1.1(1), plain masonry foundation walls shall comply with the following:

1. Wall height shall not exceed 8 feet (2438 mm).
2. Unbalanced backfill height shall not exceed 4 feet (1219 mm).
3. Minimum nominal thickness for plain masonry foundation walls shall be 8 inches (203 mm).
4. Masonry stem walls shall have a minimum vertical reinforcement of one No. 4 (No. 13) bar located a maximum of 4 feet (1219 mm) on center in grouted cells. Vertical reinforcement shall be tied to the horizontal reinforcement in the footings.

Foundation walls, supporting more than 4 feet (1219 mm) of unbalanced backfill or exceeding 8 feet (2438 mm) in height shall be constructed in accordance with Table R404.1.1(2), R404.1.1(3) or R404.1.1(4). Masonry foundation walls shall have two No. 4 (No. 13) horizontal bars located in the upper 12 inches (305 mm) of the wall.

**R404.1.4.2 Concrete foundation walls.**
In buildings assigned to Seismic Design Category D₀, D₁ or D₂, as established in Table R301.2(1), concrete foundation walls that support light-frame walls shall comply with this section, and concrete foundation walls that support above-grade concrete walls shall
comply with ACI 318, ACI 332 or PCA 100 (see Section R404.1.3). In addition to the horizontal reinforcement required by Table R404.1.2(1), plain concrete walls supporting light-frame walls shall comply with the following:

1. Wall height shall not exceed 8 feet (2438 mm).

2. Unbalanced backfill height shall not exceed 4 feet (1219 mm).

3. Minimum thickness for plain concrete foundation walls shall be 7.5 inches (191 mm) except that 6 inches (152 mm) is permitted where the maximum wall height is 4 feet, 6 inches (1372 mm).

Foundation walls less than 7.5 inches (191 mm) in thickness, supporting more than 4 feet (1219 mm) of unbalanced backfill or exceeding 8 feet (2438 mm) in height shall be provided with horizontal reinforcement in accordance with Table R404.1.2(1), and vertical reinforcement in accordance with Table R404.1.2(2), R404.1.2(3), R404.1.2(4), R404.1.2(5), R404.1.2(6), R404.1.2(7) or R404.1.2(8). Where Tables R404.1.2(2) through R404.1.2(8) permit plain concrete walls, not less than No. 4 (No. 13) vertical bars at a spacing not exceeding 48 inches (1219 mm) shall be provided.

**R404.1.5 Foundation wall thickness based on walls supported.**
The thickness of masonry or concrete foundation walls shall be not less than that required by Section R404.1.5.1 or R404.1.5.2, respectively.
FIGURE R404.1.5(1)
FOUNDATION WALL CLAY MASONRY CURTAIN WALL WITH CONCRETE MASONRY PIERS

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.
Max pier spacing limited to girder span or 12'-0", whichever is less

Max pier spacing limited to girder span or 12'-0", whichever is less

**FIGURE R404.1.5(1)**

**ALTERNATE ANCHORAGE FOR MASONRY CURTAIN WALL WITH CONCRETE MASONRY PIERS**
R404.1.5.1 Masonry wall thickness.
Masonry foundation walls shall be not less than the thickness of the wall supported, except that masonry foundation walls of at least 8-inch (203 mm) nominal thickness shall be permitted under brick veneered frame walls and under 10-inch-wide (254 mm) cavity walls where the total height of the wall supported, including gables, is not more than 20 feet (6096 mm), provided the requirements of Section R404.1.1 are met.

R404.1.5.2 Concrete wall thickness.
The thickness of concrete foundation walls shall be equal to or greater than the thickness of the wall in the story above. Concrete foundation walls with corbels, brackets or other projections built into the wall for support of masonry veneer or other purposes are not within the scope of the tables in this section.

Where a concrete foundation wall is reduced in thickness to provide a shelf for the support of masonry veneer, the reduced thickness shall be equal to or greater than the thickness of the wall in the story above. Vertical reinforcement for the foundation wall shall be based on Table R404.1.2(8) and located in the wall as required by Section R404.1.3.3.7.2 where that table is used. Vertical reinforcement shall be based on the thickness of the thinner portion of the wall.

Exception: Where the height of the reduced thickness portion measured to the underside of the floor assembly or sill plate above is less than or equal to 24 inches (610 mm) and the reduction in thickness does not exceed 4 inches (102 mm), the vertical reinforcement is permitted to be based on the thicker portion of the wall.

R404.1.5.3 Pier and curtain wall foundations.
Use of pier and curtain wall foundations shall be permitted to support light-frame construction not more than two stories in height, provided the following requirements are met:

1. All load-bearing walls shall be placed on continuous concrete footings placed integrally with the exterior wall footings. Curtain walls shall be bonded into piers and supported on concrete footings poured integrally with pier footings.

2. The minimum actual thickness of a load-bearing masonry curtain walls shall be not less than 4 inches (102 mm) nominal or 3 3/8 inches (92 mm) actual thickness, and shall be bonded integrally with piers spaced in accordance with Section R606.6.4.

3. Piers shall be constructed in accordance with Sections R606.7 and R606.7.1, and shall be bonded into the load-bearing masonry wall in accordance with Section R606.13.1 or R606.13.1.1.

4. The maximum height of a 4-inch (102 mm) load-bearing masonry foundation wall supporting wood-frame walls and floors pier and curtain wall foundations shall be not more than 4 feet (1219 mm) 6 feet (1829 mm).

5. Anchorage shall be in accordance with Section R403.1.6, Figure R404.1.5(1), or as specified by engineered design accepted by the building official.
6. The unbalanced fill for 4-inch (102 mm) foundation walls shall not exceed 24 inches (610 mm) for solid masonry or 12 inches (305 mm) 16 inches (406 mm) for hollow masonry.

7. In Seismic Design Categories D, D, and D, prescriptive reinforcement shall be provided in the horizontal and vertical direction. Provide minimum horizontal joint reinforcement of two No. 9 gage wires spaced not less than 6 inches (152 mm) or one 1/4-inch diameter (6.4 mm) wire at 10 inches (254 mm) on center vertically. Provide minimum vertical reinforcement of one No. 4 bar at 48 inches (1220 mm) on center horizontally grouted in place.

Pier size shall be based on Table R403.1(2).

8. See Chapter 45 for special anchorage and reinforcement in high wind zones.

**R404.1.5.4 Piers.**
The unsupported height of masonry piers shall not exceed 10 times their least dimension. When structural clay tile or hollow concrete masonry units are used for isolated piers to support beams and girders, the cellular spaces shall be filled solidly with concrete or Type M or S mortar, except that unfilled hollow piers may be used if their unsupported height is not more than four times their least dimension. When hollow masonry units are solidly filled with concrete or Type M or S mortar, the allowable compressive stress may be increased as provided in Table R606.9.

**R404.1.6 Height above finished grade.**
Concrete and masonry foundation walls shall extend above the finished grade adjacent to the foundation at all points a minimum of 4 inches (102 mm) where masonry veneer is used and a minimum of 6 inches (152 mm) elsewhere.

**R404.1.7 Backfill placement.**
Backfill shall not be placed against the wall until the wall has sufficient strength and has been anchored to the floor above, or has been sufficiently braced to prevent damage by the backfill.

*Exception:* Bracing is not required for walls supporting less than 4 feet (1219 mm) of unbalanced backfill.

**R404.1.8 Rubble stone masonry.**
Rubble stone masonry foundation walls shall have a minimum thickness of 16 inches (406 mm), shall not support an unbalanced backfill exceeding 8 feet (2438 mm) in height, shall not support a soil pressure greater than 30 pounds per square foot per foot (4.71 kPa/m), and shall not be constructed in Seismic Design Categories D, D, or D or townhouses in Seismic Design Category C, as established in Figure R301.2(2) or Table R301.2(7).
R404.1.9 Isolated masonry piers. Deleted.
Isolated masonry piers shall be constructed in accordance with this section and the general masonry construction requirements of Section R606. Hollow masonry piers shall have a minimum nominal thickness of 8 inches (203 mm), with a nominal height not exceeding four times the nominal thickness and a nominal length not exceeding three times the nominal thickness. Where hollow masonry units are solidly filled with concrete or grout, piers shall be permitted to have a nominal height not exceeding ten times the nominal thickness. Footings for isolated masonry piers shall be sized in accordance with Section R403.1.1.

R404.1.9.1 Pier cap.
Hollow masonry piers shall be capped with 4 inches (102 mm) of solid masonry or concrete, a masonry cap block, or shall have cavities of the top course filled with concrete or grout. Where required, termite protection for the pier cap shall be provided in accordance with Section R318.

R404.1.9.2 Masonry piers supporting floor girders.
Masonry piers supporting wood girders sized in accordance with Tables R602.7(1) and R602.7(2) shall be permitted in accordance with this section. Piers supporting girders for interior bearing walls shall have a minimum nominal dimension of 12 inches (305 mm) and a maximum height of 10 feet (3048 mm) from top of footing to bottom of sill plate or girder. Piers supporting girders for exterior bearing walls shall have a minimum nominal dimension of 12 inches (305 mm) and a maximum height of 4 feet (1220 mm) from top of footing to bottom of sill plate or girder. Girders and sill plates shall be anchored to the pier or footing in accordance with Section R403.1.6 or Figure R404.1.5(1). Floor girder bearing shall be in accordance with Section R502.6.

R404.1.9.3 Masonry piers supporting braced wall panels.
Masonry piers supporting braced wall panels shall be designed in accordance with accepted engineering practice.

R404.1.9.4 Seismic design of masonry piers.
Masonry piers in dwellings located in Seismic Design Category D₀, D₁, or D₂, and townhouses in Seismic Design Category C, shall be designed in accordance with accepted engineering practice.

R404.1.9.5 Masonry piers in flood hazard areas.
Masonry piers for dwellings in flood hazard areas shall be designed in accordance with Section R322.

R404.2 Wood foundation walls.
Wood foundation walls shall be constructed in accordance with the provisions of Sections R404.2.1 through R404.2.6 and with the details shown in Figures R403.1(2) and R403.1(3).

R404.2.1 Identification.
Load-bearing lumber shall be identified by the grade mark of a lumber grading or inspection agency which has been approved by an accreditation body that complies with DOC PS 20. In lieu of a grade mark, a certificate of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted. Wood structural panels
shall conform to DOC PS 1 or DOC PS 2 and shall be identified by a grade mark or certificate of inspection issued by an approved agency.

R404.2.2 Stud size.
The studs used in foundation walls shall be 2-inch by 6-inch (51 mm by 152 mm) members. When spaced 16 inches (406 mm) on center, a wood species with an $F_b$ value of not less than 1,250 pounds per square inch (8619 kPa) as listed in ANSI AWC NDS shall be used. When spaced 12 inches (305 mm) on center, an $F_b$ of not less than 875 psi (6033 kPa) shall be required.

R404.2.3 Height of backfill.
For wood foundations that are not designed and installed in accordance with AWC PWF, the height of backfill against a foundation wall shall not exceed 4 feet (1219 mm). When the height of fill is more than 12 inches (305 mm) above the interior grade of a crawl space or floor of a basement, the thickness of the plywood sheathing shall meet the requirements of Table R404.2.3.

**TABLE R404.2.3**

**PLYWOOD GRADE AND THICKNESS FOR WOOD FOUNDATION CONSTRUCTION (30 pcf equivalent-fluid weight soil pressure)**

<table>
<thead>
<tr>
<th>HEIGHT OF FILL (inches)</th>
<th>STUD SPACING (inches)</th>
<th>FACE GRAIN ACROSS STUDS</th>
<th>FACE GRAIN PARALLEL TO STUDS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grade a</td>
<td>Minimum thickness (inches)</td>
</tr>
<tr>
<td>24</td>
<td>12</td>
<td>B</td>
<td>15 / 32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>B</td>
<td>15 / 32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>12</td>
<td>B</td>
<td>15 / 32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>12</td>
<td>B</td>
<td>15 / c</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per cubic foot = 0.1572 kN/m³.

a. Plywood shall be of the following minimum grades in accordance with DOC PS 1 or DOC PS 2:

1. DOC PS 1 Plywood grades marked:
   1.1. Structural I C-D (Exposure 1).
   1.2. C-D (Exposure 1).

2. DOC PS 2 Plywood grades marked:
   2.1. Structural I Sheathing (Exposure 1).
   2.2. Sheathing (Exposure 1).

3. Where a major portion of the wall is exposed above ground and a better appearance is desired, the following plywood grades marked exterior are suitable:
   3.1. Structural I A-C, Structural I B-C or Structural I C-C (Plugged) in accordance with DOC PS 1.
   3.2. A-C Group 1, B-C Group 1, C-C (Plugged) Group 1 or MDO Group 1 in accordance with DOC PS 1.
   3.3. Single Floor in accordance with DOC PS 1 or DOC PS 2.

b. Minimum thickness 15/32 inch, except crawl space sheathing shall have not less than 3/8 inch for face grain across studs 16 inches on center and maximum 2-foot depth of unequal fill.

c. For this fill height, thickness and grade combination, panels that are continuous over less than three spans (across less than three stud spacings) require blocking 16 inches above the bottom plate. Offset adjacent blocks and fasten through studs with two 16d corrosion-resistant nails at each end.

**R404.2.4 Backfilling.**

Wood foundation walls shall not be backfilled until the basement floor and first floor have been constructed or the walls have been braced. For crawl space construction, backfill or bracing shall be installed on the interior of the walls prior to placing backfill on the exterior.

**R404.2.5 Drainage and dampproofing.**

Wood foundation basements shall be drained and dampproofed in accordance with Sections R405 and R406, respectively.

**R404.2.6 Fastening.**

Wood structural panel foundation wall sheathing shall be attached to framing in accordance with Table R602.3(1) and Section R402.1.1.

**R404.3 Wood sill plates.**

Wood sill plates shall be a minimum of 2-inch by 4-inch (51 mm by 102 mm) nominal lumber. Sill plate anchorage shall be in accordance with Sections R403.1.6 and R602.11.

**R404.4 Retaining walls.**

Retaining walls that are not laterally supported at the top and that retain in excess of 48 inches (1219 mm) of unbalanced fill, or retaining walls exceeding 24 inches (610 mm) in height that resist lateral loads in addition to soil, shall be designed in accordance with accepted engineering practice to ensure stability against overturning, sliding, excessive foundation pressure and water uplift. Retaining walls shall be designed for a safety factor of 1.5 against lateral sliding and overturning. This section shall not apply to foundation walls supporting buildings.
Retaining walls that are not laterally supported at the top and that retain in excess of 48 inches (1219 mm) of unbalanced fill shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift. In addition any retaining wall which meets the following:

1. Any retaining wall systems on a residential site that cross over adjacent property lines regardless of vertical height, and
2. Retaining walls that support buildings and their accessory structures.

Retaining walls shall be designed for a safety factor of 1.5 against lateral sliding and overturning.

R404.5 Precast concrete foundation walls.

R404.5.1 Design.
Precast concrete foundation walls shall be designed in accordance with accepted engineering practice. The design and manufacture of precast concrete foundation wall panels shall comply with the materials requirements of Section R402.3 or ACI 318. The panel design drawings shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed in accordance with Section R106.1.

R404.5.2 Precast concrete foundation design drawings.
Precast concrete foundation wall design drawings shall be submitted to the building official and approved prior to installation. Drawings shall include, at a minimum, the following information:

1. Design loading as applicable.
2. Footing design and material.
3. Concentrated loads and their points of application.
4. Soil bearing capacity.
5. Maximum allowable total uniform load.
6. Seismic design category.
7. Basic wind speed.

R404.5.3 Identification.
Precast concrete foundation wall panels shall be identified by a certificate of inspection label issued by an approved third-party inspection agency.
R405.1 Concrete or masonry foundations. Drains shall be provided around concrete or masonry foundations that retain earth and enclose habitable or usable spaces located below grade. Drainage tiles, gravel or crushed stone drains, perforated pipe or other approved systems or materials shall be installed at or below the area to be protected and shall discharge by gravity or mechanical means into an approved drainage system. Gravel or crushed stone drains shall extend not less than 1 foot (305 mm) beyond the outside edge of the footing and 6 inches (152 mm) above the top of the footing and be covered with an approved filter membrane material. The top of open joints of drain tiles shall be protected with strips of building paper. Except where otherwise recommended by the drain manufacturer, perforated drains shall be surrounded with an approved filter membrane or the filter membrane shall cover the washed gravel or crushed rock covering the drain. Drainage tiles or perforated pipe shall be placed on a minimum of 2 inches (51 mm) of washed gravel or crushed rock not less than one sieve size larger than the tile joint opening or perforation and covered with not less than 6 inches (152 mm) of the same material.

Exception: A drainage system is not required where the foundation is installed on well-drained ground or sand-gravel mixture soils according to the Unified Soil Classification System, Group I soils, as detailed in Table R405.1.

<table>
<thead>
<tr>
<th>SOIL GROUP</th>
<th>UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL</th>
<th>SOIL DESCRIPTION</th>
<th>DRAINAGE CHARACTERISTICS a</th>
<th>FROST HEAVE POTENTIAL</th>
<th>VOLUME CHANGE POTENTIAL EXPANSION b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>GW</td>
<td>Well-graded gravels, gravel sand mixtures, little or no fines</td>
<td>Good</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>GP</td>
<td>Poorly graded gravels or gravel sand mixtures, little or no fines</td>
<td>Good</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Soil Type</td>
<td>Description</td>
<td>Percolation Rate</td>
<td>Plasticity</td>
<td>Potential Expansion</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td>------------------</td>
<td>------------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>SW</td>
<td>Well-graded sands, gravelly sands, little or no fines</td>
<td>Good</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>Poorly graded sands or gravelly sands, little or no fines</td>
<td>Good</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>Silty gravels, gravel-sand-silt mixtures</td>
<td>Good</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>Silty sand, sand-silt mixtures</td>
<td>Good</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>Clayey gravels, gravel-sand-clay mixtures</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Clayey sands, sand-clay mixture</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>ML</td>
<td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>CL</td>
<td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium to Low</td>
<td></td>
</tr>
<tr>
<td>CH</td>
<td>Inorganic clays of high plasticity, fat clays</td>
<td>Poor</td>
<td>Medium</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>MH</td>
<td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts</td>
<td>Poor</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>OL</td>
<td>Organic silts and organic silty clays of low plasticity</td>
<td>Poor</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>OH</td>
<td>Organic clays of medium to high plasticity, organic silts</td>
<td>Unsatisfactory</td>
<td>Medium</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Pt</td>
<td>Peat and other highly organic soils</td>
<td>Unsatisfactory</td>
<td>Medium</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. The percolation rate for good drainage is over 4 inches per hour, medium drainage is 2 inches to 4 inches per hour, and poor is less than 2 inches per hour.

b. Soils with a low potential expansion typically have a plasticity index (PI) of 0 to 15, soils with a medium potential expansion have a PI of 10 to 35 and soils with a high potential expansion have a PI greater than 20.

**R405.1.1 Precast concrete foundation.**

Precast concrete walls that retain earth and enclose habitable or useable space located below-grade that rest on crushed stone footings shall have a perforated drainage pipe installed below the base of the wall on either the interior or exterior side of the wall, not less than 1 foot (305 mm) beyond the edge of the wall. If the exterior drainage pipe is used, an approved filter membrane material shall cover the pipe. The drainage system shall discharge into an approved sewer system or to daylight.
R405.2 Wood foundations.
Wood foundations enclosing habitable or usable spaces located below grade shall be adequately drained in accordance with Sections R405.2.1 through R405.2.3.

R405.2.1 Base.
A porous layer of gravel, crushed stone or coarse sand shall be placed to a minimum thickness of 4 inches (102 mm) under the basement floor. Provision shall be made for automatic draining of this layer and the gravel or crushed stone wall footings.

R405.2.2 Vapor retarder.
A 6-mil-thick (0.15 mm) polyethylene vapor retarder shall be applied over the porous layer with the basement floor constructed over the polyethylene.

R405.2.3 Drainage system.
In other than Group I soils, a sump shall be provided to drain the porous layer and footings. The sump shall be not less than 24 inches (610 mm) in diameter or 20 inches square \((0.0129 \text{ m}^2)\), shall extend not less than 24 inches (610 mm) below the bottom of the basement floor and shall be capable of positive gravity or mechanical drainage to remove any accumulated water. The drainage system shall discharge into an approved sewer system or to daylight.

SECTION R406
FOUNDATION WATERPROOFING AND DAMPPROOFING

R406.1 Concrete and masonry foundation dampproofing.
Except where required by Section R406.2 to be waterproofed, foundation walls that retain earth and enclose interior spaces and floors below grade shall be dampproofed from the higher of (a) the top of the footing or (b) 6 inches (152 mm) below the top of the basement floor, to the finished grade. Masonry walls shall have not less than \(\frac{3}{8}\) inch (9.5 mm) portland cement parging applied to the exterior of the wall. The parging shall be dampproofed in accordance with one of the following:

1. Bituminous coating.

2. Three pounds per square yard \((1.63 \text{ kg/m}^2)\) of acrylic modified cement.

3. One-eighth-inch \((3.2 \text{ mm})\) coat of surface-bonding cement complying with ASTM C 887.

4. Any material permitted for waterproofing in Section R406.2.

5. Other approved methods or materials.

**Exception:** Parging of unit masonry walls is not required where a material is approved for direct application to the masonry.

Concrete walls shall be dampproofed by applying any one of the listed dampproofing materials or any one of the waterproofing materials listed in Section R406.2 to the exterior of the wall.
Foundation walls where the outside grade is higher than the inside grade shall be dampproofed from the top of the footing to the finished grade. The foundation walls shall be dampproofed with a bituminous coating, 3 pounds per square yard (1.63 kg/m) of acrylic modified cement, or 1/8-inch (3.2 mm) coat of surface bonding mortar complying with ASTM C 887 or any material permitted for waterproofing in Section R406.2. Concrete walls shall be dampproofed by applying any one of the above listed dampproofing materials or any one of the waterproofing materials listed in Section R406.2 to the exterior of the wall.

R406.2 Concrete and masonry foundation waterproofing.
In areas where a high water table or other severe soil-water conditions are known to exist, exterior foundation walls that retain earth and enclose interior spaces and floors below grade shall be waterproofed from the higher of (a) the top of the footing or (b) 6 inches (152 mm) below the top of the basement floor, to the finished grade. Walls shall be waterproofed in accordance with one of the following:

1. Two-ply hot-mopped felts.
2. Fifty-five-pound (25 kg) roll roofing.
3. Six-mil (0.15 mm) polyvinyl chloride.
4. Six-mil (0.15 mm) polyethylene.
5. Forty-mil (1 mm) polymer-modified asphalt.
6. Sixty-mil (1.5 mm) flexible polymer cement.
7. One-eighth-inch (3 mm) cement-based, fiber-reinforced, waterproof coating.
8. Sixty-mil (1.5 mm) solvent-free liquid-applied synthetic rubber.

Exception: Organic-solvent-based products such as hydrocarbons, chlorinated hydrocarbons, ketones and es-ters shall not be used for ICF walls with expanded polystyrene form material. Use of plastic roofing cements, acrylic coatings, latex coatings, mortars and pargings to seal ICF walls is permitted. Cold-setting asphalt or hot asphalt shall conform to Type C of ASTM D 449. Hot asphalt shall be applied at a temperature of less than 200°F (93°C).

All joints in membrane waterproofing shall be lapped and sealed with an adhesive compatible with the membrane.

R406.3 Dampproofing for wood foundations.
Wood foundations enclosing habitable or usable spaces located below grade shall be dampproofed in accordance with Sections R406.3.1 through R406.3.4.

R406.3.1 Panel joint sealed.
Plywood panel joints in the foundation walls shall be sealed full length with a caulking compound capable of producing a moisture-proof seal under the conditions of temperature and moisture content at which it will be applied and used.
**R406.3.2 Below-grade moisture barrier.**
A 6-mil-thick (0.15 mm) polyethylene film shall be applied over the below-grade portion of exterior foundation walls prior to backfilling. Joints in the polyethylene film shall be lapped 6 inches (152 mm) and sealed with adhesive. The top edge of the polyethylene film shall be bonded to the sheathing to form a seal. Film areas at grade level shall be protected from mechanical damage and exposure by a pressure-preservative treated lumber or plywood strip attached to the wall several inches above finished grade level and extending approximately 9 inches (229 mm) below grade. The joint between the strip and the wall shall be caulked full length prior to fastening the strip to the wall. Where approved, other coverings appropriate to the architectural treatment shall be permitted to be used. The polyethylene film shall extend down to the bottom of the wood footing plate but shall not overlap or extend into the gravel or crushed stone footing.

**R406.3.3 Porous fill.**
The space between the excavation and the foundation wall shall be backfilled with the same material used for footings, up to a height of 1 foot (305 mm) above the footing for well-drained sites, or one-half the total back-fill height for poorly drained sites. The porous fill shall be covered with strips of 30-pound (13.6 kg) asphalt paper or 6-mil (0.15 mm) polyethylene to permit water seepage while avoiding infiltration of fine soils.

**R406.3.4 Backfill.**
The remainder of the excavated area shall be backfilled with the same type of soil as was removed during the excavation.

**R406.4 Precast concrete foundation system dampproofing.**
Except where required by Section R406.2 to be waterproofed, precast concrete foundation walls enclosing habitable or useable spaces located below grade shall be dampproofed in accordance with Section R406.1.

**R406.4.1 Panel joints sealed.**
Precast concrete foundation panel joints shall be sealed full height with a sealant meeting ASTM C 920, Type S or M, Grade NS, Class 25, Use NT, M or A. Joint sealant shall be installed in accordance with the manufacturer’s instructions.

**SECTION R407**
**COLUMNS**

**R407.1 Wood column protection.**
Wood columns shall be protected against decay as set forth in Section R317.

**R407.2 Steel column protection.**
All surfaces (inside and outside) of steel columns shall be given a shop coat of rust-inhibitive paint, except for corrosion-resistant steel and steel treated with coatings to provide corrosion resistance.

**R407.3 Structural requirements.**
The columns shall be restrained to prevent lateral displacement at the top and bottom ends. Wood columns shall be not less in nominal size than 4 inches by 4 inches (102 mm by 102
Steel columns shall be not less than 3-inch-diameter (76 mm) Schedule 40 pipe manufactured in accordance with ASTM A 53 Grade B or approved equivalent.

**Exception:** In Seismic Design Categories A, B and C, columns not more than 48 inches (1219 mm) in height on a pier or footing are exempt from the bottom end lateral displacement requirement within under-floor areas enclosed by a continuous foundation.

**SECTION R408 UNDER-FLOOR SPACE WALL VENTED CRAWL SPACES**

**R408.1 Ventilation.**
The under-floor space between the bottom of the floor joists and the earth under any building (except space occupied by a basement) shall have ventilation openings through foundation walls or exterior walls. The minimum net area of ventilation openings shall be not less than 1 square foot (0.0929 m$^2$) for each 150 square feet (14 m$^2$) of under-floor space area, unless the ground surface is covered by a Class 1 vapor retarder material. Where a Class 1 vapor retarder material is used, the minimum net area of ventilation openings shall be not less than 1 square foot (0.0929 m$^2$) for each 1,500 square feet (140 m$^2$) of under-floor space area. One such ventilating opening shall be within 3 feet (914 mm) of each corner of the building.

**R408.2 Openings for under-floor ventilation.**
The minimum net area of ventilation openings shall be not less than 1 square foot (0.0929 m$^2$) for each 150 square feet (14 m$^2$) of under-floor area. One ventilation opening shall be within 3 feet (915 mm) of each corner of the building. Ventilation openings shall be covered for their height and width with any of the following materials provided that the least dimension of the covering shall not exceed $\frac{1}{4}$ inch (6.4 mm):

1. Perforated sheet metal plates not less than 0.070 inch (1.8 mm) thick.
2. Expanded sheet metal plates not less than 0.047 inch (1.2 mm) thick.
3. Cast-iron grill or grating.
4. Extruded load-bearing brick vents.
5. Hardware cloth of 0.035 inch (0.89 mm) wire or heavier.
6. Corrosion-resistant wire mesh, with the least dimension being $\frac{1}{8}$ inch (3.2 mm) thick.

**Exception:** The total area of ventilation openings shall be permitted to be reduced to $\frac{1}{1500}$ of the under-floor area where the ground surface is covered with an approved Class I vapor retarder material and the required openings are placed to provide cross ventilation of the space. The installation of operable louvers shall not be prohibited.
R408.3 Unvented crawl space.
Ventilation openings in under-floor spaces specified in Sections R408.1 and R408.2 shall not be required where the following items are provided:

1. Exposed earth is covered with a continuous Class I vapor retarder. Joints of the vapor retarder shall overlap by 6 inches (152 mm) and shall be sealed or taped. The edges of the vapor retarder shall extend not less than 6 inches (152 mm) up the stem wall and shall be attached and sealed to the stem wall or insulation.

2. One of the following is provided for the under-floor space:
   2.1. Continuously operated mechanical exhaust ventilation at a rate equal to 1 cubic foot per minute (0.47 L/s) for each 50 square feet (4.7 m²) of crawl space floor area, including an air pathway to the common area (such as a duct or transfer grille), and perimeter walls insulated in accordance with Section N1102.2.11 of this code.
   2.2. Conditioned air supply sized to deliver at a rate equal to 1 cubic foot per minute (0.47 L/s) for each 50 square feet (4.7 m²) of under-floor area, including a return air pathway to the common area (such as a duct or transfer grille), and perimeter walls insulated in accordance with Section N1102.2.11 of this code.
   2.3. Plenum in existing structures complying with Section M1601.5, if under-floor space is used as a plenum.

R408.4 Access.
Access shall be provided to all under-floor spaces. Access openings through the floor shall be a minimum of 18 inches by 24 inches (457 mm by 610 mm). Openings through a perimeter wall shall be not less than 16 inches by 24 inches (407 mm by 610 mm). Where any portion of the through-wall access is below grade, an areaway not less than 16 inches by 24 inches (407 mm by 610 mm) shall be provided. The bottom of the areaway shall be below the threshold of the access opening. Through wall access openings shall not be located under a door to the residence. See Section M1305.1.4 for access requirements where mechanical equipment is located under floors.

R408.5 Removal of debris.
The under-floor grade shall be cleaned of all vegetation and organic material. All wood forms used for placing concrete shall be removed before a building is occupied or used for any purpose. All construction materials shall be removed before a building is occupied or used for any purpose.

R408.6 Finished grade.
The finished grade of under-floor surface shall be permitted to be located at the bottom of the footings; however, where there is evidence that the groundwater table can rise to within 6 inches (152 mm) of the finished floor at the building perimeter or where there is evidence that the surface water does not readily drain from the building site, the grade in the under-floor space shall be as high as the outside finished grade, unless an approved drainage system is provided.
R408.1 Space moisture vapor control.
Vented crawl space foundations shall be provided with foundation vent openings through the exterior foundation walls.

R408.1.1 Foundation vent sizing.
The minimum net area of ventilation openings shall be not less than 1 square foot (0.0929 m²) for each 150 square feet (13.9 m²) of crawl space ground area.

Exception: The total area of ventilation openings may be reduced to 1/1,500 of the under-floor area where the ground surface is treated with an approved vapor retarder material in accordance with Section R408.2 and the required openings are placed so as to provide cross-ventilation of the crawl space. The installation of operable louvers shall not be prohibited.

R408.1.2 Foundation vent location.
One foundation vent shall be within 3 feet (914 mm) of each corner of the building. To prevent rainwater entry when the crawlspace is built on a sloped site, the uphill foundation walls may be constructed without wall vent openings. Vent dams shall be provided when the bottom of the foundation vent opening is less than 4 inches (102 mm) above the finished exterior grade.

R408.1.3 Covering material.
To prevent rodent entry, foundation vents shall be covered with any of the following materials provided that the ventilation holes through the covering material shall not exceed 1/4 inch (6.4 mm) in any direction:

1. Perforated sheet metal plates not less than 0.070 inch (1.8 mm) thick.
2. Expanded sheet metal plates no less than 0.047 inch (1.2 mm) thick.
3. Cast iron grills or grating.
4. Extruded load-bearing brick vents.
5. Hardware cloth of 0.035 inch (0.89 mm) wire or heavier.
6. Corrosion-resistant mesh, with the least dimension being 1/8 inch (3.2 mm).

R408.1.4 Drains and vent terminations.
Drains (including but not limited to pressure relief and drain pans) shall terminate outdoors, to crawl space floor drains or interior pumps, and shall not intentionally discharge water into the crawl space. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains. Dryer vents shall terminate outdoors.

R408.1.5 Space separation.
Wall vented crawl spaces shall be separated from adjoining basements, porches and garages by permanent solid wall surfaces with all utility penetrations through the separating wall sealed. Latched, weather-stripped doors or access panels shall provide access between the crawl space and such adjoining spaces.

R408.2 Ground vapor retarder.
When required by Section R408.1.1 Exception, a minimum 6-mil (0.15 mm) polyethylene vapor retarder or equivalent shall be installed to nominally cover all exposed earth in the crawl space, with joints lapped not less than 12 inches (305 mm). Where there is no evidence that the groundwater table can rise to within 6 inches (152 mm) of the floor of the crawl space, it is
acceptable to puncture the ground vapor retarder at low spots to prevent water puddles from forming on top of the vapor retarder due to condensation.

**R408.3 Wall damp proofing.**
Where the outside grade is higher than the inside grade the exterior walls shall be dampproofed from the top of the footing to the finished grade as required by Section R406.1.

**R408.4 Site grading.**
Building site shall be graded to drain water away from the crawl space foundation per the requirements of Section R401.3.

**R408.5 Insulation.**
The thermal insulation in a wall vented crawl space shall be placed in the floor system. Wall insulation is not allowed as the only insulation system in a wall vented crawl space. The required insulation value can be determined from Table N1102.1.

**R408.6 Floor air leakage control.**
All plumbing, electrical, duct, plenum, phone, cable, computer wiring and other penetrations through the subfloor shall be sealed with non-porous materials, caulks, or sealants. The use of rock wool or fiberglass insulation is prohibited as an air sealant.

**R408.7 Duct air leakage control.**
All heating and cooling ductwork located in the crawl space shall be sealed with mastic or other industry approved duct closure systems.

**R408.8 Access.**
A minimum access opening measuring 18 inches by 24 inches (457 mm by 610 mm) shall be provided to the crawl space. See the *North Carolina Mechanical Code* for access requirements where mechanical equipment is located under floors.

**R408.9 Removal of debris.**
The crawl space floor shall be cleaned of all vegetation and organic material. All wood forms used for placing shall be removed before the building is occupied or used for any purpose. All construction materials shall be removed before the building is occupied or used for any purpose.

**R408.10 Finished grade.**
The finished grade of the crawl space is permitted to be located at the bottom of the footings; however, where there is evidence that the groundwater table can rise to within 6 inches (152 mm) of the finished grade of the crawl space at the perimeter or where there is evidence that the surface water does not readily drain from the building site, the grade in the crawl space shall be as high as the outside finished grade, unless an approved drainage system is provided.

**R408.11 Flood resistance.**
For buildings located in flood hazard areas as established in Table R301.2(1):

1. Walls enclosing the under-floor space shall be provided with flood openings in accordance with Section R322.2.2.

2. The finished ground level of the under-floor space shall be equal to or higher than the outside finished ground level on at least one side.
Exception: Under-floor spaces that meet the requirements of FEMA/FIA TB 11-1.

SECTION R409
CLOSED CRAWL SPACES

R409.1 Air sealed walls.
Closed crawl spaces shall be built to minimize the entry of outdoor air into the crawl space. Specifically prohibited are foundation wall vents and wall openings to ventilated porch foundations. When outdoor packaged heating and cooling equipment is used, solid blocking and sealants shall be used to seal gaps between the exterior wall opening and the smaller supply and return ducts that pass through the opening.

R409.1.1 Caulking and sealants.
Air sealing caulks, gaskets or sealants shall be applied to the foundation wall and floor assemblies that separate the crawl space from outside and other ventilated areas such as joints around access door and frame, between foundation and sill plate, at penetrations for plumbing, mechanical, electrical and gas lines and at duct penetrations.

R409.1.2 Access panel/door.
A minimum access opening measuring 18 inches by 24 inches (457 mm by 610 mm) shall be provided to the crawl space. See the North Carolina Mechanical Code for access requirements where mechanical equipment is located under floors. To minimize air entry, provide a tight fitting access panel/door with a latch mechanism. Access panels or doors shall be insulated to a minimum of R-2.

R409.2 Groundwater vapor retarder.
Closed crawl spaces shall be protected from water entry by the evaporation of water from the ground surface.

R409.2.1 Ground vapor retarder.
A minimum 6-mil (0.15 mm) polyethylene vapor retarder or equivalent shall be installed to nominally cover all exposed earth in the crawl space, with joints lapped not less than 12 inches (305 mm). Minor pockets or wrinkles that prevent total drainage across the surface of the vapor retarder are allowed. The floor of the crawl space shall be graded so that it drains to one or more low spots. Install a drain to daylight or sump pump at each low spot. Crawl space drains shall be kept separate from roof gutter drain systems and foundation perimeter drains.

R409.2.2 Liner.
The ground vapor retarder is permitted to be installed as a full interior liner by sealing the edges to the walls and beam columns and sealing the seams. Single piece liner systems are approved. The top edge of the wall liner shall terminate 3 inches (76 mm) below the top edge of the masonry foundation wall. The top edge of the liner shall be brought up the interior columns a minimum of 4 inches (102 mm) above the crawl space floor. The floor of the crawl space shall be graded so that it drains to one or more low spots. Install a drain to daylight or sump pump at each low spot. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains.
R409.2.2.1 Wall liner termite inspection gap.
Provide a clear and unobstructed 3 inch (76 mm) minimum, 4 inch (102 mm) maximum inspection gap between the top of the wall liner and the bottom of the wood sill. This inspection gap may be ignored with regards to energy performance and is not intended to create an energy penalty.

R409.2.3 Concrete floor surfacing.
The ground vapor retarder may be protected against ripping and displacement by pouring an unreinforced, minimum 2 inch (51 mm) thick, concrete surface directly over the vapor barrier. A base course of gravel or other drainage material under the ground moisture barrier is not required. The floor of the crawl space shall be graded so that the concrete surface drains to one or more low spots. Install a drain to daylight or sump pump at each low spot. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains.

R409.2.4 Drains and vent terminations.
Drains (including but not limited to pressure relief and drain pans) shall terminate outdoors, to crawl space floor drains or interior pumps, and shall not intentionally discharge water into the crawl space. Crawl space drains shall be separate from roof gutter drain systems and foundation perimeter drains. Dryer vents shall terminate outdoors.

R409.3 Wall damp proofing.
Where the outside grade is higher than the inside grade, the exterior walls shall be dampproofed from the top of the footing to the finished grade as required by Section R406.1.

R409.4 Site grading.
Building site shall be graded to drain water away from the crawl space foundation per the requirements of Section R401.3.

R409.5 Space moisture vapor control.
Closed crawl spaces shall be provided with a mechanical drying capability to control space moisture levels. The allowed methods are listed below in Sections R409.5.1 through R409.5.5. At least one method shall be provided; however, combination systems shall be allowed.

R409.5.1 Dehumidifier.
A permanently installed dehumidifier shall be provided in the crawl space. The minimum rated capacity per day is 15 pints (7.1 Liters). Condensate discharge shall be drained to daylight or interior condensate pump. Permanently installed dehumidifier shall be provided with an electrical outlet.

R409.5.2 Supply air.
Supply air from the dwelling air conditioning system shall be ducted into the crawl space at the rate of 1 cubic foot per minute (0.5 L/s) per 30 square feet (4.6 m²) of crawl space floor area. No return air duct from the crawl space to the dwelling air conditioning system is allowed. The crawl space supply air duct shall be fitted with a backflow damper to prevent the entry of crawl space air into the supply duct system when the system fan is not operating. An air relief vent to the outdoors may be installed. Crawl spaces with moisture vapor control installed in accordance with this section are not considered plenums.

R409.5.3 House air.
House air shall be blown into the crawl space with a fan at the rate of 1 cubic foot per minute
(0.5 L/s) per 50 square feet (4.6 m²) of crawl space floor area. The fan motor shall be rated for continuous duty. No return air duct from the crawl space to the dwelling air conditioning system is allowed. An air relief vent to the outdoors may be installed. Crawl spaces with moisture vapor control installed in accordance with this section are not considered plenums.

**R409.5.4 Exhaust fan.**
Crawl space air shall be exhausted to outside with a fan at the rate of 1 cubic foot per minute (0.5 L/s) per 50 square feet (4.6 m²) of crawl space floor area. The fan motor shall be rated for continuous duty. There is no requirement for make-up air.

**R409.5.5 Conditioned space.**
The crawl space shall be designed as a heated and cooled, conditioned space with wall insulation installed in accordance with the requirements of Section R409.8. Intentionally returning air from the crawl space to space-conditioning equipment that serves the dwelling shall be allowed. Foam plastic insulation located in a crawl space plenum shall be protected against ignition by an approved thermal barrier.

**R409.6 Plenums.**
Closed crawl spaces used as supply or return plenums for distribution of heated or cooled air shall comply with the requirements of the North Carolina Mechanical Code. Crawl space plenums shall not contain plumbing cleanouts, gas lines or other prohibited components. Foam plastic insulation located in a crawl space plenum shall be protected against ignition by an approved thermal barrier.

**R409.7 Combustion air.**
The air sealing requirements of a closed crawl space may result in a foundation which cannot provide adequate combustion air for fuel-burning appliances; therefore, fuel-burning appliances located in the crawl space such as furnaces and water heaters shall obtain combustion air from outdoors as per the North Carolina Mechanical Code.

**R409.8 Insulation.**
The thermal insulation in a crawl space may be located in the floor system or at the exterior walls. The required insulation value can be determined from Table N1102.1.

**Exception:** Insulation shall be placed at the walls when the closed crawl space is designed to be intentionally heated or cooled, conditioned space.

**R409.8.1 Wall insulation.**
Where the floor above a crawl space is not insulated, the walls shall be insulated. Wall insulation is permitted to be located on any combination of the exterior and interior surfaces and within the structural cavities or materials of the exterior crawl space walls. Wall insulation systems require that the band joist area of the floor frame be insulated. Wall insulation shall begin 3 inches (76 mm) below the top of the masonry foundation wall and shall extend down to 3 inches (76 mm) above the top of the footing or concrete floor, 3 inches (76 mm) above the interior ground surface or 24-inches (610 mm) below the outside finished ground level, whichever is less. No insulation shall be required on masonry walls of 9 inches (229 mm) height or less.

**R409.8.1.1 Foam plastic termite inspection gap.**
For outside walls, Section R318.4 governs applications. When expanded polystyrene, polyisocyanurate, or other foam plastic insulation is installed on the inside surface of the exterior foundation walls, provisions in Sections R409.8.1.1 through R409.8.1.2 below apply.

**R409.8.1.1 Earth floored crawl spaces.**
Provide a clear and unobstructed 3-inch (76 mm) minimum, 4 inch (102 mm) maximum termite inspection gap between the top of the foam plastic wall insulation and the bottom of the wood sill. Because insulation ground contact is not allowed, provide a continuous 3-inch (76 mm) minimum clearance gap between the bottom edge of the foam plastic wall insulation and the earth floor surface. Refer to Section N1102.2.9 to determine maximum allowances for insulation gaps.

**R409.8.1.2 Concrete floor surfaced crawl spaces.**
Provide a clear and unobstructed 3-inch (76 mm) minimum, 4 inch (102 mm) maximum termite inspection gap between the top of the foam plastic wall insulation and the bottom of the wood sill. Provide a continuous 3-inch (76 mm) minimum clearance gap between the bottom edge of the foam plastic wall insulation and the concrete floor surface. Refer to Section N1102.2.9 to determine maximum allowances for insulation gaps.

**R409.8.2 Porous insulation material.**
When fiberglass, rockwool, cellulose or other porous insulation materials are installed on the inside wall surface of a closed crawl space, provide a clear and unobstructed 3-inch (76 mm) minimum termite inspection gap between the top of the porous wall insulation and the bottom of the wood sill.

To reduce wicking potential, porous insulation ground contact is not allowed in earth floored or concrete surfaces crawl spaces. Provide a continuous 3-inch (76 mm) minimum wicking gap between the bottom edge of the porous wall insulation and the earth or concrete floor surface. Refer to Section N1102.1.7 to determine maximum allowances for insulation gaps.

**R409.8.2 Foam plastic fire safety.**
Foam plastic insulation may be installed inside crawl spaces without a thermal cover when the insulation product has been tested in accordance with ASTM E 84 to have a flame-spread rating of not more than 25 and a smoke developed rating of not more than 450. Foam plastics that have not been tested to meet these ratings shall be protected against ignition by covering them with a thermal barrier. Acceptable thermal barriers include but are not limited to 1/2 inch (13 mm) cement board, metal foil sheets, metal foil tape, steel or aluminum metal sheets or other approved materials installed in such a manner that the foam is not exposed.

**Exception:** Foam plastic insulation located in closed crawl spaces used as conditioned spaces or plenums shall be protected against ignition by an approved thermal barrier.

**R409.9 Floor air leakage control.**
All plumbing, electrical, duct, plenum, phone, cable, computer wiring and other penetrations through the subfloor shall be sealed with non-porous materials, caulks, or sealants. The use of rockwool or fiberglass insulation is prohibited as an air sealant.
R409.10 Duct air leakage control.
All heating and cooling ductwork located in the crawl space shall be sealed with mastic or other industry approved duct closure systems.

R409.11 Access.
A minimum access opening measuring 18 inches by 24 inches (457 mm by 610 mm) shall be provided to the crawl space. See the North Carolina Mechanical Code for access requirements where mechanical equipment is located under floors.

R409.12 Removal of debris.
The crawl space floor shall be cleaned of all vegetation and organic material. All wood forms used for placing shall be removed before the building is occupied or used for any purpose. All construction materials shall be removed before the building is occupied or used for any purpose.

R409.13 Finished grade.
The finished grade of the crawlspace is permitted to be located at the bottom of the footings; however, where there is evidence that the groundwater table can rise to within 6 inches (152 mm) of the finished grade of the crawl space at the perimeter or where there is evidence that the surface water does not readily drain from the building site, the grade in the crawl space shall be as high as the outside finished grade, unless an approved drainage system is provided.
CHAPTER 5
FLOORS

SECTION R501
GENERAL

R501.1 Application.
The provisions of this chapter shall control the design and construction of the floors for buildings, including the floors of attic spaces used to house mechanical or plumbing fixtures and equipment.

R501.2 Requirements.
Floor construction shall be capable of accommodating all loads in accordance with Section R301 and of transmitting the resulting loads to the supporting structural elements.

SECTION R502
WOOD FLOOR FRAMING

R502.1 General.
Wood and wood-based products used for load-supporting purposes shall conform to the applicable provisions of this section.

R502.1.1 Sawn lumber.
Sawn lumber shall be identified by a grade mark of an accredited lumber grading or inspection agency and have design values certified by an accreditation body that complies with DOC PS 20. In lieu of a grade mark, a certificate of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted.

R502.1.1.1 Preservative-treated lumber.
Preservative treated dimension lumber shall also be identified as required by Section R317.2.

R502.1.1.2 End-jointed lumber.
Approved end-jointed lumber identified by a grade mark conforming to Section R502.1.1 shall be permitted to be used interchangeably with solid-sawn members of the same species and grade. End-jointed lumber used in an assembly required elsewhere in this code to have a fire-resistance rating shall have the designation “Heat Resistant Adhesive” or “HRA” included in its grade mark.

R502.1.2 Prefabricated wood I-joists.
Structural capacities and design provisions for prefabricated wood I-joists shall be established and monitored in accordance with ASTM D 5055.

R502.1.3 Structural glued laminated timbers.
Glued laminated timbers shall be manufactured and identified as required in ANSI/AITC A190.1 and ASTM D 3737.

R502.1.4 Structural log members.
Structural log members shall comply with the provisions of ICC-400.
R502.1.5 Structural composite lumber.
Structural capacities for structural composite lumber shall be established and monitored in accordance with ASTM D 5456.

R502.1.6 Cross-laminated timber.
Cross-laminated timber shall be manufactured and identified as required by ANSI/APA PRG 320.

R502.1.7 Engineered wood rim board.
Engineered wood rim boards shall conform to ANSI/APA PRR 410 or shall be evaluated in accordance with ASTM D 7672. Structural capacities shall be in accordance with ANSI/APA PRR 410 or established in accordance with ASTM D 7672. Rim boards conforming to ANSI/APA PRR 410 shall be marked in accordance with that standard.

R502.2 Design and construction.
Floors shall be designed and constructed in accordance with the provisions of this chapter, Figure R502.2 and Sections R317 and R318 or in accordance with ANSI AWC NDS.
R502.2.1 Framing at braced wall lines.
A load path for lateral forces shall be provided between floor framing and braced wall panels located above or below a floor, as specified in Section R602.10.8-R602.10.4.

R502.2.2 Blocking and subflooring.
Blocking for fastening panel edges or fixtures shall be a minimum of utility grade lumber. Subflooring shall be a minimum of utility grade lumber or No. 4 common grade boards. Fireblocking shall be of any grade lumber.
R502.3 Allowable joist spans.
Spans for floor joists shall be in accordance with Tables R502.3.1(1) and R502.3.1(2). For other grades and species and for other loading conditions, refer to the AWC STJR.

R502.3.1 Sleeping areas and attic joists.
Table R502.3.1(1) shall be used to determine the maximum allowable span of floor joists that support sleeping areas and attics that are accessed by means of a fixed stairway in accordance with Section R311.7 provided that the design live load does not exceed 30 pounds per square foot (1.44 kPa) and the design dead load does not exceed 20 pounds per square foot (0.96 kPa). The allowable span of ceiling joists that support attics used for limited storage or no storage shall be determined in accordance with Section R802.4.

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<td>#1</td>
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TABLE R502.3.1(1)
FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES
(Residential sleeping areas, live load = 30 psf, L/D = 360)
<table>
<thead>
<tr>
<th>JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 6</td>
<td>2 x 8</td>
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<tr>
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<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
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<tr>
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<td>Douglas fir-larch</td>
<td>#3 7-10</td>
<td>10-0</td>
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<td>Hem-fir</td>
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<td>Hem-fir</td>
<td>#1 9-10</td>
<td>13-0</td>
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<tr>
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<td>Hem-fir</td>
<td>#2 9-5</td>
<td>12-5</td>
</tr>
<tr>
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<td>Hem-fir</td>
<td>#3 7-8</td>
<td>9-9</td>
</tr>
<tr>
<td></td>
<td>Southern pine</td>
<td>SS 10-6</td>
<td>13-10</td>
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</tbody>
</table>

(continued)

TABLE R502.3.1(1)—continued
FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES
(Residential sleeping areas, live load = 30 psf, L/D = 360)"
| Southern pine | #1 | 10-1 | 13-4 | 16-5 | 19-6 | 9-11 | 12-7 | 14-8 | 17-5 |
| Southern pine | #2 | 9-6  | 12-1 | 14-4 | 16-10| 8-6  | 10-10 | 12-10 | 15-1 |
| Southern pine | #3 | 7-3  | 9-1  | 11-0 | 13-1 | 6-5  | 8-2  | 9-10 | 11-8 |
| Spruce-pine-fir | SS | 9-10 | 13-0 | 16-7 | 20-2 | 9-10 | 13-0 | 16-7 | 19-6 |
| Spruce-pine-fir | #1 | 9-8  | 12-9 | 15-8 | 18-3 | 9-1 | 11-6 | 14-1 | 16-3 |
| Spruce-pine-fir | #2 | 9-8  | 12-9 | 15-8 | 18-3 | 9-1 | 11-6 | 14-1 | 16-3 |
| Spruce-pine-fir | #3 | 7-8  | 9-9  | 11-10| 13-9 | 6-10 | 8-8  | 10-7 | 12-4 |
| Douglas fir-larch | SS | 9-11 | 13-1 | 16-8 | 20-3 | 9-11 | 13-1 | 16-5 | 19-1 |
| Douglas fir-larch | #1 | 9-7  | 12-4 | 15-0 | 17-5 | 8-8  | 11-0 | 13-5 | 15-7 |
| Douglas fir-larch | #2 | 9-3  | 11-8 | 14-3 | 16-6 | 8-3  | 10-5 | 12-9 | 14-9 |
| Douglas fir-larch | #3 | 7-0  | 8-11 | 10-11| 12-7 | 6-3  | 8-0  | 9-9  | 11-3 |
| Hem-fir | #1 | 9-2  | 12-1 | 14-10| 17-2 | 8-7  | 10-10| 13-3 | 15-5 |
| Hem-fir | #2 | 8-9  | 11-4 | 13-10| 16-1 | 8-0  | 10-2 | 12-5 | 14-4 |
| Hem-fir | #3 | 6-10 | 8-8  | 10-7 | 12-4 | 6-2  | 7-9  | 9-6  | 11-0 |
| Southern pine | SS | 9-9  | 12-10| 16-5 | 19-11| 9-9  | 12-10| 16-5 | 19-8 |
| Southern pine | #1 | 9-4  | 12-4 | 14-8 | 17-5 | 8-10 | 11-3 | 13-1 | 15-7 |
| Southern pine | #2 | 8-6  | 10-10| 12-10| 15-1 | 7-7  | 9-8  | 11-5 | 13-6 |
| Southern pine | #3 | 6-5  | 8-2  | 9-10 | 11-8 | 5-9  | 7-3  | 8-10 | 10-5 |
| Spruce-pine-fir | SS | 9-2  | 12-1 | 15-5 | 18-9 | 9-2  | 12-1 | 15-0 | 17-5 |
| Spruce-pine-fir | #1 | 8-11 | 11-6 | 14-1 | 16-3 | 8-1  | 10-3 | 12-7 | 14-7 |
| Spruce-pine-fir | #2 | 8-11 | 11-6 | 14-1 | 16-3 | 8-1  | 10-3 | 12-7 | 14-7 |
| Spruce-pine-fir | #3 | 6-10 | 8-8  | 10-7 | 12-4 | 6-2  | 7-9  | 9-6  | 11-0 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

Note: Check sources for availability of lumber in lengths greater than 20 feet.

a. Dead load limits for townhouses in Seismic Design Category C and all structures in Seismic Design Categories D₁, D₂, and D₃ shall be determined in accordance with Section R301.2.2.2.1.

**TABLE R502.3.1(2)**
FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES
(Residential living areas, live load = 40 psf, L/D = 360)
<table>
<thead>
<tr>
<th>JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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</thead>
<tbody>
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<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
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<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
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<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum floor joist spans</td>
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<td>10-8 13-6 16-5 19-1</td>
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### TABLE R502.3.1(2)—continued

**FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES**

(Residential living areas, live load = 40 psf, L/D = 360)

<table>
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<tr>
<th>JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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<td>(ft. - in.)</td>
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<td>#</td>
<td>8-9</td>
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<tr>
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<td>6-10</td>
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<td>#1</td>
<td>8-8</td>
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</table>

2018 North Carolina Residential Code
### R502.3.2 Other floor joists.

Table R502.3.1(2) shall be used to determine the maximum allowable span of floor joists that support other areas of the building, other than sleeping rooms and attics, provided that the design live load does not exceed 40 pounds per square foot (1.92 kPa) and the design dead load does not exceed 20 pounds per square foot (0.96 kPa).

### R502.3.3 Floor cantilevers.

Floor cantilever spans shall not exceed the nominal depth of the wood floor joist. Floor cantilevers constructed in accordance with Table R502.3.3(1) shall be permitted where supporting a light-frame bearing wall and roof only. Floor cantilevers supporting an exterior balcony are permitted to be constructed in accordance with Table R502.3.3(2).

#### TABLE R502.3.3(1)

CANTILEVER SPANS FOR FLOOR JOISTS SUPPORTING LIGHT-FRAME EXTERIOR BEARING WALL AND ROOF ONLY

<table>
<thead>
<tr>
<th>MEMBER &amp; SPACING</th>
<th>MAXIMUM CANTILEVER SPAN (uplift force at backspan support in lbs.)&lt;sup&gt;d, e&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Snow Load</td>
<td>D, E</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

**Note:** Check sources for availability of lumber in lengths greater than 20 feet.

a. End bearing length shall be increased to 2 inches.

b. Dead load limits for townhouses in Seismic Design Category C and all structures in Seismic Design Categories D, E, and F shall be determined in accordance with Section R301.2.2.1.

---

<table>
<thead>
<tr>
<th>Wood Type</th>
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<th>12-9</th>
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<td>7-1</td>
<td>8-8</td>
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<td>8-10</td>
<td>11-8</td>
<td>14-11</td>
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<tr>
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<td>#1</td>
<td>8-6</td>
<td>11-3</td>
<td>13-1</td>
<td>15-7</td>
<td>8-1</td>
<td>10-3</td>
<td>12-0</td>
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<td>9-8</td>
<td>11-5</td>
<td>13-6</td>
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<td>13-4</td>
</tr>
<tr>
<td>Spruce-pine-fir</td>
<td>#2</td>
<td>8-1</td>
<td>10-3</td>
<td>12-7</td>
<td>14-7</td>
<td>7-5</td>
<td>9-5</td>
<td>11-6</td>
<td>13-4</td>
</tr>
<tr>
<td>Spruce-pine-fir</td>
<td>#3</td>
<td>6-2</td>
<td>7-9</td>
<td>9-6</td>
<td>11-0</td>
<td>5-7</td>
<td>7-1</td>
<td>8-8</td>
<td>10-1</td>
</tr>
</tbody>
</table>
h. Linear interpolation shall be permitted for building widths and ground snow loads other than shown.

**TABLE R502.3.3(2)**

<table>
<thead>
<tr>
<th>MEMBER SIZE</th>
<th>SPACING</th>
<th>MAXIMUM CANTILEVER SPAN (uplift force at backspan support in lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ground Snow Load</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 30 psf</td>
</tr>
<tr>
<td>2 × 8</td>
<td>12&quot;</td>
<td>42&quot; (139)</td>
</tr>
<tr>
<td>2 × 8</td>
<td>16&quot;</td>
<td>36&quot; (151)</td>
</tr>
<tr>
<td>2 × 10</td>
<td>12&quot;</td>
<td>61&quot; (164)</td>
</tr>
<tr>
<td>2 × 10</td>
<td>16&quot;</td>
<td>53&quot; (180)</td>
</tr>
<tr>
<td>2 × 10</td>
<td>24&quot;</td>
<td>43&quot; (212)</td>
</tr>
<tr>
<td>2 × 12</td>
<td>16&quot;</td>
<td>72&quot; (228)</td>
</tr>
<tr>
<td>2 × 12</td>
<td>24&quot;</td>
<td>58&quot; (279)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Tabulated values are for clear-span roof supported solely by exterior bearing walls.
b. Spans are based on No. 2 Grade lumber of Douglas fir-larch, hem-fir, and spruce-pine-fir for repetitive (three or more) members. No. 1 or better shall be used for southern pine or spans shall be multiplied by 0.85 for No. 2 southern pine.
c. Ratio of backspan to cantilever span shall be not less than 3:1.
d. Connections capable of resisting the indicated uplift force shall be provided at the backspan support.
e. Uplift force is for a backspan to cantilever span ratio of 3:1. Tabulated uplift values are permitted to be reduced by multiplying by a factor equal to 3 divided by the actual backspan ratio provided (3/backspan ratio).
f. See Section R301.2.2.2.5, Item 1, for additional limitations on cantilevered floor joists for detached single- and two-family dwellings in Seismic Design Category D, or D, and townhouses in Seismic Design Category C, D, or D.
g. A full-depth rim joist shall be provided at the unsupported end of the cantilever joists. Solid blocking shall be provided at the supported end. Where the cantilever length is 24 inches or less and the building is assigned to Seismic Design Category A, B or C, solid blocking at the support for the cantilever shall not be required.
h. Linear interpolation shall be permitted for building widths and ground snow loads other than shown.
a. Spans are based on No. 2 Grade lumber of Douglas fir-larch, hem-fir, and spruce-pine-fir for repetitive (three or more) members. No.1 or better shall be used for southern pine or spans shall be multiplied by 0.85 for No. 2 southern pine.
b. Ratio of backspan to cantilever span shall be not less than 2:1.
c. Connections capable of resisting the indicated uplift force shall be provided at the backspan support.
d. Uplift force is for a backspan to cantilever span ratio of 2:1. Tabulated uplift values are permitted to be reduced by multiplying by a factor equal to 2 divided by the actual backspan ratio provided (2/backspan ratio).
e. A full-depth rim joist shall be provided at the unsupported end of the cantilever joists. Solid blocking shall be provided at the supported end. Where the cantilever length is 24 inches or less and the building is assigned to Seismic Design Category A, B or C, solid blocking at the support for the cantilever shall not be required.
f. Linear interpolation shall be permitted for ground snow loads other than shown.

R502.4 Joists under bearing partitions.
Joists under parallel bearing partitions shall be of adequate size to support the load. Double joists, sized to adequately support the load, that are separated to permit the installation of piping or vents shall be full depth solid blocked with lumber not less than 2 inches (51 mm) in nominal thickness spaced not more than 4 feet (1219 mm) on center. Bearing partitions perpendicular to joists shall not be offset from supporting girders, walls or partitions more than the joist depth unless such joists are of sufficient size to carry the additional load.

R502.5 Allowable girder and header spans.
The allowable spans of girders and headers fabricated of dimension lumber shall not exceed the values set forth in Tables R602.7(1), R602.7(2) and R602.7(3).

R502.6 Bearing.
The ends of each joist, beam or girder shall have not less than 1 1/2 inches (38 mm) of bearing on wood or metal and not less than 3 inches (76 mm) on masonry or concrete except where supported on a 1-inch by 4-inch (25 mm by 102 mm) ribbon strip and nailed to the adjacent stud or by the use of approved joist hangers. The bearing on masonry or concrete shall be direct, or a sill plate of 2-inch-minimum (51 mm) nominal thickness shall be provided under the joist, beam or girder. The sill plate shall provide a minimum nominal bearing area of 48 square inches (30 865 square mm).

R502.6.1 Floor systems.
Joists framing from opposite sides over a bearing support shall lap not less than 3 inches (76 mm) and shall be nailed together with a minimum three 10d face nails. A wood or metal splice with strength equal to or greater than that provided by the nailed lap is permitted.

R502.6.2 Joist framing.
Joists framing into the side of a wood girder shall be supported by approved framing anchors or on ledger strips not less than nominal 2 inches by 2 inches (51 mm by 51 mm).

R502.7 Lateral restraint at supports.
Joists shall be supported laterally at the ends by full-depth solid blocking not less than 2 inches (51 mm) nominal in thickness; or by attachment to a full-depth header, band or rim joist, or to an adjoining stud or shall be otherwise provided with lateral support to prevent rotation.

Exceptions:
1. Trusses, structural composite lumber, structural glued-laminated members and I-
   joists shall be supported laterally as required by the manufacturer’s
   recommendations.

2. In Seismic Design Categories D₂, D₁, and D₀, lateral restraint shall be provided at
   each intermediate support. Deleted.

R502.7.1 Bridging.
Joists exceeding a nominal 2 inches by 12 inches (51 mm by 305 mm) shall be supported
laterally by solid blocking, diagonal bridging (wood or metal), or a continuous 1 inch by 3
inch (25.4 mm by 76 mm) strip nailed across the bottom of joists perpendicular to joists at
intervals not exceeding 8 feet (2438 mm).

   Exception: Trusses, structural composite lumber, structural glued-laminated members
   and I-joists shall be supported laterally as required by the manufacturer’s
   recommendations.

R502.8 Cutting, drilling and notching.
Structural floor members shall not be cut, bored or notched in excess of the limitations specified
in this section. See Figure R502.8(1) and Figure R502.8(2).
FIGURE R502.8(1)
CUTTING, NOTCHING AND DRILLING

For SI: 1 inch = 25.4 mm.
1. Do not drill in center 2/10’s of joist span.
2. Do not drill directly under load bearing walls at end.
3. Do not drill closer than 2" to top or bottom edge.
4. Apply 4’ joist width x 1/2” CDX plywood with face grain running with joist to both sides using 6d nails or 1 1/2” screws 1” from top and bottom 4” o.c.
5. Holes shall not be closer than 2′-0” o.c. within unhatched area only.
6. Plywood shall be attached such that 2′ minimum of plywood is centered on each side of the hole location, except when the hole is located within 2′ of the end of joist.

**FIGURE R502.8(2)**
ACCEPTABLE LOCATION OF 3 5/8 -inch DIAMETER HOLE IN 2 x 10 JOIST

**R502.8.1 Sawn lumber.**
Notches in solid lumber joists, rafters and beams shall not exceed one-sixth of the depth of the member, shall not be longer than one-third of the depth of the member and shall not be located in the middle one-third of the span. Notches at the ends of the member shall not exceed one-fourth the depth of the member. The tension side of members 4 inches (102 mm) or greater in nominal thickness shall not be notched except at the ends of the members. The diameter of holes bored or cut into members shall not exceed one-third the depth of the member. Holes shall not be closer than 2 inches (51 mm) to the top or bottom of the member, or to any other hole located in the member. Where the member is also notched, the hole shall not be closer than 2 inches (51 mm) to the notch.

**R502.8.2 Engineered wood products.**
Cuts, notches and holes bored in trusses, structural composite lumber, structural glue-laminated members, cross-laminated timber members or I-joists are prohibited except where permitted by the manufacturer’s recommendations or where the effects of such alterations are specifically considered in the design of the member by a registered design professional.

**R502.9 Fastening.**
Floor framing shall be nailed in accordance with Table R602.3(1). Where posts and beam or girder construction is used to support floor framing, positive connections shall be provided to ensure against uplift and lateral displacement.

**R502.10 Framing of openings.**
Openings in floor framing shall be framed with a header and trimmer joists. Where the header joist span does not exceed 4 feet (1219 mm), the header joist shall be a single member the
same size as the floor joist. Single trimmer joists shall be used to carry a single header joist that is located within 3 feet (914 mm) of the trimmer joist bearing. Where the header joist span exceeds 4 feet (1219 mm), the trimmer joists and the header joist shall be doubled and of sufficient cross section to support the floor joists framing into the header.

R502.11 Wood trusses.

R502.11.1 Design.
Wood trusses shall be designed in accordance with approved engineering practice. The design and manufacture of metal-plate-connected wood trusses shall comply with ANSI/TPI 1. The truss design drawings shall be prepared by a registered professional where required by the statutes of the jurisdiction in which the project is to be constructed in accordance with Section R106.1.

R502.11.2 Bracing.
Trusses shall be braced to prevent rotation and provide lateral stability in accordance with the requirements specified in the construction documents for the building and on the individual truss design drawings. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practices, such as, the SBCA Building Component Safety Information (BCSI) Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses.

R502.11.3 Alterations to trusses.
Truss members and components shall not be cut, notched, spliced or otherwise altered in any way without the approval of a registered design professional. Alterations resulting in the addition of load that exceed the design load for the truss, shall not be permitted without verification that the truss is capable of supporting the additional loading.

R502.11.4 Truss design drawings.
Truss design drawings, prepared in compliance with Section R502.11.1, shall be submitted to the building official and approved prior to installation. Truss design drawings shall be provided with the shipment of trusses delivered to the job site. Truss design drawings shall include, at a minimum, the information specified as follows:

1. Slope or depth, span and spacing.
2. Location of all joints.
3. Required bearing widths.
4. Design loads as applicable:
   4.1. Top chord live load.
4.2. Top chord dead load.

4.3. Bottom chord live load.

4.4. Bottom chord dead load.

4.5. Concentrated loads and their points of application.

4.6. Controlling wind and earthquake loads.

5. Adjustments to lumber and joint connector design values for conditions of use.

6. Each reaction force and direction.

7. Joint connector type and description, such as size, thickness or gage, and the dimensioned location of each joint connector except where symmetrically located relative to the joint interface.

8. Lumber size, species and grade for each member.

9. Connection requirements for:
   
   
   9.2. Truss ply-to-ply.
   
   9.3. Field splices.

10. Calculated deflection ratio and/or maximum description for live and total load.

11. Maximum axial compression forces in the truss members to enable the building designer to design the size, connections and anchorage of the permanent continuous lateral bracing. Forces shall be shown on the truss drawing or on supplemental documents.

12. Required permanent truss member bracing location.

R502.12 Draftstopping required.
Draftstopping shall be provided in accordance with Section R302.12.

R502.13 Fireblocking required.
Fireblocking shall be provided in accordance with Section R302.11.

SECTION R503
FLOOR SHEATHING
R503.1 Lumber sheathing.
Maximum allowable spans for lumber used as floor sheathing shall conform to Tables R503.1, R503.2.1.1(1) and R503.2.1.1(2).

**TABLE R503.1
MINIMUM THICKNESS OF LUMBER FLOOR SHEATHING**

<table>
<thead>
<tr>
<th>JOIST OR BEAM SPACING (inches)</th>
<th>MINIMUM NET THICKNESS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perpendicular to joist</td>
<td>Diagonal to joist</td>
</tr>
<tr>
<td>24</td>
<td>11/16</td>
<td>3/4</td>
</tr>
<tr>
<td>16</td>
<td>5/8</td>
<td>5/8</td>
</tr>
<tr>
<td>48</td>
<td>1/2 T &amp; G</td>
<td>N/A</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa.
N/A = Not applicable.
a. For this support spacing, lumber sheathing shall have a minimum F<sub>b</sub> of 675 and minimum E of 1,100,000 (see ANSI AWC NDS).
b. For this support spacing, lumber sheathing shall have a minimum F<sub>b</sub> of 765 and minimum E of 1,400,000 (see ANSI AWC NDS).
c. For this support spacing, lumber sheathing shall have a minimum F<sub>b</sub> of 855 and minimum E of 1,700,000 (see ANSI AWC NDS).

R503.1.1 End joints.
End joints in lumber used as subflooring shall occur over supports unless end-matched lumber is used, in which case each piece shall bear on not less than two joists. Subflooring shall be permitted to be omitted where joist spacing does not exceed 16 inches (406 mm) and a 1-inch (25 mm) nominal tongue-and-groove wood strip flooring is applied perpendicular to the joists.

R503.2 Wood structural panel sheathing.

R503.2.1 Identification and grade.
Wood structural panel sheathing used for structural purposes shall conform to DOC PS 1, DOC PS 2, CSA O437 or CSA O325. Panels shall be identified for grade, bond classification and Performance Category by a grade mark or certificate of inspection issued by an approved agency. The Performance Category value shall be used as the “nominal panel thickness” or “panel thickness” wherever referenced in this code.

R503.2.1.1 Subfloor and combined subfloor underlayment.
Where used as subflooring or combination subfloor underlayment, wood structural panels shall be of one of the grades specified in Table R503.2.1.1(1). Where sanded plywood is used as combination subfloor underlayment, the grade, bond classification, and Performance Category shall be as specified in Table R503.2.1.1(2).
<table>
<thead>
<tr>
<th>SPAN RATING</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (inch)</th>
<th>ALLOWABLE LIVE LOAD h, i (psf)</th>
<th>MAXIMUM SPAN (inches)</th>
<th>LOAD (pounds per square foot, at maximum span)</th>
<th>MAXIMUM SPAN (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SPAN 16 o.c.</td>
<td>SPAN 24 o.c.</td>
<td>With edge support</td>
<td>Without edge support</td>
<td></td>
</tr>
<tr>
<td>Sheathing e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16/0</td>
<td>3/8</td>
<td>—</td>
<td>16</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>20/0</td>
<td>3/8</td>
<td>—</td>
<td>20</td>
<td>20</td>
<td>40</td>
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<tr>
<td>24/0</td>
<td>3/8</td>
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<td>24</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>24/16</td>
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<td>100</td>
<td>24</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>32/16</td>
<td>15/32, 1/2</td>
<td>180</td>
<td>32</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>40/20</td>
<td>19/32, 5/8</td>
<td>305</td>
<td>40</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>48/24</td>
<td>23/32, 3/4</td>
<td>—</td>
<td>48</td>
<td>36</td>
<td>45</td>
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<tr>
<td>60/32</td>
<td>7/8</td>
<td>305</td>
<td>48</td>
<td>45</td>
<td>35</td>
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<table>
<thead>
<tr>
<th>Roof f</th>
<th>Load Total</th>
<th>Live load</th>
<th></th>
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<tbody>
<tr>
<td>16/0</td>
<td>16</td>
<td>40</td>
<td>30</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20/0</td>
<td>20</td>
<td>40</td>
<td>30</td>
<td>0</td>
<td></td>
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</tr>
<tr>
<td>24/16</td>
<td>24</td>
<td>50</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>32/16</td>
<td>28</td>
<td>40</td>
<td>30</td>
<td>16 h</td>
<td></td>
</tr>
<tr>
<td>40/20</td>
<td>32</td>
<td>40</td>
<td>30</td>
<td>20 h</td>
<td></td>
</tr>
<tr>
<td>48/24</td>
<td>36</td>
<td>45</td>
<td>35</td>
<td>24</td>
<td></td>
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<tr>
<td>60/32</td>
<td>45</td>
<td>50</td>
<td>35</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Underlayment, C-C plugged, single floor e</th>
<th>LOAD Total</th>
<th>Load Live load</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16 o.c.</td>
<td>24</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 o.c.</td>
<td>32</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 o.c.</td>
<td>35</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 o.c.</td>
<td>40</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48 o.c.</td>
<td>48</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.
a. The allowable total loads were determined using a dead load of 10 psf. If the dead load exceeds 10 psf, then the live load shall be reduced accordingly.

b. Panels continuous over two or more spans with long dimension (strength axis) perpendicular to supports. Spans shall be limited to values shown because of possible effect of concentrated loads.

c. Applies to panels 24 inches or wider.

d. Lumber blocking, panel edge clips (one midway between each support, except two equally spaced between supports where span is 48 inches), tongue-and-groove panel edges, or other approved type of edge support.

e. Includes Structural I panels in these grades.

f. Uniform load deflection limitation: \( \frac{1}{180} \) of span under live load plus dead load, \( \frac{1}{240} \) of span under live load only.

g. Maximum span 24 inches for \( \frac{15}{32} \) - and \( \frac{1}{2} \) -inch panels.

h. Maximum span 24 inches where \( \frac{3}{4} \) -inch wood finish flooring is installed at right angles to joists.

i. Maximum span 24 inches where 1.5 inches of lightweight concrete or approved cellular concrete is placed over the subfloor.

j. Unsupported edges shall have tongue-and-groove joints or shall be supported with blocking unless minimum nominal \( \frac{1}{4} \) -inch-thick wood panel-type underlayment, fiber-cement underlayment with end and edge joints offset not less than 2 inches or 11/2 inches of lightweight concrete or approved cellular concrete is placed over the subfloor, or \( \frac{3}{4} \) -inch wood finish flooring is installed at right angles to the supports. Fiber-cement underlayment shall comply with ASTM C1288 or ISO 8336 Category C. Allowable uniform live load at maximum span, based on deflection of \( \frac{1}{360} \) of span, is 100 psf.

k. Unsupported edges shall have tongue-and-groove joints or shall be supported by blocking unless nominal \( \frac{1}{4} \) -inch-thick wood panel-type underlayment, fiber-cement underlayment with end and edge joints offset not less than 2 inches or \( \frac{3}{4} \) -inch wood finish flooring is installed at right angles to the supports. Fiber-cement underlayment shall comply with ASTM C1288 or ISO 8336 Category C. Allowable uniform live load at maximum span, based on deflection of \( \frac{1}{360} \) of span, is 100 psf, except panels with a span rating of 48 on center are limited to 65 psf total uniform load at maximum span.

l. Allowable live load values at spans of 16 inches on center and 24 inches on center taken from reference standard APA E30, APA Engineered Wood Construction Guide. Refer to reference standard for allowable spans not listed in the table.

### TABLE R503.2.1.1(2)
### ALLOWABLE SPANS FOR SANDED PLYWOOD COMBINATION SUBFLOOR UNDERLAYMENT

<table>
<thead>
<tr>
<th>IDENTIFICATION</th>
<th>SPACING OF JOISTS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Species group</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Plywood continuous over two or more spans and face grain perpendicular to supports. Unsupported edges shall be tongue-and-groove or blocked except where nominal 1/4-inch-thick wood panel-type underlayment, fiber-cement underlayment or 3/4-inch wood finish floor is used. Fiber-cement underlayment shall comply with ASTM C 1288 or ISO 8336 Category C. Allowable uniform live load at maximum span based on deflection of 1/360 of span is 100 psf.

b. Applicable to all grades of sanded exterior-type plywood.

**R503.2.2 Allowable spans.**
The maximum allowable span for wood structural panels used as subfloor or combination subfloor underlayment shall be as set forth in Table R503.2.1.1(1), or APA E30. The maximum span for sanded plywood combination subfloor underlayment shall be as set forth in Table R503.2.1.1(2).

**R503.2.3 Installation.**
Wood structural panels used as subfloor or combination subfloor underlayment shall be attached to wood framing in accordance with Table R602.3(1) and shall be attached to cold-formed steel framing in accordance with Table R505.3.1(2).

**R503.3 Particleboard.**

**R503.3.1 Identification and grade.**
Particleboard shall conform to ANSI A208.1 and shall be so identified by a grade mark or certificate of inspection issued by an approved agency.

**R503.3.2 Floor underlayment.**
Particleboard floor underlayment shall conform to Type PBU and shall be not less than 1/4 inch (6.4 mm) in thickness.

**R503.3.3 Installation.**
Particleboard underlayment shall be installed in accordance with the recommendations of the manufacturer and attached to framing in accordance with Table R602.3(1).

**SECTION R504**
**PRESSURE PRESERVATIVE-TREATED WOOD FLOORS (ON GROUND)**

**R504.1 General.**
Pressure preservative treated-wood basement floors and floors on ground shall be designed to withstand axial forces and bending moments resulting from lateral soil pressures at the base of
the exterior walls and floor live and dead loads. Floor framing shall be designed to meet joist deflection requirements in accordance with Section R301.

**R504.1.1 Unbalanced soil loads.**

Unless special provision is made to resist sliding caused by unbalanced lateral soil loads, wood basement floors shall be limited to applications where the differential depth of fill on opposite exterior foundation walls is 2 feet (610 mm) or less.

**R504.1.2 Construction.**

Joists in wood basement floors shall bear tightly against the narrow face of studs in the foundation wall or directly against a band joist that bears on the studs. Plywood subfloor shall be continuous over lapped joists or over butt joints between in-line joists. Sufficient blocking shall be provided between joists to transfer lateral forces at the base of the end walls into the floor system.

**R504.1.3 Uplift and buckling.**

Where required, resistance to uplift or restraint against buckling shall be provided by interior bearing walls or properly designed stub walls anchored in the supporting soil below.

**R504.2 Site preparation.**

The area within the foundation walls shall have all vegetation, topsoil and foreign material removed, and any fill material that is added shall be free of vegetation and foreign material. The fill shall be compacted to ensure uniform support of the pressure preservative treated-wood floor sleepers.

**R504.2.1 Base.**

A minimum 4-inch-thick (102 mm) granular base of gravel having a maximum size of \(\frac{3}{4}\) inch (19.1 mm) or crushed stone having a maximum size of \(\frac{1}{2}\) inch (12.7 mm) shall be placed over the compacted earth.

**R504.2.2 Moisture barrier.**

Polyethylene sheeting of minimum 6-mil (0.15 mm) thickness shall be placed over the granular base. Joints shall be lapped 6 inches (152 mm) and left unsealed. The polyethylene membrane shall be placed over the pressure preservative treated-wood sleepers and shall not extend beneath the footing plates of the exterior walls.

**R504.3 Materials.**

Framing materials, including sleepers, joists, blocking and plywood subflooring, shall be pressure-preservative treated and dried after treatment in accordance with AWPA U1 (Commodity Specification A, Use Category 4B and Section 5.2), and shall bear the label of an accredited agency.

**SECTION R505**

**COLD-FORMED STEEL FLOOR FRAMING**

*Deleted*

**R505.1 Cold-formed steel floor framing.**

Elements shall be straight and free of any defects that would significantly affect structural...
performance. Cold-formed steel floor framing members shall be in accordance with the requirements of this section.

**R505.1.1 Applicability limits.**
The provisions of this section shall control the construction of cold-formed steel floor framing for buildings not greater than 60 feet (18 288 mm) in length perpendicular to the joist span, not greater than 40 feet (12 192 mm) in width parallel to the joist span and less than or equal to three stories above grade plane. Cold-formed steel floor framing constructed in accordance with the provisions of this section shall be limited to sites where the ultimate design wind speed is less than 139 miles per hour (62 m/s), Exposure Category B or C, and the ground snow load is less than or equal to 70 pounds per square foot (3.35 kPa).

**R505.1.2 In-line framing.**
Where supported by cold-formed steel framed walls in accordance with Section R603, cold-formed steel floor framing shall be constructed with floor joists located in-line with load-bearing studs located below the joists in accordance with Figure R505.1.2 and the tolerances specified as follows:

1. The maximum tolerance shall be $\frac{3}{4}$ inch (19.1 mm) between the centerline of the horizontal framing member and the centerline of the vertical framing member.

2. Where the centerline of the horizontal framing member and bearing stiffener are located to one side of the centerline of the vertical framing member, the maximum tolerance shall be $\frac{1}{8}$ inch (3 mm) between the web of the horizontal framing member and the edge of the vertical framing member.
R505.1.3 Floor trusses.
Cold-formed steel trusses shall be designed, braced and installed in accordance with AISI S100, Section D4. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practices, such as the SBCA Cold-Formed Steel Building Component Safety Information (CFSBCSI). Guide to Good Practice for Handling, Installing & Bracing of Cold-Formed Steel Trusses. Truss members shall not be notched, cut or altered in any manner without an approved design.

R505.1.3 Floor trusses. Cold-formed steel trusses shall be designed, braced and installed in accordance with AISI S100, Section D4. Truss members shall not be notched, cut or altered in any manner without an approved design.

R505.2 Structural framing.
Load-bearing cold-formed steel floor framing members shall be in accordance with this section.

R505.2.1 Material.
Load-bearing cold-formed steel framing members shall be cold formed to shape from structural quality sheet steel complying with the requirements of ASTM A 1003: Structural Grades 33 Type H and 50 Type H.

R505.2.1 Material. Load-bearing cold-formed steel framing members shall be cold formed to shape from structural quality sheet steel complying with the requirements of one of the following:
1. ASTM A 653: Grades 33 and 50 (Class 1 and 3).

2. ASTM A 792: Grades 33 and 50A.

3. ASTM A 1003: Structural Grades 33 Type H and 50 Type H.

**R505.2.2 Corrosion protection.**
Load-bearing cold-formed steel framing shall have a metallic coating complying with ASTM A 1003 and one of the following:

1. A minimum of G 60 in accordance with ASTM A 653.

2. A minimum of AZ 50 in accordance with ASTM A 792.

**R505.2.3 Dimension, thickness and material grade.**
Load-bearing cold-formed steel floor framing members shall comply with Figure R505.2.3(1) and with the dimensional and thickness requirements specified in Table R505.2.3. Additionally, all C-shaped sections shall have a minimum flange width of 1.625 inches (41 mm) and a maximum flange width of 2 inches (51 mm). The minimum lip size for C-shaped sections shall be $\frac{1}{2}$ inch (12.7 mm). Track sections shall comply with Figure R505.2.3(2) and shall have a minimum flange width of $\frac{1}{4}$ inch (32 mm). Minimum Grade 33 ksi steel shall be used wherever 33 mil and 43 mil thicknesses are specified. Minimum Grade 50 ksi steel shall be used wherever 54 and 68 mil thicknesses are specified.
FIGURE R505.2.3(1)
C-SHAPED SECTION
### FIGURE R505.2.3(2)
**TRACK SECTION**

### TABLE R505.2.3
**COLD-FORMED STEEL JOIST SIZES AND THICKNESS**

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>WEB DEPTH (inches)</th>
<th>MINIMUM BASE STEEL THICKNESS mil (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>550S162-t</td>
<td>5.5</td>
<td>33 (0.0329), 43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
<tr>
<td>800S162-t</td>
<td>8</td>
<td>33 (0.0329), 43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
<tr>
<td>1000S162-t</td>
<td>10</td>
<td>43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
<tr>
<td>1200S162-t</td>
<td>12</td>
<td>43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mil = 0.0254 mm.

a. The member designation is defined by the first number representing the member depth in 0.01 inch, the letter “S” representing a stud or joist member, the second number representing the flange width in 0.01 inch, and the letter “t” shall be a number representing the minimum base metal thickness in mils.

### R505.2.4 Identification.
Load-bearing cold-formed steel framing members shall have a legible label, stencil, stamp or embossment with the following information as a minimum:

1. Manufacturer’s identification.
2. Minimum base steel thickness in inches (mm).

4. Minimum yield strength, in kips per square inch (ksi) (MPa).

**R505.2.5 Fastening.**

Screws for steel-to-steel connections shall be installed with a minimum edge distance and center-to-center spacing of \( \frac{1}{2} \) inch (12.7 mm), shall be self-drilling tapping, and shall conform to ASTM C 1513. Floor sheathing shall be attached to cold-formed steel joists with minimum No. 8 self-drilling tapping screws that conform to ASTM C 1513. Screws attaching floor sheathing to cold-formed steel joists shall have a minimum head diameter of 0.292 inch (7.4 mm) with countersunk heads and shall be installed with a minimum edge distance of \( \frac{3}{8} \) inch (9.5 mm). Gypsum board ceilings shall be attached to cold-formed steel joists with minimum No. 6 screws conforming to ASTM C 954 or ASTM C 1513 with a bugle head style and shall be installed in accordance with Section R702. For all connections, screws shall extend through the steel a minimum of three exposed threads. All fasteners shall have rust-inhibitive coating suitable for the installation in which they are being used, or be manufactured from material not susceptible to corrosion.

**R505.2.6 Web holes, web hole reinforcing and web hole patching.**

Web holes, web hole reinforcing, and web hole patching shall be in accordance with this section.

**R505.2.6.1 Web holes.**

Web holes in floor joists shall comply with all of the following conditions:

1. Holes shall conform to Figure R505.2.6.1.

2. Holes shall be permitted only along the centerline of the web of the framing member.

3. Holes shall have a center-to-center spacing of not less than 24 inches (610 mm).

4. Holes shall have a web hole width not greater than 0.5 times the member depth, or \( 2 \frac{1}{4} \) inches (64.5 mm).

5. Holes shall have a web hole length not exceeding \( 4 \frac{1}{2} \) inches (114 mm).

6. Holes shall have a minimum distance between the edge of the bearing surface and the edge of the web hole of not less than 10 inches (254 mm).

Framing members with web holes not conforming to the above requirements shall be reinforced in accordance with Section R505.2.6.2, patched in accordance with Section R505.2.6.3 or designed in accordance with accepted engineering practices.
R505.2.6.2 Web hole reinforcing.
Reinforcement of web holes in floor joists not conforming to the requirements of Section R505.2.6.1 shall be permitted if the hole is located fully within the center 40 percent of the span and the depth and length of the hole does not exceed 65 percent of the flat width of the web. The reinforcing shall be a steel plate or C-shape section with a hole that does not exceed the web hole size limitations of Section R505.2.6.1 for the member being reinforced. The steel reinforcing shall be the same thickness as the receiving member and shall extend not less than 1 inch (25 mm) beyond all edges of the hole. The steel reinforcing shall be fastened to the web of the receiving member with No. 8 screws spaced not more than 1 inch (25 mm) center-to-center along the edges of the patch with minimum edge distance of \( \frac{1}{2} \) inch (12.7 mm).

R505.2.6.3 Hole patching.
Patching of web holes in floor joists not conforming to the requirements in Section R505.2.6.1 shall be permitted in accordance with either of the following methods:

1. Framing members shall be replaced or designed in accordance with accepted engineering practices where web holes exceed the following size limits:

   1.1. The depth of the hole, measured across the web, exceeds 70 percent of the flat width of the web.

   1.2. The length of the hole, measured along the web, exceeds 10 inches (254 mm) or the depth of the web, whichever is greater.

2. Web holes not exceeding the dimensional requirements in Section R505.2.6.3, Item 1, shall be patched with a solid steel plate, stud section or track section in accordance with Figure R505.2.6.3. The steel patch shall, as a minimum, be of the same thickness as the receiving member and shall extend not less than 1 inch (25 mm) beyond all edges of the hole. The steel patch shall be fastened to the web of the receiving member with No. 8 screws spaced not more than 1 inch.
(25 mm) center-to-center along the edges of the patch with minimum edge distance of \( \frac{1}{2} \) inch (12.7 mm).

For SI: 1 inch = 25.4 mm.

**FIGURE R505.2.6.3**
FLOOR JOIST WEB HOLE PATCH

**R505.3 Floor construction.**
Cold-formed steel floors shall be constructed in accordance with this section.

**R505.3.1 Floor to foundation or load-bearing wall connections.**
Cold-formed steel framed floors shall be anchored to foundations, wood sills or load-bearing walls in accordance with Table R505.3.1(1) and Figure R505.3.1(1), R505.3.1(2), R505.3.1(3), R505.3.1(4), R505.3.1(5) or R505.3.1(6). Anchor bolts shall be located not more than 12 inches (305 mm) from corners or the termination of bottom tracks. Continuous cold-formed steel joists supported by interior load-bearing walls shall be constructed in accordance with Figure R505.3.1(7). Lapped cold-formed steel joists shall be constructed in accordance with Figure R505.3.1(8). End floor joists constructed on foundation walls parallel to the joist span shall be doubled unless a C-shaped bearing stiffener, sized in accordance with Section R505.3.4, is installed web-to-web with the floor joist beneath each supported wall stud, as shown in Figure R505.3.1(9). Fastening of cold-formed steel joists to other framing members shall be in accordance with Section R505.2.5 and Table R505.3.1(2).

**TABLE R505.3.1(1)**
FLOOR TO FOUNDATION OR BEARING WALL CONNECTION REQUIREMENTS
FRAMING CONDITION

<table>
<thead>
<tr>
<th>BASIC ULTIMATE WIND SPEED (mph) AND EXPOSURE</th>
<th>Floor joist to wall track of exterior wall in accordance with Figure R505.3.1(1)</th>
<th>Rim track or end joist to load-bearing wall top track in accordance with Figure R505.3.1(1)</th>
<th>Rim track or end joist to wood sill in accordance with Figure R505.3.1(2)</th>
<th>Rim track or end joist to foundation in accordance with Figure R505.3.1(3)</th>
<th>Cantilevered joist to foundation in accordance with Figure R505.3.1(4)</th>
<th>Cantilevered joist to wood sill in accordance with Figure R505.3.1(5)</th>
<th>Cantilevered joist to exterior load-bearing wall track in accordance with Figure R505.3.1(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 mph Exposure Category C or less than 139 mph Exposure Category B</td>
<td>2-No. 8 screws</td>
<td>1-No. 8 screw at 24 inches o.c.</td>
<td>Steel plate spaced at 4 feet o.c. with 4-No. 8 screws and 4-10d or 6-8d common nails</td>
<td>(\frac{1}{2}) inch minimum diameter anchor bolt and clip angle spaced at 6 feet o.c. with 8-No. 8 screws</td>
<td>(\frac{1}{2}) inch minimum diameter anchor bolt and clip angle spaced at 6 feet o.c. with 8-No. 8 screws</td>
<td>Steel plate spaced at 4 feet o.c. with 4-No. 8 screws and 4-10d or 6-8d common nails</td>
<td>2-No. 8 screws</td>
</tr>
<tr>
<td>Less than 139 mph Exposure Category C</td>
<td>3-No. 8 screws</td>
<td>1-No. 8 screw at 24 inches o.c.</td>
<td>Steel plate spaced at 2 feet o.c. with 4-No. 8 screws and 4-10d or 6-8d common nails</td>
<td>(\frac{1}{2}) inch minimum diameter anchor bolt and clip angle spaced at 4 feet o.c. with 8-No. 8 screws</td>
<td>(\frac{1}{2}) inch minimum diameter anchor bolt and clip angle spaced at 4 feet o.c. with 8-No. 8 screws</td>
<td>Steel plate spaced at 2 feet o.c. with 4-No. 8 screws and 4-10d or 6-8d common nails</td>
<td>3-No. 8 screws</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s, 1 foot = 304.8 mm.

a. Anchor bolts are to be located not more than 12 inches from corners or the termination of bottom tracks such as at door openings or corners. Bolts extend a minimum of 15 inches into masonry or 7 inches into concrete. Anchor bolts connecting cold-formed steel framing to the foundation structure are to be installed so that the distance from the center of the bolt hole to the edge of the connected member is not less than one and one-half bolt diameters.

b. All screw sizes shown are minimum.

**TABLE R505.3.1(2)**

**FLOOR FASTENING SCHEDULE**

<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND SIZE OF FASTENERS</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor joist to track of an interior load-bearing wall in accordance with Figures R505.3.1(7) and R505.3.1(8)</td>
<td>2 No. 8 screws</td>
<td>Each joist</td>
</tr>
<tr>
<td>Floor joist to track at end of joist</td>
<td>2 No. 8 screws</td>
<td>One per flange or two per bearing stiffener</td>
</tr>
</tbody>
</table>
Subfloor to floor joists | No. 8 screws | 6 in. o.c. on edges and 12 in. o.c. at intermediate supports

For SI: 1 inch = 25.4 mm.

a. All screw sizes shown are minimum.

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm.

**FIGURE 505.3.1(1)**
FLOOR TO EXTERIOR LOAD-BEARING WALL STUD CONNECTION
FIGURE R505.3.1(2)
FLOOR TO WOOD SILL CONNECTION

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm.
FIGURE R505.3.1(3)
FLOOR TO FOUNDATION CONNECTION

FIGURE R505.3.1(4)
CANTILEVERED FLOOR TO FOUNDATION CONNECTION

For SI: 1 mil = 0.0254 mm.
For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm.

**FIGURE R505.3.1(5)**
CANTILEVERED FLOOR TO WOOD SILL CONNECTION

For SI: 1 mil = 0.0254 mm.

**FIGURE R505.3.1(6)**
CANTILEVERED FLOOR TO EXTERIOR LOAD-BEARING WALL CONNECTION
FIGURE R505.3.1(7)
CONTINUOUS SPAN JOIST SUPPORTED ON INTERIOR LOAD-BEARING WALL
For SI: 1 inch = 25.4 mm.

**FIGURE R505.3.1(8)**
LAPPED JOISTS SUPPORTED ON INTERIOR LOAD-BEARING WALL
R505.3.2 Minimum floor joist sizes.
Floor joist size and thickness shall be determined in accordance with the limits set forth in Table R505.3.2 for single or continuous spans. Where continuous joist members are used, the interior bearing supports shall be located within 2 feet (610 mm) of midspan of the cold-formed steel joists, and the individual spans shall not exceed the spans in Table R505.3.2.

Floor joists shall have a bearing support length of not less than $1\frac{1}{2}$ inches (38 mm) for exterior wall supports and $3\frac{1}{2}$ inches (89 mm) for interior wall supports. Tracks shall be not less than 33 mils (0.84 mm) thick except when used as part of a floor header or trimmer in accordance with Section R505.3.8. Bearing stiffeners shall be installed in accordance with Section R505.3.4.
R505.3.3 Joist bracing and blocking.
Joist bracing and blocking shall be in accordance with this section.

R505.3.3.1 Joist top flange bracing.
The top flanges of cold-formed steel joists shall be laterally braced by the application of floor sheathing fastened to the joists in accordance with Section R505.2.5 and Table R505.3.1(2).

R505.3.3.2 Joist bottom flange bracing/blocking.
Floor joists with spans that exceed 12 feet (3658 mm) shall have the bottom flanges laterally braced in accordance with one of the following:

1. Gypsum board installed with minimum No. 6 screws in accordance with Section R702.

2. Continuous steel straps installed in accordance with Figure R505.3.3.2(1). Steel straps shall be spaced at a maximum of 12 feet (3658 mm) on center and shall be at least $\frac{1}{4}$ inches (38 mm) in width and 33 mils (0.84 mm) in thickness.

   Straps shall be fastened to the bottom flange of each joist with one No. 8 screw, fastened to blocking with two No. 8 screws, and fastened at each end (of strap)
with two No. 8 screws. Blocking in accordance with Figure R505.3.3.2(1) or R505.3.3.2(2) shall be installed between joists at each end of the continuous strapping and at a maximum spacing of 12 feet (3658 mm) measured along the continuous strapping (perpendicular to the joist run). Blocking shall also be located at the termination of all straps. As an alternative to blocking at the ends, anchoring the strap to a stable building component with two No. 8 screws shall be permitted.

For SI: 1 mil = 0.0254, 1 inch = 25.4 mm.

FIGURE R505.3.3.2(1)
JOIST BLOCKING (SOLID)
R505.3.3 Blocking at interior bearing supports.
Blocking is not required for continuous back-to-back floor joists at bearing supports. Blocking shall be installed between every other joist for single continuous floor joists across bearing supports in accordance with Figure R505.3.1(7). Blocking shall consist of C-shape or track section with a minimum thickness of 33 mils (0.84 mm). Blocking shall be fastened to each adjacent joist through a 33-mil (0.84 mm) clip angle, bent web of blocking or flanges of web stiffeners with two No. 8 screws on each side. The minimum depth of the blocking shall be equal to the depth of the joist minus 2 inches (51 mm). The minimum length of the angle shall be equal to the depth of the joist minus 2 inches (51 mm).

R505.3.4 Blocking at cantilevers.
Blocking shall be installed between every other joist over cantilever bearing supports in accordance with Figure R505.3.1(4), R505.3.1(5) or R505.3.1(6). Blocking shall consist of C-shape or track section with minimum thickness of 33 mils (0.84 mm). Blocking shall be fastened to each adjacent joist through bent web of blocking, 33-mil clip angle or flange of web stiffener with two No. 8 screws at each end. The depth of the blocking shall be equal to the depth of the joist. The minimum length of the angle shall be equal to the depth of the joist minus 2 inches (51 mm). Blocking shall be fastened through the floor sheathing and to the support with three No. 8 screws (top and bottom).

R505.3.4 Bearing stiffeners.
Bearing stiffeners shall be installed at each joist bearing location in accordance with this
section, except for joists lapped over an interior support not carrying a load-bearing wall above. Floor joists supporting jamb studs with multiple members shall have two bearing stiffeners in accordance with Figure R505.3.4(1). Bearing stiffeners shall be fabricated from a C-shaped, track or clip angle member in accordance with the one of following:

1. C-shaped bearing stiffeners:

   1.1. Where the joist is not carrying a load-bearing wall above, the bearing stiffener shall be a minimum 33 mil (0.84 mm) thickness.

   1.2. Where the joist is carrying a load-bearing wall above, the bearing stiffener shall be not less than the same designation thickness as the wall stud above.

2. Track bearing stiffeners:

   2.1. Where the joist is not carrying a load-bearing wall above, the bearing stiffener shall be a minimum 43 mil (1.09 mm) thickness.

   2.2. Where the joist is carrying a load-bearing wall above, the bearing stiffener shall be not less than one designation thickness greater than the wall stud above.

The minimum length of a bearing stiffener shall be the depth of member being stiffened minus \( \frac{3}{8} \) inch (9.5 mm). Each bearing stiffener shall be fastened to the web of the member it is stiffening as shown in Figure R505.3.4(2).

![Figure R505.3.4(1) Bearing Stiffeners Under Jamb Studs](image-url)
FIGURE R505.3.4(2)
BEARING STIFFENER

R505.3.5 Cutting and notching.
Flanges and lips of load-bearing cold-formed steel floor framing members shall not be cut or notched.

R505.3.6 Floor cantilevers.
Floor cantilevers for the top floor of a two- or three-story building or the first floor of a one-story building shall not exceed 24 inches (610 mm). Cantilevers, not exceeding 24 inches (610 mm) and supporting two stories and roof (first floor of a two-story building), shall be permitted provided that all cantilevered joists are doubled (nested or back-to-back). The doubled cantilevered joists shall extend not less than 6 feet (1829 mm) toward the inside and shall be fastened with not less than two No. 8 screws spaced at 24 inches (610 mm) on center through the webs (for back-to-back) or flanges (for nested joists).

R505.3.7 Splicing.
Joists and other structural members shall not be spliced. Splicing of tracks shall conform to Figure R505.3.7.
R505.3.8 Framing of floor openings.
Openings in floors shall be framed with header and trimmer joists. Header joist spans shall not exceed 6 feet (1829 mm) or 8 feet (2438 mm) in length in accordance with Figure R505.3.8(1) or R505.3.8(2), respectively. Header and trimmer joists shall be fabricated from joist and track members, having a minimum size and thickness at least equivalent to the adjacent floor joists, and shall be installed in accordance with Figures R505.3.8(1), R505.3.8(2), R505.3.8(3) and R505.3.8(4). Each header joist shall be connected to trimmer joists with four 2-inch by 2-inch (51 mm by 51 mm) clip angles. Each clip angle shall be fastened to both the header and trimmer joists with four No. 8 screws, evenly spaced, through each leg of the clip angle. The clip angles shall have a thickness not less than that of the floor joist. Each track section for a built-up header or trimmer joist shall extend the full length of the joist (continuous).
FIGURE R505.3.8(1)
COLD-FORMED STEEL FLOOR CONSTRUCTION—6-FOOT FLOOR OPENING

For SI: 1 foot = 304.8 mm.
FIGURE R505.3.8(2)
COLD-FORMED STEEL FLOOR CONSTRUCTION—8-FOOT FLOOR OPENING

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE R505.3.8(3)
COLD-FORMED STEEL FLOOR CONSTRUCTION: FLOOR HEADER TO TRIMMER CONNECTION—6-FOOT OPENING

For SI: 1 foot = 304.8 mm.
R506.1 General.
Concrete slab-on-ground floors shall be designed and constructed in accordance with the provisions of this section or ACI 332. Floors shall be a minimum $3\frac{1}{2}$ inches (89 mm) thick (for expansive soils, see Section R403.1.8). The specified compressive strength of concrete shall be as set forth in Section R402.2.

R506.2 Site preparation.
The area within the foundation walls shall have all vegetation, top soil and foreign material removed.

R506.2.1 Fill.
Fill material shall be free of vegetation and foreign material. The fill shall be compacted to ensure uniform support of the slab, and except where approved, the fill depths shall not exceed 24 inches (610 mm) for clean sand or gravel and 8 inches (203 mm) for earth.

R506.2.2 Base.
A 4-inch-thick (102 mm) base course consisting of clean graded sand, gravel, crushed stone, crushed concrete or crushed blast-furnace slag passing a 2-inch (51 mm) sieve shall be placed on the prepared subgrade where the slab is below grade.
**Exception:** A base course is not required where the concrete slab is installed on well-drained or sand-gravel mixture soils classified as Group I according to the United Soil Classification System in accordance with Table R405.1.

**R506.2.3 Vapor retarder.**
A 6-mil (0.006 inch; 152 μm) polyethylene or approved vapor retarder with joints lapped not less than 6 inches (152 mm) shall be placed between the concrete floor slab and the base course or the prepared subgrade where no base course exists.

**Exception:** The vapor retarder is not required for the following:

1. Garages, utility buildings and other unheated accessory structures.
2. For unheated storage rooms having an area of less than 70 square feet (6.5 m²) and carports.
3. Driveways, walks, patios and other flatwork not likely to be enclosed and heated at a later date.
4. Where approved by the building official, based on local site conditions.

**R506.2.4 Reinforcement support.**
Where provided in slabs-on-ground, reinforcement shall be supported to remain in place from the center to upper one-third of the slab for the duration of the concrete placement.

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**SECTION R507**
**EXTERIOR DECKS**
Deleted. See Appendix M.

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**R507.1 Decks.**
Wood-framed decks shall be in accordance with this section or Section R301 for materials and conditions not prescribed herein. Where supported by attachment to an exterior wall, decks shall be positively anchored to the primary structure and designed for both vertical and lateral loads.

Such attachment shall not be accomplished by the use of toenails or nails subject to withdrawal. Where positive connection to the primary building structure cannot be verified during inspection, decks shall be self-supporting. For decks with cantilevered framing members, connections to exterior walls or other framing members shall be designed and constructed to resist uplift resulting from the full live load specified in Table R301.5 acting on the cantilevered portion of the deck.

**R507.2 Deck ledger connection to band joist.**
Deck ledger connections to band joists shall be in accordance with this section, Tables R507.2 and R507.2.1, and Figures R507.2.1(1) and R507.2.1(2). For other grades, species, connection details and loading conditions, deck ledger connections shall be designed in accordance with Section R301.
TABLE R507.2
DECK LEDGER CONNECTION TO BAND JOIST\textsuperscript{a–b}
(Deck live load = 40 psf, deck dead load = 10 psf, snow load \leq 40 psf)

<table>
<thead>
<tr>
<th>CONNECTION DETAILS</th>
<th>JOIST SPAN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6\textsuperscript{1} and less</td>
</tr>
<tr>
<td>On-center spacing of fasteners</td>
<td></td>
</tr>
</tbody>
</table>

1/2-inch diameter lag screw with 1/2-inch maximum sheathing 
30 23 18 15 13 11 10

1/2-inch diameter bolt with 1/2-inch maximum sheathing 
36 36 34 29 24 21 19

1/2-inch diameter bolt with 1-inch maximum sheathing 
36 36 29 24 21 18 16

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Ledgers shall be flashed in accordance with Section R703.8 to prevent water from contacting the house band joist.
b. Snow load shall not be assumed to act concurrently with live load.
c. The tip of the lag screw shall fully extend beyond the inside face of the band joist.
d. Sheathing shall be wood structural panel or solid sawn lumber.
e. Sheathing shall be permitted to be wood structural panel, gypsum board, fiberboard, lumber or foam sheathing. Up to 1/2-inch thickness of stacked washers shall be permitted to substitute for up to 1/2-inch of allowable sheathing thickness where combined with wood structural panel or lumber sheathing.

R507.2.1 Ledger details.
Deck ledgers installed in accordance with Section R507.2 shall be a minimum 2-inch by 8-inch (51 mm by 203 mm) nominal, pressure-preserved, treated southern pine, incised pressure-preserved, treated Hem-fir, or approved, naturally durable, No. 2 grade or better lumber. Deck ledgers installed in accordance with Section R507.2 shall not support concentrated loads from beams or girders. Deck ledgers shall not be supported on stone or masonry veneer.

TABLE 507.2.1
PLACEMENT OF LAG SCREWS AND BOLTS IN DECK LEDGERS AND BAND JOISTS

| MINIMUM END AND EDGE DISTANCES AND SPACING BETWEEN ROWS |
|----------------|----------------|----------------|----------------|
| TOP EDGE | BOTTOM EDGE | ENDS | ROW SPACING |
a. Lag screws or bolts shall be staggered from the top to the bottom along the horizontal run of the deck ledger in accordance with Figure R507.2.1(1).
b. Maximum 5 inches.
c. For engineered rim joists, the manufacturer’s recommendations shall govern.
d. The minimum distance from bottom row of lag screws or bolts to the top edge of the ledger shall be in accordance with Figure R507.2.1(1).

---

**Figure R507.2.1(1)**

Placement of Lag Screws and Bolts in Ledgers

---

**Figure R507.2.1(2)**

Placement of Lag Screws and Bolts in Band Joists

---

R507.2.2 Band joist details.

Band joists attached by a ledger in accordance with Section R507.2 shall be a minimum 2-
inch-nominal (51 mm), solid-sawn, spruce-pine-fir lumber or a minimum 1-inch by 91/2-inch (25 mm x 241 mm) dimensional, Douglas fir, laminated veneer lumber. Band joists attached by a ledger in accordance with Section R507.2 shall be fully supported by a wall or sill plate below.

**R507.2.3 Ledger to band joist fastener details.**
Fasteners used in deck ledger connections in accordance with Table R507.2 shall be hot-dipped galvanized or stainless steel and shall be installed in accordance with Table R507.2.1 and Figures R507.2.1(1) and R507.2.1(2).

---

**FIGURE 507.2.3(1)**
DECK ATTACHMENT FOR LATERAL LOADS
FIGURE R507.2.3(2)
DECK ATTACHMENT FOR LATERAL LOADS

R507.2.4 Deck lateral load connection.
The lateral load connection required by Section R507.1 shall be permitted to be in accordance with Figure R507.2.3(1) or R507.2.3(2). Where the lateral load connection is provided in accordance with Figure R507.2.3(1), hold-down tension devices shall be installed in not less than two locations per deck, within 24 inches of each end of the deck. Each device shall have an allowable stress design capacity of not less than 1,500 pounds (6672 N). Where the lateral load connections are provided in accordance with Figure R507.2.3(2), the hold-down tension devices shall be installed in not less than four locations per deck, and each device shall have an allowable stress design capacity of not less than 750 pounds (3336 N).

R507.3 Plastic composite deck boards, stair treads, guards, or handrails.
Plastic composite exterior deck boards, stair treads, guards and handrails shall comply with the requirements of ASTM D 7032 and the requirements of Section 507.3.

R507.3.1 Labeling.
Plastic composite deck boards and stair treads, or their packaging, shall bear a label that indicates compliance to ASTM D 7032 and includes the allowable load and maximum allowable span determined in accordance with ASTM D 7032. Plastic or composite handrails and guards, or their packaging, shall bear a label that indicates compliance to ASTM D 7032 and includes the maximum allowable span determined in accordance with ASTM D 7032.

R507.3.2 Flame spread index.
Plastic composite deck boards, stair treads, guards, and handrails shall exhibit a flame spread index not exceeding 200 when tested in accordance with ASTM E 84 or UL 723 with the test specimen remaining in place during the test.

Exception: Plastic composites determined to be noncombustible.

R507.3.3 Decay resistance.
Plastic composite deck boards, stair treads, guards and handrails containing wood, cellulosic or other biodegradable materials shall be decay resistant in accordance with ASTM D 7032.

R507.3.4 Termite resistance.
Where required by Section 318, plastic composite deck boards, stair treads, guards and handrails containing wood, cellulosic or other biodegradable materials shall be termite resistant in accordance with ASTM D 7032.

R507.3.5 Installation of plastic composites.
Plastic composite deck boards, stair treads, guards and handrails shall be installed in accordance with this code and the manufacturer’s instructions.

R507.4 Decking.
Maximum allowable spacing for joists supporting decking shall be in accordance with Table

2018 North Carolina Residential Code
R507.4 Wood decking shall be attached to each supporting member with not less than (2) 8d threaded nails or (2) No. 8 wood screws.

**TABLE R507.4**  
**MAXIMUM JOIST SPACING**

<table>
<thead>
<tr>
<th>MATERIAL TYPE AND NOMINAL SIZE</th>
<th>MAXIMUM ON-CENTER JOIST SPACING</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perpendicular to joist</td>
<td>Diagonal to joist</td>
</tr>
<tr>
<td>1/4-inch-thick wood</td>
<td>16 inches</td>
<td>12 inches</td>
</tr>
<tr>
<td>2-inch-thick wood</td>
<td>24 inches</td>
<td>16 inches</td>
</tr>
<tr>
<td>Plastic composite</td>
<td>In accordance with Section R507.3</td>
<td>In accordance with Section R507.3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.01745 rad.
a. Maximum angle of 45 degrees from perpendicular for wood deck boards

**R507.5 Deck joists.**

Maximum allowable spans for wood deck joists, as shown in Figure R507.5, shall be in accordance with Table R507.5. Deck joists shall be permitted to cantilever not greater than one-fourth of the actual, adjacent joist span.

**TABLE R507.5**

**DECK JOIST SPANS FOR COMMON LUMBER SPECIES**  
(ft.-in.)

<table>
<thead>
<tr>
<th>SPECIES a</th>
<th>SIZE</th>
<th>SPACING OF DECK JOISTS WITH NO CANTILEVER b (inches)</th>
<th>SPACING OF DECK JOISTS WITH CANTILEVERS c (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Southern pine</td>
<td>2 x 6</td>
<td>9-11</td>
<td>9-0</td>
</tr>
<tr>
<td></td>
<td>2 x 8</td>
<td>13-1</td>
<td>11-10</td>
</tr>
<tr>
<td></td>
<td>2 x 10</td>
<td>16-2</td>
<td>14-0</td>
</tr>
<tr>
<td></td>
<td>2 x 12</td>
<td>18-0</td>
<td>16-6</td>
</tr>
<tr>
<td>Douglas fir, larch, hem-fir, spruce, pine-fir</td>
<td>2 x 6</td>
<td>9-6</td>
<td>8-8</td>
</tr>
<tr>
<td></td>
<td>2 x 8</td>
<td>12-6</td>
<td>11-1</td>
</tr>
<tr>
<td></td>
<td>2 x 10</td>
<td>15-8</td>
<td>13-7</td>
</tr>
<tr>
<td></td>
<td>2 x 12</td>
<td>18-0</td>
<td>15-9</td>
</tr>
<tr>
<td>Redwood, western cedars, ponderosa pine, red pine</td>
<td>2 x 6</td>
<td>8-10</td>
<td>8-0</td>
</tr>
<tr>
<td></td>
<td>2 x 8</td>
<td>11-8</td>
<td>10-7</td>
</tr>
<tr>
<td></td>
<td>2 x 10</td>
<td>14-11</td>
<td>13-0</td>
</tr>
<tr>
<td></td>
<td>2 x 12</td>
<td>17-5</td>
<td>15-1</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound = 0.454 kg.
a. No. 2 grade with wet service factor.
b. Ground snow load, live load = 40 psf, dead load = 10 psf, L/D = 360.
c. Ground snow load, live load = 40 psf, dead load = 10 psf, L/D = 360 at main span, L/D = 180 at cantilever with a 220-pound point load applied to end.
d. Includes incising factor.
e. Northern species with no incising factor.
f. Cantilevered spans not exceeding the nominal depth of the joist are permitted.

FIGURE R507.5
TYPICAL DECK JOIST SPANS

R507.5.1 Lateral restraint at supports.
Joist ends and bearing locations shall be provided with lateral restraint to prevent rotation. Where lateral restraint is provided by joist hangers or blocking between joists, their depth shall equal not less than 60 percent of the joist depth. Where lateral restraint is provided by rim joists, they shall be secured to the end of each joist with not less than (3) 10d (3-inch × 0.128-inch) nails or (3) No. 10 × 3-inch (76 mm) long wood screws.

R507.6 Deck Beams.
Maximum allowable spans for wood deck beams, as shown in Figure R507.6, shall be in accordance with Table R507.6. Beam plies shall be fastened with two rows of 10d (3-inch × 0.128-inch) nails minimum at 16 inches (406 mm) on center along each edge. Beams shall be permitted to cantilever at each end up to one-fourth of the actual beam span. Splices of multispan beams shall be located at interior post locations.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SIZE</th>
<th>DECK JOIST SPAN LESS THAN OR EQUAL TO:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(feet)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Southern-pine</td>
<td>2-2×6</td>
<td>6-11</td>
</tr>
<tr>
<td>2-2×8</td>
<td>8-9</td>
<td>7-7</td>
</tr>
<tr>
<td>2-2×10</td>
<td>10-4</td>
<td>9-0</td>
</tr>
<tr>
<td>2-2×12</td>
<td>12-2</td>
<td>10-7</td>
</tr>
<tr>
<td>2-2×6</td>
<td>8-2</td>
<td>7-5</td>
</tr>
<tr>
<td>3-2×8</td>
<td>10-10</td>
<td>9-6</td>
</tr>
<tr>
<td>3-2×10</td>
<td>13-0</td>
<td>11-3</td>
</tr>
<tr>
<td>3-2×12</td>
<td>15-3</td>
<td>13-3</td>
</tr>
<tr>
<td>Douglas fir-larch</td>
<td>3×6 or 2-2×6</td>
<td>5-5</td>
</tr>
<tr>
<td>3×8 or 2-2×8</td>
<td>6-10</td>
<td>5-11</td>
</tr>
<tr>
<td>Hem-fir</td>
<td>3×10 or 2-2×10</td>
<td>8-4</td>
</tr>
</tbody>
</table>
spruce-pine-fir, redwood, western cedars, ponderosa pine, red pine

<table>
<thead>
<tr>
<th>Section</th>
<th>Size</th>
<th>3×12 or 2—2×12</th>
<th>9-8</th>
<th>8-5</th>
<th>7-6</th>
<th>6-10</th>
<th>6-4</th>
<th>5-11</th>
<th>5-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>4×6</td>
<td>6-5</td>
<td>5-6</td>
<td>4-11</td>
<td>4-6</td>
<td>4-2</td>
<td>3-11</td>
<td>3-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4×8</td>
<td>8-5</td>
<td>7-3</td>
<td>6-6</td>
<td>5-11</td>
<td>5-6</td>
<td>5-2</td>
<td>4-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4×10</td>
<td>9-11</td>
<td>8-7</td>
<td>7-8</td>
<td>7-0</td>
<td>6-6</td>
<td>6-1</td>
<td>5-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4×12</td>
<td>11-5</td>
<td>9-11</td>
<td>8-10</td>
<td>8-1</td>
<td>7-6</td>
<td>7-0</td>
<td>6-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3×2×6</td>
<td>7-4</td>
<td>6-8</td>
<td>6-6</td>
<td>5-6</td>
<td>5-1</td>
<td>4-9</td>
<td>4-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3×2×8</td>
<td>9-8</td>
<td>8-6</td>
<td>7-7</td>
<td>6-11</td>
<td>6-5</td>
<td>6-0</td>
<td>5-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3×2×10</td>
<td>12-0</td>
<td>10-5</td>
<td>9-4</td>
<td>8-6</td>
<td>7-10</td>
<td>7-4</td>
<td>6-11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3×2×12</td>
<td>13-11</td>
<td>12-1</td>
<td>10-9</td>
<td>9-10</td>
<td>9-1</td>
<td>8-6</td>
<td>8-1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound = 0.454 kg.

a. Ground snow load, live load = 40 psf, dead load = 10 psf, L/A = 360 at main span, L/A = 180 at cantilever with a 220 pound point load applied at the end.
b. Beams supporting deck joists from one side only.
c. No. 2 grade, wet service factor.
d. Beam depth shall be greater than or equal to depth of joists with a flush beam condition.
e. Includes incising factor.
f. Northern species. Incising factor not included.

R507.6 Deck joist and deck beam bearing.
The ends of each joist and beam shall have not less than 1 1/2 inches (38 mm) of bearing on wood or metal and not less than 3 inches (76 mm) on concrete or masonry for the entire width of the beam. Joist framing into the side of a ledger board or beam shall be supported by approved joist hangers. Joists bearing on a beam shall be connected to the beam to resist lateral displacement.

R507.7.1 Deck post to deck beam.
Deck beams shall be attached to deck posts in accordance with Figure R507.7.1 or by other equivalent means capable to resist lateral displacement. Manufactured post-to-beam connectors shall be sized for the post and beam sizes. All bolts shall have washers under the head and nut.

Exception: Where deck beams bear directly on footings in accordance with Section R507.8.1.
R507.8 Deck posts.
For single-level wood-framed decks with beams sized in accordance with Table R507.6, deck post size shall be in accordance with Table R507.8.

**TABLE R507.8**

<table>
<thead>
<tr>
<th>DECK POST SIZE</th>
<th>MAXIMUM HEIGHT a</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 × 4</td>
<td>8’</td>
</tr>
<tr>
<td>4 × 6</td>
<td>8’</td>
</tr>
<tr>
<td>6 × 6</td>
<td>14’</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.
aMeasured to the underside of the beam.

**R507.8.1 Deck post to deck footing.**
Posts shall bear on footings in accordance with Section R403 and Figure R507.8.1. Posts shall be restrained to prevent lateral displacement at the bottom support. Such lateral restraint shall be provided by manufactured connectors installed in accordance with Section R507 and the manufacturers’ instructions or a minimum post embedment of 12 inches (305 mm) in surrounding soils or concrete piers.
FIGURE R507.8.1
TYPICAL DECK POSTS TO DECK FOOTINGS
CHAPTER 6
WALL CONSTRUCTION

SECTION R601
GENERAL

R601.1 Application.
The provisions of this chapter shall control the design and construction of walls and partitions for buildings.

R601.2 Requirements.
Wall construction shall be capable of accommodating all loads imposed in accordance with Section R301 and of transmitting the resulting loads to the supporting structural elements.

R601.2.1 Compressible floor-covering materials.
Compressible floor-covering materials that compress more than $\frac{1}{32}$ inch (0.8 mm) when subjected to 50 pounds (23 kg) applied over 1 inch square (645 mm) of material and are greater than $\frac{1}{8}$ inch (3.2 mm) in thickness in the uncompressed state shall not extend beneath walls, partitions or columns, which are fastened to the floor.

SECTION R602
WOOD WALL FRAMING

R602.1 General.
Wood and wood-based products used for load-supporting purposes shall conform to the applicable provisions of this section.

R602.1.1 Sawn lumber.
Sawn lumber shall be identified by a grade mark of an accredited lumber grading or inspection agency and have design values certified by an accreditation body that complies with DOC PS 20. In lieu of a grade mark, a certification of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted.

R602.1.2 End-jointed lumber.
Approved end-jointed lumber identified by a grade mark conforming to Section R602.1 shall be permitted to be used interchangeably with solid-sawn members of the same species and grade. End-jointed lumber used in an assembly required elsewhere in this code to have a fire-resistance rating shall have the designation “Heat Resistant Adhesive” or “HRA” included in its grade mark.

R602.1.3 Structural glued-laminated timbers.
Glued-laminated timbers shall be manufactured and identified as required in ANSI/AITC A190.1 and ASTM D 3737.

R602.1.4 Structural log members.
Structural log members shall comply with the provisions of ICC 400.
R602.1.5 Structural composite lumber.
Structural capacities for structural composite lumber shall be established and monitored in accordance with ASTM D 5456.

R602.1.6 Cross-laminated timber.
Cross-laminated timber shall be manufactured and identified as required by ANSI/APA PRG 320.

R602.1.7 Engineered wood rim board.
Engineered wood rim boards shall conform to ANSI/APA PRR 410 or shall be evaluated in accordance with ASTM D 7672. Structural capacities shall be in accordance with either ANSI/APA PRR 410 or established in accordance with ASTM D 7672. Rim boards conforming to ANSI/APA PRR 410 shall be marked in accordance with that standard.

R602.1.8 Wood structural panels.
Wood structural panel sheathing shall conform to DOC PS 1, DOC PS 2 or, when manufactured in Canada, CSA O437 or CSA O325. Panels shall be identified for grade, bond classification, and performance category by a grade mark or certificate of inspection issued by an approved agency.

R602.1.9 Particleboard.
Particleboard shall conform to ANSI A208.1. Particleboard shall be identified by the grade mark or certificate of inspection issued by an approved agency.

R602.1.10 Fiberboard.
Fiberboard shall conform to ASTM C 208. Fiberboard sheathing, where used structurally, shall be identified by an approved agency as conforming to ASTM C 208.

R602.2 Grade.
Studs shall be a minimum No. 3, standard or stud grade lumber.

Exception: Bearing studs not supporting floors and nonbearing studs shall be permitted to be utility grade lumber, provided the studs are spaced in accordance with Table R602.3(5).

R602.3 Design and construction.
Exterior walls of wood-frame construction shall be designed and constructed in accordance with the provisions of this chapter and Figures R602.3(1) and R602.3(2), or in accordance with AWC NDS. Components of exterior walls shall be fastened in accordance with Tables R602.3(1) through R602.3(4). Wall sheathing shall be fastened directly to framing members and, where placed on the exterior side of an exterior wall, shall be capable of resisting the wind pressures listed in Table R301.2(2) adjusted for height and exposure using Table R301.2(3) and shall conform to the requirements of Table R602.3(3). Wall sheathing used only for exterior wall covering purposes shall comply with Section R703.

Studs shall be continuous from support at the sole plate to a support at the top plate to resist loads perpendicular to the wall. The support shall be a foundation or floor, ceiling or roof diaphragm or shall be designed in accordance with accepted engineering practice.

Exception: Jack studs, trimmer studs and cripple studs at openings in walls that comply with Tables R602.7(1) and R602.7(2).
<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Blocking between ceiling joists or rafters to top plate</td>
<td>4-8d box $(2 \frac{1}{2} \times 0.113\text{&quot;)}$ or $3-8d$ common $(2 \frac{1}{2} \times 0.131\text{&quot;)}$; or 3-10d box $(3'' = 0.128\text{&quot;)}$; or $3-3'' \times 0.131''$ nails</td>
<td>Toe nail</td>
</tr>
<tr>
<td>2</td>
<td>Ceiling joists to top plate</td>
<td>$4-8d$ box $(2 \frac{1}{2} \times 0.113\text{&quot;)}$; or $3-8d$ common $(2 \frac{1}{2} \times 0.131\text{&quot;)}$; or 3-10d box $(3'' = 0.128\text{&quot;)}$; or $3-3'' \times 0.131''$ nails</td>
<td>Per joist, toe nail</td>
</tr>
<tr>
<td>3</td>
<td>Ceiling joist not attached to parallel rafter, laps over partitions [see Sections R802.3.1, R802.3.2 and Table R802.5.1(9)]</td>
<td>$4-10d$ box $(3'' = 0.128\text{&quot;)}$; or $3-16d$ common $(3 \frac{1}{2} \times 0.148\text{&quot;)}$; or $4-3'' \times 0.131''$ nails</td>
<td>Face nail</td>
</tr>
<tr>
<td>4</td>
<td>Ceiling joist attached to parallel rafter (heel joint) [see Sections R802.3.1 and R802.3.2 and Table R802.5.1(9)]</td>
<td>Table R802.5.1(9)</td>
<td>Face nail</td>
</tr>
<tr>
<td>5</td>
<td>Collar tie to rafter, face nail or $\frac{3}{4}'' \times 20$ ga. ridge strap to rafter</td>
<td>$4-10d$ box $(3'' = 0.128\text{&quot;)}$; or $3-10d$ common $(3'' = 0.148\text{&quot;)}$; or $4-3'' \times 0.131''$ nails</td>
<td>Face nail each rafter</td>
</tr>
<tr>
<td>6</td>
<td>Rafter or roof truss to plate</td>
<td>$3-16d$ box nails $(3 \frac{1}{2} \times 0.135\text{&quot;)}$; or $3-10d$ common nails $(3'' = 0.148\text{&quot;)}$; or $4-10d$ box $(3'' = 0.128\text{&quot;)}$; or $4-3'' \times 0.131''$ nails</td>
<td>2 toe nails on one side and 1 toe nail on opposite side of each rafter or truss</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Details</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Roof rafters to ridge, valley or hip rafters or roof rafter to minimum 2&quot; ridge beam</td>
<td>4-16d (3/2&quot;, 0.135&quot;) or 3-10d common (3/2&quot;, 0.148&quot;) or 4-10d box (3&quot; x 0.128&quot;) or 4-3&quot; x 0.131&quot; nails. Toe nail.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-16d box 3/2&quot; x 0.135&quot;; or 2-16d common (3/2&quot;, 0.162&quot;) or 3-10d box (3&quot; x 0.128&quot;) or 3-3&quot; x 0.131&quot; nails. End nail.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Stud to stud (not at braced wall panels)</td>
<td>16d common (3/2&quot;, 0.162&quot;) or 10d box (3&quot; x 0.128&quot;) or 3&quot; x 0.131&quot; nails. 24&quot; o.c. face nail.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Stud to stud and abutting studs at intersecting wall corners (at braced wall panels)</td>
<td>16d box 3/2&quot; x 0.135&quot;; or 16d common (3/2&quot;, 0.162&quot;) or 3&quot; x 0.131&quot; nails. 12&quot; o.c. face nail.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Built-up header (2&quot; to 2&quot; header with 1/2&quot; spacer)</td>
<td>16d common (3/2&quot;, 0.162&quot;) or 16d box 3/2&quot; x 0.135&quot;. 16&quot; o.c. each edge face nail.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Continuous header to stud</td>
<td>5-8d box 2/2&quot; x 0.113&quot;; or 4-8d common (2/2&quot;, 0.131&quot;) or 4-10d box (3&quot; x 0.128&quot;). Toe nail.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Top plate to top plate</td>
<td>16d common (3/2&quot;, 0.162&quot;) or 10d box (3&quot; x 0.128&quot;) or 3&quot; x 0.131&quot; nails. 12&quot; o.c. face nail.</td>
<td></td>
</tr>
<tr>
<td>ITEM</td>
<td>DESCRIPTION OF BUILDING ELEMENTS</td>
<td>NUMBER AND TYPE OF FASTENER</td>
<td>SPACING AND LOCATION</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------</td>
<td>-----------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>13</td>
<td>Double top plate splice for SDCs A-D2 with seismic braced wall line spacing &lt; 25'</td>
<td>8-16d common (3 \frac{1}{2} &quot; × 0.162&quot;) ; or 12-16d box (3 \frac{1}{2} &quot; × 0.135&quot;) ; or 12-10d box (3&quot; × 0.128&quot;) ; or 12-3&quot; × 0.131” nails</td>
<td>Face nail on each side of end joint (minimum 24” lap splice length each side of end joint)</td>
</tr>
<tr>
<td></td>
<td>Double top plate splice SDCs D _D _1 or D _2 ; and braced wall line spacing ≥ 25'</td>
<td>12-16d (3 \frac{1}{2} &quot; × 0.135&quot;)</td>
<td>(continued)</td>
</tr>
</tbody>
</table>

**TABLE R602.3(1)—continued**

**FASTENING SCHEDULE**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Bottom plate to joist, rim joist, band joist or blocking (not at braced wall panels)</td>
<td>16d common (3 \frac{1}{2} &quot; × 0.162&quot;) ; or 16d box (3 \frac{1}{2} &quot; × 0.135&quot;) ; or 3&quot; × 0.131” nails</td>
<td>16&quot; o.c. face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 each 16&quot; o.c. face nail</td>
<td>12&quot; o.c. face nail</td>
</tr>
<tr>
<td>15</td>
<td>Bottom plate to joist, rim joist, band joist or blocking (at braced wall panel)</td>
<td>3-16d box (3 \frac{1}{2} &quot; × 0.135&quot;) ; or 2-16d common (3 \frac{1}{2} &quot; × 0.162&quot;) ; or 4-3&quot; × 0.131” nails</td>
<td>3 each 16&quot; o.c. face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 each 16&quot; o.c. face nail</td>
<td>4 each 16&quot; o.c. face nail</td>
</tr>
<tr>
<td>16</td>
<td>Top or bottom plate to stud</td>
<td>4-8d box (2 \frac{1}{2} &quot; × 0.113&quot;) ; or 1-16d box (3 \frac{1}{2} &quot; × 0.135&quot;) ; or 4-8d common (2 \frac{1}{2} &quot; × 0.131&quot;) ; or 4-10d box (3&quot; × 0.128&quot;) ; or 4-3&quot; × 0.131” nails</td>
<td>Toe nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-16d box (3 \frac{1}{2} &quot; × 0.135&quot;) ; or 2-16d common (3 \frac{1}{2} &quot; × 0.162&quot;) ; or 3-10d box (3&quot; × 0.128&quot;) ; or 3-3&quot; × 0.131” nails</td>
<td>End nail</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Details</td>
<td>Fastening Type</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>17</td>
<td>Top plates, laps at corners and intersections</td>
<td>3-10d box (3” × 0.128”); or 2-16d common (3 1/2” × 0.162”); or 3-3” × 0.131” nails</td>
<td>Face nail</td>
</tr>
<tr>
<td>18</td>
<td>1” brace to each stud and plate</td>
<td>3-8d box (2 1/2” × 0.113”); or 2-8d common (2 1/2” × 0.131”); or 2-10d box (3” × 0.128”); or 2 staples 1 3/4” crown, 16 ga., 1 3/4” long</td>
<td>Face nail</td>
</tr>
<tr>
<td>19</td>
<td>1” × 6” sheathing to each bearing</td>
<td>3-8d box (2 1/2” × 0.113”); or 2-8d common (2 1/2” × 0.131”); or 2-10d box (3” × 0.128”); or 2 staples, 1” crown, 16 ga., 1 3/4” long</td>
<td>Face nail</td>
</tr>
<tr>
<td>20</td>
<td>1” × 8” and wider sheathing to each bearing</td>
<td>3-8d box (2 1/2” × 0.113”); or 3-8d common (2 1/2” × 0.131”); or 3-10d box (3” × 0.128”); or 3 staples, 1” crown, 16 ga., 1 3/4” long</td>
<td>Face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wider than 1” × 8”</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-8d box (2 1/2” × 0.113”); or 3-8d common (2 1/2” × 0.131”); or 3-10d box (3” × 0.128”); or 4 staples, 1” crown, 16 ga., 1 3/4” long</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 staples, 1” crown, 16 ga., 1 3/4” long</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4” o.c. toe nail</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Joist to sill, top plate or girder</td>
<td>4-8d box (2 1/2” × 0.113”); or 3-8d common (2 1/2” × 0.131”); or 3-10d box (3” × 0.128”); or 3-3” × 0.131” nails</td>
<td>Toe nail</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>8d box (2 1/2” × 0.113”)</td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
### TABLE 602.3(1)-continued

**FASTENING SCHEDULE**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>1” x 6” subfloor or less to each joist</td>
<td>3-8d box (2 3/8” x 0.135”); or 2-8d common (2 3/8” x 0.131”); or 3-10d box (3” x 0.128”); or 3-3” x 0.131” nails</td>
<td>Face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 staples, 1” crown, 16 ga.., 1 3/4” long</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>2” subfloor to joist or girder</td>
<td>3-16d box (3 1/2” x 0.135”); or 2-16d common (3 1/2” x 0.162”)</td>
<td>Blind and face nail</td>
</tr>
<tr>
<td>25</td>
<td>2” planks (plank &amp; beam—floor &amp; roof)</td>
<td>3-16d box (3 1/2” x 0.135”); or 2-16d common (3 1/2” x 0.162”)</td>
<td>At each bearing, face nail</td>
</tr>
<tr>
<td>26</td>
<td>Band or rim joist to joist</td>
<td>3-16d common (3 1/2” x 0.162”)</td>
<td>End-nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-10 box (3” x 0.128”); or 4-3” x 0.131” nails; or 4-3” x 14 ga. staples, 7/16” crown</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Built-up girders and beams, 2-inch lumber layers</td>
<td>20d common (4” x 0.192”; or 10d box (3” x 0.128”); or 3” x 0.131” nails</td>
<td>Nail each layer as follows: 32” o.c. at top and bottom and staggered.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-20d common (4” x 0.192”; or 3-10d box (3” x 0.128”); or 3-3” x 0.131” nails</td>
<td>24” o.c. face nail at top and bottom staggered on opposite sides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>And:</td>
<td>Face nail at ends and at each splice</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>At each joist or rafter, face nail</td>
<td></td>
</tr>
</tbody>
</table>
Ledger strip supporting joists or rafters:
- 4-16d box ($3\frac{1}{2}''$ x 0.135''); or
- 3-16d common ($3\frac{1}{2}''$ x 0.162''); or
- 4-10d box ($3''$ x 0.128''); or
- 4-3'' x 0.131'' nails

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridging to joist</td>
<td>2-10d ($3''$ x 0.128'')</td>
<td>Each end, toe nail</td>
<td></td>
</tr>
</tbody>
</table>

### Wood structural panels, subfloor, roof and interior wall sheathing to framing and particleboard wall sheathing to framing

[see Table R602.3(3) for wood structural panel exterior wall sheathing to wall framing]

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>3\frac{1}{8}'' – 1\frac{1}{2}''</td>
<td>6d common ($2''$ x 0.113'') nail (subfloor, wall)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8d common ($2\frac{1}{2}''$ x 0.131'') nail (roof)</td>
<td>12f</td>
</tr>
<tr>
<td>31</td>
<td>19/32'' – 1''</td>
<td>8d common nail ($2\frac{1}{2}''$ x 0.131'')</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12f</td>
</tr>
<tr>
<td>32</td>
<td>1\frac{1}{8}'' – 1\frac{1}{4}''</td>
<td>10d common ($3''$ x 0.148'') nail; or 8d ($2\frac{1}{2}''$ x 0.131'') deformed nail</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

### Other wall sheathing

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>1\frac{1}{2}'' structural cellulosic fiberboard sheathing</td>
<td>4\frac{1}{2}'' galvanized roofing nail, 7/16'' head diameter, or 1'' crown staple 16 ga., 1\frac{1}{4}'' long</td>
<td>3</td>
</tr>
<tr>
<td>34</td>
<td>25\frac{1}{32}'' structural cellulosic fiberboard sheathing</td>
<td>4\frac{1}{4}'' galvanized roofing nail, 7/16'' head diameter, or 1'' crown staple 16 ga., 1\frac{1}{4}'' long</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>1\frac{1}{2}'' gypsum sheathing</td>
<td>4\frac{1}{2}'' galvanized roofing nail; staple galvanized; 1\frac{1}{4}'' long; 1\frac{1}{4}'' screws, Type W or S</td>
<td>Z</td>
</tr>
</tbody>
</table>
Gypsum sheathing shall conform to ASTM C 1396 and shall be installed in accordance with GA 253. Fiberboard sheathing shall conform to ASTM C 208.

Spacing of fasteners not included in this table shall be based on Table R602.3(2).

Where a rafter is fastened to an adjacent parallel ceiling joist in accordance with this schedule, provide two toe nails on one side of the rafter and toe nails from the ceiling joist to top plate in accordance with this schedule. The toe nail on the opposite side of the rafter shall not be required.

<table>
<thead>
<tr>
<th>Panel Width (inches)</th>
<th>Nails for Framing</th>
<th>Nails for Sheathing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4</td>
<td>6d deformed (2” × 0.120”)</td>
<td>8d deformed (2” × 0.120”)</td>
</tr>
<tr>
<td>7/8</td>
<td>8d deformed (2” × 0.120”)</td>
<td>8d deformed (2” × 0.120”)</td>
</tr>
<tr>
<td>11/8</td>
<td>10d common (3” × 0.148”)</td>
<td>8d deformed (2” × 0.120”)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s; 1 ksi = 6.895 MPa.

a. Nails are smooth common, box or deformed shanks except where otherwise stated. Nails used for framing and sheathing connections shall have minimum average bending yield strengths as shown: 80 ksi for shank diameter of 0.192 inch (20d common nail), 90 ksi for shank diameters larger than 0.142 inch but not larger than 0.177 inch, and 100 ksi for shank diameters of 0.142 inch or less.

b. Staples are 16 gage wire and have a minimum 7/16-inch on diameter crown width.

c. Nails shall be spaced at not more than 6 inches on center at all supports where spans are 48 inches or greater.

d. Four-foot by 8-foot or 4-foot by 9-foot panels shall be applied vertically.

e. Spacing of fasteners not included in this table shall be based on Table R602.3(2).

f. Where the ultimate design wind speed is 130 mph or less, nails for attaching wood structural panel roof sheathing to gable end wall framing shall be spaced 6 inches on center. Where the ultimate design wind speed is greater than 130 mph, nails for attaching panel roof sheathing to intermediate supports shall be spaced 6 inches on center for minimum 48-inch distance from ridges, eaves and gable end walls, and 4 inches on center to gable end wall framing.

g. Gypsum sheathing shall conform to ASTM C 1396 and shall be installed in accordance with GA 253. Fiberboard sheathing shall conform to ASTM C 208.

h. Spacing of fasteners on floor sheathing panel edges applies to panel edges supported by framing members and required blocking and at floor perimeters only. Spacing of fasteners on roof sheathing panel edges applies to panel edges supported by framing members and required blocking. Blocking of roof or floor sheathing panel edges perpendicular to the framing members need not be provided except as required by other provisions of this code. Floor perimeter shall be supported by framing members or solid blocking.

i. Where a rafter is fastened to an adjacent parallel ceiling joist in accordance with this schedule, provide two toe nails on one side of the rafter and toe nails from the ceiling joist to top plate in accordance with this schedule. The toe nail on the opposite side of the rafter shall not be required.
TABLE R602.3(1)
WALL FRAMING a,b,c,f
TABLE R602.3(1)—continued
WALL FRAMING

<table>
<thead>
<tr>
<th>CONNECTION</th>
<th>FASTENER MINIMUM NOMINAL LENGTH IN INCHES</th>
<th>QUANTITY FOR CONNECTION OR SPACING BETWEEN FASTENERS (INCHES ON CENTER)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top or sole plate to stud (face nail)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{3}{4}&quot; \times 0.162&quot; ) (16d common)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.148&quot; ) nail (10d common)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td>Stud to top or sole plate (toe nail)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{3}{4}&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.113&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 2&quot; \times 0.113&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.105&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.099&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td>Cap/top plate laps and intersections</td>
<td>( \frac{3}{4}&quot; \times 0.162&quot; ) (16d common)</td>
<td>2 each side of lap</td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.148&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td>Diagonal bracing</td>
<td>( \frac{3}{4}&quot; \times 0.131&quot; ) nail</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.122&quot; ) (16d common)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.148&quot; ) nail (10d common)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.113&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 2&quot; \times 0.113&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.105&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.099&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td>Sole plate to joist or blocking at braced panels</td>
<td>( \frac{3}{4}&quot; \times 0.135&quot; ) nail (16d box)</td>
<td>3 per 16&quot; space</td>
</tr>
<tr>
<td></td>
<td>( \frac{3}{8}&quot; \times 0.162&quot; ) (16d common)</td>
<td>2 per 16&quot; space</td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.148&quot; ) (10d common)</td>
<td>2 per 16&quot; space</td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.131&quot; ) nail</td>
<td>3 per 16&quot; space</td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.131&quot; ) nail</td>
<td>4 per 16&quot; space</td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td>Sole plate to joist or blocking</td>
<td>( \frac{3}{8}&quot; \times 0.162&quot; ) (16d common)</td>
<td>16&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.148&quot; ) (10d common)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2}&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.131&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \frac{5}{8}&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 3&quot; \times 0.120&quot; ) nail</td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>CONNECTIONS (NAIL SIZE AND POSITION EXAGGERATED FOR ILLUSTRATIVE PURPOSES)</th>
<th>FASTENER MINIMUM NOMINAL LENGTH IN INCHES X MINIMUM NOMINAL NAIL DIAMETER IN INCHES</th>
<th>QUANTITY PER CONNECTION OR SPACING BETWEEN FASTENERS, INCHES ON CENTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double top plate</td>
<td>3(\frac{1}{2}) x 0.148&quot; nail (10d common) 3(\frac{1}{4}) x 0.162&quot; nail (16d common) 3(\frac{1}{2}) x 0.131&quot; nail 3(\frac{3}{4}) x 0.120&quot; nail 3 x 0.120&quot; nail</td>
<td>16&quot; o.c.</td>
</tr>
<tr>
<td>Double Studs</td>
<td>3(\frac{1}{2}) x 0.148&quot; nail (10d common) 3(\frac{1}{4}) x 0.162&quot; nail (16d common) 3(\frac{1}{2}) x 0.131&quot; nail 3(\frac{3}{4}) x 0.120&quot; nail 3 x 0.120&quot; nail</td>
<td>12&quot; o.c.</td>
</tr>
<tr>
<td>Corner Studs</td>
<td>3(\frac{1}{2}) x 0.162&quot; nail (16d common) 3 x 0.148&quot; nail (10d common) 3(\frac{1}{2}) x 0.131&quot; nail 3 x 0.131&quot; nail 3(\frac{3}{4}) x 0.120&quot; nail 3 x 0.120&quot; nail</td>
<td>8&quot; o.c.</td>
</tr>
</tbody>
</table>

**TABLE R602.3(1)—continued**

CEILING AND ROOF FRAMING
<table>
<thead>
<tr>
<th>Connection (Nail size and position flaggerate for illustrative purposes)</th>
<th>Fastener (Minimum nominal length in inches x minimum nominal nail diameter in inches)</th>
<th>Quantity per connection or spacing between fasteners inches on center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling joist to plate</td>
<td>2 1/2&quot; x 0.162&quot; nail (16d common)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.148&quot; nail (16d common)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.131&quot; nail</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.131&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td>Ceiling joist, laps over partition</td>
<td>2 1/2&quot; x 0.162&quot; nail (16d common)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.148&quot; nail (16d common)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.131&quot; nail</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.131&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td>Ceiling joist to parallel rafter</td>
<td>2 1/2&quot; x 0.162&quot; nail (16d common)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.148&quot; nail (16d common)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.131&quot; nail</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.131&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td>Collar tie to rafter</td>
<td>2 1/2&quot; x 0.162&quot; nail (16d common)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.148&quot; nail (16d common)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.131&quot; nail</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.131&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td>Jack rafter to hip, toe-nailed</td>
<td>2 1/2&quot; x 0.162&quot; nail (16d common)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.148&quot; nail (16d common)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.131&quot; nail</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.131&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td>Jack rafter to hip, face nailed</td>
<td>2 1/2&quot; x 0.162&quot; nail (16d common)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.148&quot; nail (16d common)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.131&quot; nail</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.131&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td>Roof rafter to plate (too-nailed)</td>
<td>2 1/2&quot; x 0.131&quot; nail (8d common)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.162&quot; nail (16d common)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.148&quot; nail (16d common)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.131&quot; nail</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>3&quot; x 0.131&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.105&quot; nail</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2 1/2&quot; x 0.090&quot; nail</td>
<td>6</td>
</tr>
</tbody>
</table>

(continued)
### TABLE 602.3(1)-continued

#### FLOOR FRAMING

<table>
<thead>
<tr>
<th>Connection</th>
<th>Fastener</th>
<th>Minimum Nominal Length x Minimum Nominal Nail Diameter</th>
<th>Quantity Per Connection or Spacing Between Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof rafter to 2-by ridge beam, face nailed</td>
<td>$3\frac{1}{4}'' 	imes 0.162''$ nail (16d common)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$3'' 	imes 0.148''$ nail (10d common)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$2\frac{1}{4}'' 	imes 0.131''$ nail</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$3'' 	imes 0.131''$ nail</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Roof rafter to 2-by ridge beam, toe-nailed</td>
<td>$2\frac{1}{4}'' 	imes 0.162''$ nail (16d common)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$3'' 	imes 0.148''$ nail (10d common)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$2\frac{1}{4}'' 	imes 0.131''$ nail</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$3'' 	imes 0.131''$ nail</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
### Connection

<table>
<thead>
<tr>
<th>Fastener</th>
<th>Minimum Nominal Length in Inches</th>
<th>Quantity per Connection or Spacing Between Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Joist to Band Joist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block &amp; Casing nails (16d common)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&quot; x 0.118&quot; nail (10d common)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Ledger Strip</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block &amp; Casing nails (16d common)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&quot; x 0.118&quot; nail (10d common)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Joist to sill or girder</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block &amp; Casing nails (16d common)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&quot; x 0.118&quot; nail (10d common)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Bridging to Joist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block &amp; Casing nails (16d common)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&quot; x 0.118&quot; nail (10d common)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Rim Joist to Top Plate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block &amp; Casing nails (16d common)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&quot; x 0.118&quot; nail (10d common)</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

### Built-up Girders and Beams

<table>
<thead>
<tr>
<th>Fastener</th>
<th>Minimum Nominal Length in Inches</th>
<th>Spacing of Fasteners along the Top and Bottom of Beam, Staggered on Each Side of Each Layer</th>
<th>Number of Fasteners at Each End and Splice for Each Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot; x 0.112&quot; nail (10d common)</td>
<td>32&quot; o.c.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2&quot; x 0.118&quot; nail (10d common)</td>
<td>24&quot; o.c.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2&quot; x 0.131&quot; nail</td>
<td>16&quot; o.c.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2&quot; x 0.120&quot; nail</td>
<td>16&quot; o.c.</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

*Change to 4" o.c.*

*Change to 6" o.c.*

---

2018 North Carolina Residential Code
**TABLE 602.3(1)-continued**  
FLOOR FRAMING\(^{a,e}\)

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.44 m/s, 1 foot = 304.8 mm.

a. This fastening schedule applies to framing members having an actual thickness of 1 1/2” (nominal “2-by” lumber).

b. Fastenings listed above may also be used for other connections that are not listed but that have the same configuration and the same code requirement for fastener quantity/spacing and fastener size (pennyweight and style, e.g., 8d common, “8-penny common nail”).

c. This fastener, in the quantity or spacing shown in the rightmost column, comprises the most stringent fastening of the connection listed in the International, National, *International One- and Two-family Dwelling*, Standard or Uniform Building Codes.

d. Fastening schedule only applies to buildings of conventional wood frame construction where wind or seismic analysis is not required by the applicable code. In areas where wind or seismic analysis is required, required fastening must be determined by structural analysis. The following are conditions for which codes require structural analysis:

i. For nominal dimensions of nails see Table R602.3(1a)

ii. *North Carolina Residential Code* – buildings located in areas where the design wind speed equals or exceeds 130 mph (58 m/s) or townhouses assigned to seismic design category C.


f. Nails and staples shall conform to the requirements of ASTM F1667.

**TABLE 602.3(1)-continued**  
FASTENER SCHEDULE FOR STRUCTURAL MEMBERS\(^{j,k}\)

<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING MATERIALS</th>
<th>DESCRIPTION OF FASTENER(^{a,**})</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Edges (inches)(^j)</td>
</tr>
<tr>
<td>Wood structural panels, subfloor, roof and interior wall sheathing to framing and particleboard wall sheathing to framing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8” - 1/2”</td>
<td>6d common (2” x 0.113”) nail (subfloor wall)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8d common (2 1/2” x 0.131”) nail (roof)(^f)</td>
<td></td>
</tr>
<tr>
<td>11/32” - 1”</td>
<td>8d common nail (2 1/2” x 0.131”)</td>
<td></td>
</tr>
<tr>
<td>11/32” - 1 1/4”</td>
<td>10d common (3” x 0.148”) nail or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8d (2 1/2” x 0.131”) deformed nail</td>
<td></td>
</tr>
<tr>
<td>Other wall sheathing(^g)</td>
<td>11/32” galvanized roofing nail, 7/32” crown or 1” crown staple 16 ga., 11/2” long</td>
<td></td>
</tr>
<tr>
<td>3/32” structural cellulose fiberboard sheathing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 3/8” galvanized roofing nail, 7/32” crown or 1” crown staple 16 ga., 11/2” long</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/4” gypsum sheathing(^d)</td>
<td>1/4” galvanized roofing nail; staple galvanized, 1/4” long; 1/4” screws, Type W or S</td>
<td></td>
</tr>
<tr>
<td>5/8” gypsum sheathing(^d)</td>
<td>5/8” galvanized roofing nail; staple galvanized, 1/2” screws; Type W or S</td>
<td></td>
</tr>
<tr>
<td>Wood structural panels, combination subfloor underlayment to framing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4” and less</td>
<td>6d deformed (2” x 0.120”) nail or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8d common (2 1/2” x 0.131”) nail</td>
<td></td>
</tr>
<tr>
<td>7/8” - 1”</td>
<td>8d common (2 1/2” x 0.131”) nail</td>
<td></td>
</tr>
<tr>
<td>1 1/8” - 1 1/4”</td>
<td>10d common (3” x 0.148”) nail or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8d deformed (2 1/2” x 0.120”) nail</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s; 1ksi = 6.895 MPa.
a. Deleted.
b. Staples are 16 gage wire and have a minimum 7/16-inch on diameter crown width.
c. Nails shall be spaced at not more than 6 inches on center at all supports where spans are 48 inches or greater.
d. Four-foot-by-8-foot or 4-foot-by-9-foot panels shall be applied vertically.
e. Spacing of fasteners not included in this table shall be based on Table R602.3(2).
f. For regions having ultimate wind speed of 130 mph or greater, 8d deformed (21/2” x 0.120) nails shall be used for attaching plywood and wood structural panel roof sheathing to framing within minimum 48-inch distance from gable end walls, if mean roof height is more than 25 feet, up to 35 feet maximum.
g. For regions having ultimate wind speed of 120 mph or less, nails for attaching wood structural panel roof sheathing to gable end wall framing shall be spaced 6 inches on center. When basic wind speed is greater than 100 mph, nails for attaching panel roof sheathing to intermediate supports shall be spaced 6 inches on center for minimum 48-inch distance from ridges, eaves and gable end walls, and 4 inches on center to gable end wall framing.
h. Gypsum sheathing shall conform to ASTM C 79 and shall be installed in accordance with GA 253. Fiberboard sheathing shall conform to ASTM C 208.
i. Spacing of fasteners on floor sheathing panel edges applies to panel edges supported by framing members and required blocking and at all floor perimeters only. Spacing of fasteners on roof sheathing panel edges applies to panel edges supported by framing members and required blocking. Blocking of roof or floor sheathing panel edges perpendicular to the framing members need not be provided except as required by other provisions of this code. Floor perimeter shall be supported by framing members or solid blocking. Roof sheathing 7/16-inch or greater in thickness does not require perimeter blocking.
j. For nominal dimensions of nails see Table R602.3(1a).
k. Nails and staples shall conform to the requirements of ASTM F1667.
### TABLE R602.3(1a)
#### NOMINAL DIMENSIONS OF NAILS LISTED IN TABLE R602.3(1)

<table>
<thead>
<tr>
<th>Pennyweight</th>
<th>Length (inches)</th>
<th>Shank diameter (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5d</td>
<td>2</td>
<td>0.099</td>
</tr>
<tr>
<td>8d</td>
<td>2 1/2</td>
<td>0.113</td>
</tr>
<tr>
<td>10d</td>
<td>3</td>
<td>0.128</td>
</tr>
<tr>
<td>Casing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5d</td>
<td>2 1/4</td>
<td>0.099</td>
</tr>
<tr>
<td>8d</td>
<td>2 1/2</td>
<td>0.113</td>
</tr>
<tr>
<td>10d</td>
<td>3</td>
<td>0.128</td>
</tr>
<tr>
<td>Common</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5d</td>
<td>2</td>
<td>0.113</td>
</tr>
<tr>
<td>8d</td>
<td>2 1/2</td>
<td>0.131</td>
</tr>
<tr>
<td>10d</td>
<td>3</td>
<td>0.148</td>
</tr>
<tr>
<td>12d</td>
<td>3 1/2</td>
<td>0.162</td>
</tr>
<tr>
<td>20d</td>
<td>4</td>
<td>0.182</td>
</tr>
<tr>
<td>Cooler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5d</td>
<td>1 1/4</td>
<td>0.086</td>
</tr>
<tr>
<td>6d</td>
<td>1 1/2</td>
<td>0.092</td>
</tr>
<tr>
<td>8d</td>
<td>1 3/4</td>
<td>0.113</td>
</tr>
<tr>
<td>Deformed(^a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3d</td>
<td>1 1/4</td>
<td>0.099</td>
</tr>
<tr>
<td>4d</td>
<td>1 1/2</td>
<td>0.099</td>
</tr>
<tr>
<td>5d</td>
<td>2</td>
<td>0.120</td>
</tr>
<tr>
<td>8d</td>
<td>2 1/2</td>
<td>0.120</td>
</tr>
<tr>
<td>Finish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8d</td>
<td>2 1/4</td>
<td>0.099</td>
</tr>
<tr>
<td>10d</td>
<td>3</td>
<td>0.113</td>
</tr>
<tr>
<td>Siding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5d</td>
<td>2 1/2</td>
<td>0.106</td>
</tr>
<tr>
<td>8d</td>
<td>2 3/4</td>
<td>0.128</td>
</tr>
<tr>
<td>Additional Recognized Nails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth Shank Nails</td>
<td>2 1/2</td>
<td>0.092</td>
</tr>
<tr>
<td></td>
<td>2 3/4</td>
<td>0.105</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>1 1/2</td>
<td>0.148</td>
</tr>
<tr>
<td></td>
<td>2 1/4</td>
<td>0.162</td>
</tr>
<tr>
<td></td>
<td>2 3/4</td>
<td>0.099</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.113</td>
</tr>
<tr>
<td>Deformed Shank Nails(^a)</td>
<td>2 1/2</td>
<td>0.113</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s; 1 ksi = 6.895 MPa.

\(^a\) A deformed shank nail must have either a helical (screw) shank or an annular (ring) shank.
### TABLE R602.3(2)

**ALTERNATE ATTACHMENTS TO TABLE R602.3(1)**

<table>
<thead>
<tr>
<th>NOMINAL MATERIAL THICKNESS (inches)</th>
<th>DESCRIPTION OF FASTENER AND LENGTH (inches)</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Edges (inches)</td>
</tr>
<tr>
<td>Wood structural panels subfloor, roof and wall sheathing to framing and particleboard wall sheathing to framing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Up to 1/2</strong></td>
<td><strong>Staple 15 ga. 3/4</strong></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>0.097 - 0.099 Nail 1/4</strong></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Staple 16 ga. 3/4</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>19/32 and 5/8</strong></td>
<td><strong>0.113 Nail 2</strong></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Staple 15 and 16 ga. 1/4</strong></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>0.097 - 0.099 Nail 2 1/4</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>23/32 and 3/4</strong></td>
<td><strong>Staple 14 ga. 2</strong></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Staple 15 ga. 3/4</strong></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>0.097 - 0.099 Nail 2 1/4</strong></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Staple 16 ga. 2</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>1</strong></td>
<td><strong>Staple 14 ga. 1/4</strong></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>0.113 Nail 2 1/4</strong></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Staple 15 ga. 1/4</strong></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>0.097 - 0.099 Nail 2 1/2</strong></td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NOMINAL MATERIAL THICKNESS (inches)</th>
<th>DESCRIPTION OF FASTENER AND LENGTH (inches)</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Edges (inches)</td>
</tr>
<tr>
<td><strong>Floor underlayment; plywood-hardboard-particleboard -fiber-cement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fiber-cement</strong></td>
<td>3d, corrosion-resistant, ring shank nails (finished flooring other than tile)</td>
<td>3</td>
</tr>
<tr>
<td>Material</td>
<td>Nail Specifications</td>
<td>Diameter</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Hardboard</td>
<td>1/2 long ring-grooved underlayment nail</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4d cement-coated sinker nail</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Staple 18 ga., 7/8 long, 3/16 crown</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Staple 16 ga., 11/8 long, 3/8 crown</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Staple 16 ga., 17/8 long, 3/8 crown</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Staple 16 ga., 19/8 long, 3/8 crown</td>
<td>6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. Nail is a general description and shall be permitted to be T-head, modified round head or round head.
b. Staples shall have a minimum crown width of $\frac{7}{16}$-inch on diameter except as noted.

c. Nails or staples shall be spaced at not more than 6 inches on center at all supports where spans are 48 inches or greater. Nails or staples shall be spaced at not more than 12 inches on center at intermediate supports for floors.

d. Fasteners shall be placed in a grid pattern throughout the body of the panel.

e. For 5-ply panels, intermediate nails shall be spaced not more than 12 inches on center each way.

f. Hardboard underlayment shall conform to CPA/ANSI A135.4

g. Specified alternate attachments for roof sheathing shall be permitted where the ultimate design wind speed is less than 130 mph. Fasteners attaching wood structural panel roof sheathing to gable end wall framing shall be installed using the spacing listed for panel edges.

h. Fiber-cement underlayment shall conform to ASTM C 1288 or ISO 8336, Category C.

i. Nails and staples shall conform to the requirements of ASTM F1667.

---

**TABLE R602.3(3)**

**REQUIREMENTS FOR WOOD STRUCTURAL PANEL WALL SHEATHING USED TO RESIST WIND PressURES**

<table>
<thead>
<tr>
<th>MINIMUM NAIL PATTERN</th>
<th>MINIMUM WOOD STRUCTURAL PANEL SPAN RATING</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (inches)</th>
<th>MAXIMUM WALL STUD SPACING (inches)</th>
<th>PANEL NAIL SPACING (inches o.c.)</th>
<th>ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph)</th>
<th>WIND EXPOSURE CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Penetration (degrees)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6d Common (2.0” x 0.113”)</td>
<td>1.5</td>
<td>24/0</td>
<td>$\frac{3}{8}$</td>
<td>16</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>8d Common (2.5” x 0.131”)</td>
<td>1.75</td>
<td>24/16</td>
<td>$\frac{7}{16}$</td>
<td>24</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. Panel strength axis parallel or perpendicular to supports. Three-ply plywood sheathing with studs spaced more than 16 inches on center shall be applied with panel strength axis perpendicular to supports.

b. Table is based on wind pressures acting toward and away from building surfaces in accordance with Section R301.2. Lateral bracing requirements shall be in accordance with Section R602.10.

c. Wood structural panels with span ratings of Wall-16 or Wall-24 shall be permitted as an alternate to panels with a 24/0 span rating. Plywood siding rated 16 o.c. or 24 o.c. shall be permitted as an alternate to panels with a 24/16 span rating. Wall-16 and Plywood siding 16 o.c. shall be used with studs spaced not more than 16 inches on center.

---

**TABLE R602.3(4)**

**ALLOWABLE SPANS FOR PARTICLEBOARD WALL SHEATHING**

<table>
<thead>
<tr>
<th>THICKNESS (inch)</th>
<th>GRADE</th>
<th>STUD SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{3}{8}$</td>
<td>M-1 Exterior glue</td>
<td>When siding is nailed to studs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm.
a. Wall sheathing not exposed to the weather. If the panels are applied horizontally, the end joints of the panel shall be offset so that four panel corners will not meet. All panel edges must be supported. Leave a $\frac{1}{16}$-inch gap between panels and nail not less than $\frac{3}{8}$ inch from panel edges.

**TABLE R602.3(5)**
SIZE, HEIGHT AND SPACING OF WOOD STUDS$^{a,d}$

<table>
<thead>
<tr>
<th>STUD SIZE (inches)</th>
<th>LATERALLY UNSUPPORTED STUD HEIGHT (feet)</th>
<th>BEARING WALLS</th>
<th>NONBEARING WALLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Maximum spacing when supporting a roof-ceiling assembly or a habitable attic assembly, only</strong> (inches)</td>
<td><strong>Maximum spacing when supporting one floor, plus a roof-ceiling assembly or a habitable attic assembly (inches)</strong></td>
</tr>
<tr>
<td>2 × 3</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 × 4</td>
<td>10</td>
<td>24$^c$</td>
<td>16$^c$</td>
</tr>
<tr>
<td>3 × 4</td>
<td>10</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>2 × 5</td>
<td>10</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>2 × 6</td>
<td>10</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Listed heights are distances between points of lateral support placed perpendicular to the plane of the wall. Bearing walls shall be sheathed on not less than one side or bridging shall be installed not greater than 4 feet apart measured vertically from either end of the stud. Increases in unsupported height are permitted where in compliance with Exception 2 of Section R602.3.1 or designed in accordance with accepted engineering practice.
b. Shall not be used in exterior walls.
c. A habitable attic assembly supported by 2 × 4 studs is limited to a roof span of 32 feet. Where the roof span exceeds 32 feet, the wall studs shall be increased to 2 × 6 or the studs shall be designed in accordance with accepted engineering practice.
d. One half of the studs interrupted by a wall opening shall be placed immediately outside the jack studs on each side of the opening as king studs to resist wind loads. King studs shall extend full height from sole plate to top plate of the wall.

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e. 2x4 studs at 12 inches maximum spacing are permitted in accordance with Table R4505(b).

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE R602.3(1)
TYPICAL WALL, FLOOR AND ROOF FRAMING
R602.3.1 Stud size, height and spacing.
The size, height and spacing of studs shall be in accordance with Table R602.3. (5).

Exceptions:

1. Utility grade studs shall not be spaced more than 16 inches (406 mm) on center, shall not support more than a roof and ceiling, and shall not exceed 8 feet (2438 mm) in height for exterior walls and load-bearing walls or 10 feet (3048 mm) for interior nonload-bearing walls.
2. Where snow loads are less than or equal to 25 pounds per square foot (1.2 kPa), and the ultimate design wind speed is less than or equal to 130 mph (58.1 m/s), 2-inch by 6-inch (38 mm by 14 mm) studs supporting a roof load with not more than 6 feet (1829 mm) of tributary length shall have a maximum height of 18 feet (5486 mm) where spaced at 16 inches (406 mm) on center, or 20 feet (6096 mm) where spaced at 12 inches (304.8 mm) on center. Studs shall be minimum No. 2 grade lumber.

R602.3.2 Top plate for bearing walls and braced wall lines.
Wood stud walls shall be capped with a double top plate installed to provide overlapping at corners and intersections with bearing partitions. End joints in top plates shall be offset not less than 24 inches (610 mm). Joints in plates need not occur over studs. Plates shall be not less than 2 inches (51 mm) nominal thickness and have a width not less than the width of the studs.

**Exception:** A single top plate used as an alternative to a double top plate shall comply with the following:

1. The single top plate shall be tied at corners, intersecting walls, and at in-line splices in straight wall lines in accordance with Table R602.3.2.

2. The rafters or joists shall be centered over the studs with a tolerance of not more than 1 inch (25 mm).

3. Omission of the top plate is permitted over headers where the headers are adequately tied to adjacent wall sections in accordance with Table R602.3.2.

### TABLE R602.3.2
SINGLE TOP-PLATE SPLICE CONNECTION DETAILS
FOR BEARING WALLS AND BRACED WALL LINES

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>TOP-PLATE SPLICE LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corners and intersecting walls</td>
<td>But joints in straight walls</td>
</tr>
<tr>
<td>Splice plate size</td>
<td>Minimum nails each side of joint</td>
</tr>
<tr>
<td>Structures in SDC A-C, and in SDC D - D, with braced wall line spacing less than 25 feet</td>
<td>$3'' \times 6'' \times 0.036''$ galvanized steel plate or equivalent</td>
</tr>
<tr>
<td>Structures in SDC D, with braced wall line spacing greater than or equal to 25 feet</td>
<td>$3'' \times 8'' \times 0.036''$ galvanized steel plate or equivalent</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

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R602.3.3 Bearing studs.
Where joists, trusses or rafters are spaced more than 16 inches (406 mm) on center and the bearing studs below are spaced 24 inches (610 mm) on center, such members shall bear within 5 inches (127 mm) of the studs beneath.

Exceptions:

1. The top plates are two 2-inch by 6-inch (38 mm by 140 mm) or two 3-inch by 4-inch (64 mm by 89 mm) members.
2. A third top plate is installed.
3. Solid blocking equal in size to the studs is installed to reinforce the double top plate.

R602.3.4 Bottom (sole) plate.
Studs shall have full bearing on a nominal 2-by (51 mm) or larger plate or sill having a width not less than the width of the studs.

R602.3.5 Braced wall panel uplift load path.
Braced wall panels located at exterior walls that support roof rafters or trusses (including stories below top story) shall have the framing members connected in accordance with one of the following:

1. Fastening in accordance with Table R602.3(1) where:
   1.1. The ultimate design wind speed does not exceed 115 mph (51 m/s), the wind exposure category is B, the roof pitch is 5:12 or greater, and the roof span is 32 feet (9754 mm) or less.
   1.2. The net uplift value at the top of a wall does not exceed 100 plf (146 N/mm). The net uplift value shall be determined in accordance with Section R802.11 and shall be permitted to be reduced by 60 plf (86 N/mm) for each full wall above.

2. Where the net uplift value at the top of a wall exceeds 100 plf (146 N/mm), installing approved uplift framing connectors to provide a continuous load path from the top of the wall to the foundation or to a point where the uplift force is 100 plf (146 N/mm) or less. The net uplift value shall be as determined in Item 1.2.

3. Wall sheathing and fasteners designed to resist combined uplift and shear forces in accordance with accepted engineering practice.

R602.4 Interior load-bearing walls.
Interior load-bearing walls shall be constructed, framed and fireblocked as specified for exterior walls.

R602.5 Interior nonbearing walls.
Interior nonbearing walls shall be permitted to be constructed with 2-inch by 3-inch (51 mm by
76 mm) studs spaced 24 inches (610 mm) on center or, where not part of a braced wall line, 2-inch by 4-inch (51 mm by 102 mm) flat studs spaced at 16 inches (406 mm) on center. Interior nonbearing walls shall be capped with not less than a single top plate. Interior nonbearing walls shall be fireblocked in accordance with Section R602.8.

**R602.6 Drilling and notching of studs.**
Drilling and notching of studs shall be in accordance with the following:

1. **Notching.** Any stud in an exterior wall or bearing partition shall be permitted to be cut or notched to a depth not exceeding 25 percent of its width. Studs in nonbearing partitions shall be permitted to be notched to a depth not to exceed 40 percent of a single stud width. Notching of bearing studs shall be on one edge only and not to exceed one-fourth the height of the stud. Notching shall not occur in the bottom or top 6 inches (152 mm) of bearing studs.

2. **Drilling.** Any stud shall be permitted to be bored or drilled, provided that the diameter of the resulting hole is not more than 60 percent of the stud width, the edge of the hole is not more than 5/8 inch (16 mm) to the edge of the stud, and the hole is not located in the same section as a cut or notch shall not be closer than 6 inches (152 mm) from an adjacent hole or notch. Holes not exceeding 3/4 inch (19 mm) diameter can be as close as 1 ½ inches (38 mm) on center spacing. Studs located in exterior walls or bearing partitions drilled over 40 percent and up to 60 percent shall be doubled with not more than two successive doubled studs bored. See Figures R602.6(1) and R602.6(2).

   **Exception:** Use of approved stud shoes is permitted where they are installed in accordance with the manufacturer’s recommendations.

3. **Cutting and notching of studs shall be permitted to be increased to 65 percent of the width of the stud in exterior and interior walls and bearing partitions, provided that one of the following conditions are met:

   (a) **The wall section is reinforced with ½ inch (13 mm) exterior grade plywood or equivalent reinforcement on the notched side of the wall.** Plywood, if used, shall reach from the floor to ceiling and at least one stud further on each side of the section that has been notched or cut.

   (b) **The exterior walls of a kitchen may be reinforced by placing ½ inch (13 mm) plywood or equivalent reinforcement on the notched side of the wall.** Plywood, if used, shall reach from the floor to counter-top height and at least one stud further on each side of the section that has been notched or cut.
For SI: 1 inch = 25.4 mm.

Note: Condition for exterior and bearing walls.

**FIGURE R602.6(1)**

**NOTCHING AND BORED HOLE LIMITATIONS FOR EXTERIOR WALLS AND BEARING WALLS**
FIGURE R602.6(2)
NOTCHING AND BORED HOLE LIMITATIONS FOR INTERIOR NONBEARING WALLS

R602.6.1 Drilling and notching of top plate.
When piping or ductwork is placed in or partly in an exterior wall or interior load-bearing wall, necessitating cutting, drilling or notching of the top plate by more than 50 percent of its width, a galvanized metal tie not less than 0.054 inch thick (1.37 mm) (16 ga) and $1\frac{1}{2}$ inches (38 mm) wide shall be fastened across and to the plate at each side of the opening with not less than eight 10d (0.148 inch diameter) nails having a minimum length of $1\frac{1}{2}$ inches (38 mm) at each side or equivalent. The metal tie must extend a minimum of 6 inches past the opening. See Figure R602.6.1.

Exception: When the entire side of the wall with the notch or cut is covered by wood structural panel sheathing.
FIGURE R602.6.1
TOP PLATE FRAMING TO ACCOMMODATE PIPING

R602.7 Headers.
For header spans, see Tables R602.7(1), R602.7(2) and R602.7(3).

TABLE R602.7(1)
GIRDER SPANS\(^a\) AND HEADER SPANS\(^a\) FOR EXTERIOR BEARING WALLS
(Maximum spans for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir\(^b\) and required number of jack studs)

<table>
<thead>
<tr>
<th>GIRDER AND HEADER SUPPORTING</th>
<th>SIZE</th>
<th>20</th>
<th>28</th>
<th>36</th>
<th>20</th>
<th>28</th>
<th>36</th>
<th>20</th>
<th>28</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof and ceiling</td>
<td>1-2 x 8</td>
<td>4-6</td>
<td>1</td>
<td>3-10</td>
<td>1</td>
<td>3-5</td>
<td>1</td>
<td>3-9</td>
<td>1</td>
<td>3-2</td>
</tr>
<tr>
<td></td>
<td>1-2 x 10</td>
<td>5-8</td>
<td>1</td>
<td>4-11</td>
<td>1</td>
<td>4-4</td>
<td>1</td>
<td>4-9</td>
<td>1</td>
<td>4-1</td>
</tr>
<tr>
<td></td>
<td>1-2 x 12</td>
<td>6-11</td>
<td>1</td>
<td>5-11</td>
<td>2</td>
<td>5-3</td>
<td>2</td>
<td>5-9</td>
<td>2</td>
<td>4-8</td>
</tr>
<tr>
<td></td>
<td>2-2 x 4</td>
<td>3-6</td>
<td>1</td>
<td>3-2</td>
<td>1</td>
<td>2-10</td>
<td>1</td>
<td>3-2</td>
<td>1</td>
<td>2-9</td>
</tr>
<tr>
<td></td>
<td>2-2 x 6</td>
<td>5-5</td>
<td>1</td>
<td>4-8</td>
<td>1</td>
<td>4-2</td>
<td>1</td>
<td>4-8</td>
<td>1</td>
<td>4-1</td>
</tr>
<tr>
<td></td>
<td>2-2 x 8</td>
<td>6-10</td>
<td>1</td>
<td>5-11</td>
<td>2</td>
<td>5-4</td>
<td>2</td>
<td>5-11</td>
<td>2</td>
<td>5-2</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
<table>
<thead>
<tr>
<th>Roof, ceiling and one center-bearing floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-2 x 10</td>
</tr>
<tr>
<td>2-2 x 12</td>
</tr>
<tr>
<td>3-2 x 8</td>
</tr>
<tr>
<td>3-2 x 10</td>
</tr>
<tr>
<td>3-2 x 12</td>
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<tr>
<td>4-2 x 8</td>
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<td>4-2 x 10</td>
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<tr>
<td>4-2 x 12</td>
</tr>
<tr>
<td>1-2 x 8</td>
</tr>
<tr>
<td>1-2 x 10</td>
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<tr>
<td>1-2 x 12</td>
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<tr>
<td>2-2 x 4</td>
</tr>
<tr>
<td>2-2 x 6</td>
</tr>
<tr>
<td>2-2 x 8</td>
</tr>
<tr>
<td>2-2 x 10</td>
</tr>
<tr>
<td>2-2 x 12</td>
</tr>
<tr>
<td>3-2 x 8</td>
</tr>
<tr>
<td>3-2 x 10</td>
</tr>
<tr>
<td>3-2 x 12</td>
</tr>
<tr>
<td>4-2 x 8</td>
</tr>
<tr>
<td>4-2 x 10</td>
</tr>
<tr>
<td>4-2 x 12</td>
</tr>
<tr>
<td>Roof, ceiling and one clear span floor</td>
</tr>
<tr>
<td>1-2 x 8</td>
</tr>
<tr>
<td>1-2 x 10</td>
</tr>
<tr>
<td>1-2 x 12</td>
</tr>
<tr>
<td>2-2 x 4</td>
</tr>
<tr>
<td>2-2 x 6</td>
</tr>
</tbody>
</table>
### TABLE R602.7(1)—continued

**GIRDERS SPANS**\(^a\) AND HEADER SPANS**\(^a\) FOR EXTERIOR BEARING WALLS

(Maximum spans for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir\(^b\) and required number of jack studs)

<table>
<thead>
<tr>
<th>GIRDERS AND HEADERS SUPPORTING</th>
<th>20</th>
<th>28</th>
<th>36</th>
<th>20</th>
<th>28</th>
<th>36</th>
<th>20</th>
<th>28</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>Span</td>
<td>Span</td>
<td>Span</td>
<td>Span</td>
<td>Span</td>
<td>Span</td>
<td>Span</td>
<td>Span</td>
<td>Span</td>
</tr>
<tr>
<td>2-2 x 4</td>
<td>2-7</td>
<td>1</td>
<td>2-3</td>
<td>1</td>
<td>2-0</td>
<td>1</td>
<td>2-6</td>
<td>1</td>
<td>2-2</td>
</tr>
<tr>
<td>2-2 x 6</td>
<td>3-9</td>
<td>2</td>
<td>3-3</td>
<td>2</td>
<td>2-11</td>
<td>2</td>
<td>3-8</td>
<td>2</td>
<td>3-2</td>
</tr>
<tr>
<td>2-2 x 8</td>
<td>4-9</td>
<td>2</td>
<td>4-2</td>
<td>2</td>
<td>3-9</td>
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<td>2</td>
<td>4-0</td>
</tr>
<tr>
<td>2-2 x 10</td>
<td>5-9</td>
<td>2</td>
<td>5-1</td>
<td>2</td>
<td>4-7</td>
<td>3</td>
<td>5-8</td>
<td>2</td>
<td>4-11</td>
</tr>
<tr>
<td>2-2 x 12</td>
<td>6-8</td>
<td>2</td>
<td>5-10</td>
<td>3</td>
<td>5-3</td>
<td>3</td>
<td>6-6</td>
<td>2</td>
<td>5-9</td>
</tr>
<tr>
<td>3-2 x 8</td>
<td>5-11</td>
<td>2</td>
<td>5-2</td>
<td>2</td>
<td>4-8</td>
<td>2</td>
<td>5-9</td>
<td>2</td>
<td>5-1</td>
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<td>3-2 x 10</td>
<td>7-3</td>
<td>2</td>
<td>6-4</td>
<td>2</td>
<td>5-8</td>
<td>2</td>
<td>7-1</td>
<td>2</td>
<td>6-2</td>
</tr>
<tr>
<td>3-2 x 12</td>
<td>8-5</td>
<td>2</td>
<td>7-4</td>
<td>2</td>
<td>6-7</td>
<td>2</td>
<td>8-2</td>
<td>2</td>
<td>7-2</td>
</tr>
<tr>
<td>4-2 x 8</td>
<td>6-10</td>
<td>1</td>
<td>6-0</td>
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<td>4-2 x 10</td>
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<td>2</td>
<td>6-7</td>
<td>2</td>
<td>8-2</td>
<td>2</td>
<td>7-2</td>
</tr>
</tbody>
</table>

\(^{a}\) Span limitations may be expressed in feet or feet and inches.

\(^{b}\) Only fir, pine, and larch of adequate quality are recommended.

\(^{c}\) Building width limitations are in feet.

\(^{d}\) Ground snow load in pounds per square foot (psf).

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**2018 North Carolina Residential Code**
### Table R602.7(2)

**GIRDER SPANS** and **HEADER SPANS** for interior bearing walls

(Maximum spans for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir and required number of jack studs)

<table>
<thead>
<tr>
<th>Headers and girders supporting</th>
<th>Size</th>
<th>Building Width (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Span</td>
</tr>
<tr>
<td>One floor only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-2 x 4</td>
<td></td>
<td>3-1</td>
</tr>
<tr>
<td>2-2 x 6</td>
<td></td>
<td>4-6</td>
</tr>
<tr>
<td>2-2 x 8</td>
<td></td>
<td>5-9</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Spans are given in feet and inches.

b. Tabulated values assume #2 grade lumber.

c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.

d. NJ = Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.

e. Use 30 psf ground snow load for cases in which ground snow load is less than 30 psf and the roof live load is equal to or less than 20 psf.
TABLE R602.7(3)
GIRDER AND HEADER SPANS for OPEN PORCHES
(Maximum span for Douglas fir-larch, hem-fir, southern pine and spruce-pine-fir)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>SUPPORTING ROOF GROUND SNOW LOAD (psf)</th>
<th>SUPPORTING FLOOR</th>
<th>DEPTH OF PORCH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>8</td>
<td>14</td>
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<tr>
<td>2-2 x 6</td>
<td>7-6</td>
<td>5-8</td>
<td>6-2</td>
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<td></td>
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<td>5-4</td>
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<td>2-2 x 8</td>
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<td>7-1</td>
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<tr>
<td>2-2 x 10</td>
<td>12-4</td>
<td>9-4</td>
<td>10-1</td>
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<tr>
<td></td>
<td></td>
<td>7-7</td>
<td>8-9</td>
</tr>
<tr>
<td>2-2 x 12</td>
<td>14-4</td>
<td>10-10</td>
<td>11-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8-10</td>
<td>10-1</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Spans are given in feet and inches.
b. Tabulated values assume #2 grade lumber.
c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.
d. NJ = Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.

R602.7.1 Single member headers.
Single headers shall be framed with a single flat 2-inch-nominal (51 mm) member or wall.
plate not less in width than the wall studs on the top and bottom of the header in accordance with Figures R602.7.1(1) and R602.7.1(2) and face nailed to the top and bottom of the header with 10d box nails (3 inches × 0.128 inches) spaced 12 inches on center.

FIGURE R602.7.1(1)
SINGLE MEMBER HEADER IN EXTERIOR BEARING WALL

FIGURE R602.7.1(2)
ALTERNATIVE SINGLE MEMBER HEADER WITHOUT CRIPPLE

R602.7.2 Rim board headers.
Rim board header size, material and span shall be in accordance with Table R602.7(1). Rim board headers shall be constructed in accordance with Figure R602.7.2 and shall be supported at each end by full-height studs. The number of full-height studs at each end shall
be not less than the number of studs displaced by half of the header span based on the maximum stud spacing in accordance with Table R602.3(5). Rim board headers supporting concentrated loads shall be designed in accordance with accepted engineering practice.

For SI: 25.4 mm = 1 inch.

**FIGURE R602.7.2**
RIM BOARD HEADER CONSTRUCTION

**R602.7.3 Wood structural panel box headers.**
Wood structural panel box headers shall be constructed in accordance with Figure R602.7.3 and Table R602.7.3.

**TABLE R602.7.3**
MAXIMUM SPANS FOR WOOD STRUCTURAL PANEL BOX HEADERS

<table>
<thead>
<tr>
<th>HEADER CONSTRUCTION</th>
<th>HEADER DEPTH (inches)</th>
<th>24</th>
<th>26</th>
<th>28</th>
<th>30</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood structural panel–one side</td>
<td>9</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Wood structural panel–both sides</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
a. Spans are based on single story with clear-span trussed roof or two story with floor and roof supported by interior-bearing walls.

b. See Figure R602.7.3 for construction details.

NOTES:

a. The top and bottom plates shall be continuous at header location.

b. Jack studs shall be used for spans over 4 feet.

c. Cripple spacing shall be the same as for studs.

d. Wood structural panel faces shall be single pieces of $\frac{15}{32}$-inch-thick Exposure 1 (exterior glue) or thicker, installed on the interior or exterior or both sides of the header.

e. Wood structural panel faces shall be nailed to framing and cripples with 8d common or galvanized box nails spaced 3 inches on center, staggering alternate nails $\frac{1}{2}$ inch. Galvanized nails shall be hot-dipped or tumbled.

FIGURE R602.7.3
TYPICAL WOOD STRUCTURAL PANEL BOX HEADER CONSTRUCTION

R602.7.4 Nonbearing walls.
Load-bearing headers are not required in interior or exterior nonbearing walls. A single flat 2-inch by 4-inch (51 mm by 102 mm) member shall be permitted to be used as a header in interior or exterior nonbearing walls for openings up to 8 feet (2438 mm) in width if the vertical distance to the parallel nailing surface above is not more than 24 inches (610 mm). For such nonbearing headers, cripples or blocking are not required above the header.

R602.7.5 Supports for headers.
Headers shall be supported on each end with one or more jack studs or with approved framing anchors in accordance with Table R602.7(1) or R602.7(2). The full-height stud adjacent to each end of the header shall be end nailed to each end of the header with four-
16d nails (3.5 inches × 0.135 inches). The minimum number of full-height studs at each end of a header shall be in accordance with Table R602.7.5.

### TABLE R602.7.5
**MINIMUM NUMBER OF FULL HEIGHT STUDS AT EACH END OF HEADERS IN EXTERIOR WALLS**

<table>
<thead>
<tr>
<th>HEADER SPAN (feet)</th>
<th>MAXIMUM STUD SPACING (inches) [per Table R602.3(5)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16</td>
</tr>
<tr>
<td>≤ 3’</td>
<td>1</td>
</tr>
<tr>
<td>4’</td>
<td>2</td>
</tr>
<tr>
<td>8’</td>
<td>3</td>
</tr>
<tr>
<td>12’</td>
<td>5</td>
</tr>
<tr>
<td>16’</td>
<td>6</td>
</tr>
</tbody>
</table>

**R602.8 Fireblocking required.**
Fireblocking shall be provided in accordance with Section R302.11.

**R602.9 Cripple walls.**
Foundation cripple walls shall be framed of studs not smaller than the studding above. When exceeding 4 feet (1219 mm) in height, such walls shall be framed of studs having the size required for an additional *story*.

Cripple walls with a stud height less than 14 inches (356 mm) shall be continuously sheathed on one side with wood structural panels fastened to both the top and bottom plates in accordance with Table R602.3(1), or the cripple walls shall be constructed of solid blocking.

Cripple walls shall be supported on continuous foundations.

**R602.10 Wall bracing.**
Buildings shall be braced in accordance with this section or, when applicable, Section R602.12. Where a building, or portion thereof, does not comply with one or more of the bracing requirements in this section, those portions shall be designed and constructed in accordance with Section R301.1.

**R602.10.1 Braced wall lines.**
For the purpose of determining the amount and location of bracing required in each story level of a building, *braced wall lines* shall be designated as straight lines in the building plan placed in accordance with this section.

**R602.10.1.1 Length of a braced wall line.**
The length of a *braced wall line* shall be the distance between its ends. The end of a *braced wall line* shall be the intersection with a perpendicular *braced wall line*, an angled *braced wall line* as permitted in Section R602.10.1.1 or an exterior wall as shown in Figure R602.10.1.1.
R602.10.1.2 Offsets along a braced wall line.
Exterior walls parallel to a braced wall line shall be offset not more than 4 feet (1219 mm) from the designated braced wall line location as shown in Figure R602.10.1.1. Interior walls used as bracing shall be offset not more than 4 feet (1219 mm) from a braced wall line through the interior of the building as shown in Figure R602.10.1.1.

R602.10.1.3 Spacing of braced wall lines.
The spacing between parallel braced wall lines shall be in accordance with Table R602.10.1.3. Intermediate braced wall lines through the interior of the building shall be permitted.

**TABLE R602.10.1.3**

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>CONDITION</th>
<th>BUILDING TYPE</th>
<th>BRACED WALL LINE SPACING CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind bracing</td>
<td>Ultimate design wind speed 100 mph to ≤ 140 mph</td>
<td>Detached, townhouse</td>
<td>60 feet</td>
</tr>
<tr>
<td>Seismic bracing</td>
<td>SDC A – C</td>
<td>Detached</td>
<td>Use wind bracing</td>
</tr>
<tr>
<td></td>
<td>SDC A – B</td>
<td>Townhouse</td>
<td>Use wind bracing</td>
</tr>
<tr>
<td></td>
<td>SDC C</td>
<td>Townhouse</td>
<td>Up to 50 feet when length of required bracing per Table R602.10.3(3) is adjusted in accordance with Table R602.10.3(4).</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.
Detached, townhouses, one- and two-story only

SDC D_0_1, D_2

25 feet

Up to 35 feet to allow for a single room not to exceed 900 square feet. Spacing of all other braced wall lines shall not exceed 25 feet.

SDC D_0_1, D_2

Detached, townhouse

25 feet

Up to 35 feet when length of required bracing per Table R602.10.3(3) is adjusted in accordance with Table R602.10.3(4).

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², 1 mile per hour = 0.447 m/s.

**R602.10.1.4 Angled walls.**

Any portion of a wall along a braced wall line shall be permitted to angle out of plane for a maximum diagonal length of 8 feet (2438 mm). Where the angled wall occurs at a corner, the length of the braced wall line shall be measured from the projected corner as shown in Figure R602.10.1.4. Where the diagonal length is greater than 8 feet (2438 mm), it shall be considered a separate braced wall line and shall be braced in accordance with Section R602.10.1.

**FIGURE R602.10.1.4**

ANGLED WALLS

**R602.10.2 Braced wall panels.**

Braced wall panels shall be full-height sections of wall that shall not have vertical or horizontal offsets. Braced wall panels shall be constructed and placed along a braced wall line in accordance with this section and the bracing methods specified in Section R602.10.4.

**R602.10.2.1 Braced wall-panel uplift load path.**

The bracing lengths in Table R602.10.3(1) apply only when uplift loads are resisted in accordance with Section R602.3.5.
R602.10.2.2 Locations of braced wall panels.
A braced wall panel shall begin within 10 feet (3810 mm) from each end of a braced wall line as determined in Section R602.10.1.1. The distance between adjacent edges of braced wall panels along a braced wall line shall be not greater than 20 feet (6096 mm) as shown in Figure R602.10.2.2.

For SI: 1 foot = 304.8 mm.

FIGURE R602.10.2.2
LOCATION OF BRACED WALL PANELS

R602.10.2.2.1 Location of braced wall panels in Seismic Design Categories D0, D1 and D2.
Braced wall panels shall be located at each end of a braced wall line.

Exception: Braced wall panels constructed of Method WSP or BV-WSP and continuous sheathing methods as specified in Section R602.10.4 shall be permitted to begin not more than 10 feet (3048 mm) from each end of a braced wall line provided each end complies with one of the following:

1. A minimum 24-inch-wide (610 mm) panel for Methods WSP, CS-WSP, CS-G and CS-PF is applied to each side of the building corner as shown in End Condition 4 of Figure R602.10.7.

2. The end of each braced wall panel closest to the end of the braced wall line shall have an 1,800 lb (8 kN) hold-down device fastened to the stud at the edge of the braced wall panel closest to the corner and to the foundation or framing below as shown in End Condition 5 of Figure R602.10.7.
R602.10.2.3 Minimum number of braced wall panels.
Braced wall lines with a length of 16 feet (4877 mm) or less shall have not less than two braced wall panels of any length or one braced wall panel equal to 48 inches (1219 mm) or more. Braced wall lines greater than 16 feet (4877 mm) shall have not less than two braced wall panels.

R602.10.3 Required length of bracing.
The required length of bracing along each braced wall line shall be determined as follows:

1. All buildings in Seismic Design Categories A and B shall use Table R602.10.3(1) and the applicable adjustment factors in Table R602.10.3(2).

2. Detached buildings in Seismic Design Category C shall use Table R602.10.3(1) and the applicable adjustment factors in Table R602.10.3(2).

3. Townhouses in Seismic Design Category C shall use the greater value determined from Table R602.10.3(1) or R602.10.3(3) and the applicable adjustment factors in Table R602.10.3(2) or R602.10.3(4), respectively.

4. All buildings in Seismic Design Categories D0, D1 and D2 shall use the greater value determined from Table R602.10.3(1) or R602.10.3(3) and the applicable adjustment factors in Table R602.10.3(2) or R602.10.3(4), respectively.

Only braced wall panels parallel to the braced wall line shall contribute toward the required length of bracing of that braced wall line. Braced wall panels along an angled wall meeting the minimum length requirements of Tables R602.10.5 and R602.10.5.2 shall be permitted to contribute its projected length toward the minimum required length of bracing for the braced wall line as shown in Figure R602.10.1.4. Any braced wall panel on an angled wall at the end of a braced wall line shall contribute its projected length for only one of the braced wall lines at the projected corner.

Exception: The length of wall bracing for dwellings in Seismic Design Categories D0, D1 and D2 with stone or masonry veneer installed in accordance with Section R703.8 and exceeding the first-story height shall be in accordance with Section R602.10.6.5.

TABLE R602.10.3(1)
BRACING REQUIREMENTS BASED ON WIND SPEED

<table>
<thead>
<tr>
<th>Ultimate Design Wind Speed (mph)</th>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method</th>
<th>Method</th>
<th>Methods WBW, WSP, SFB, PBS, PCP, HPS, BV-WSP, ABW, PFH, PFC, CS-SFB, CS, WSP, CS-G, CS-PF</th>
</tr>
</thead>
</table>
## TABLE R602.10.3(1)—continued
### BRACING REQUIREMENTS BASED ON WIND SPEED

<table>
<thead>
<tr>
<th>Exposure Category</th>
<th>Minimum Total Length (Feet) of Braced Wall Panels Required Along Each Braced Wall Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤110</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3.5</td>
</tr>
<tr>
<td>20</td>
<td>6.0</td>
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<tr>
<td>30</td>
<td>8.5</td>
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<tr>
<td>40</td>
<td>11.5</td>
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<tr>
<td>50</td>
<td>14.0</td>
</tr>
<tr>
<td>60</td>
<td>16.5</td>
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<tr>
<td>≤115</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>6.5</td>
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<td>20</td>
<td>11.5</td>
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<td>16.5</td>
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<td>26.5</td>
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<td>60</td>
<td>31.5</td>
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<td>≥120</td>
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<td>NP</td>
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<td>NP</td>
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<td>30</td>
<td>NP</td>
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<td>50</td>
<td>NP</td>
</tr>
<tr>
<td>60</td>
<td>NP</td>
</tr>
</tbody>
</table>

*(continued)*)

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<table>
<thead>
<tr>
<th>Ultimate Design Wind Speed (mph)</th>
<th>Story Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Methods DWB, WSP, SFB, PBS, PCP, HPS, BV, WSP, ABW, PFH</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤120</td>
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<td></td>
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<tr>
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<td>20.0</td>
<td>20.0</td>
<td>11.5</td>
<td>9.5</td>
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<td></td>
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<td>25.5</td>
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(continued)

TABLE R602.10.3(1)—continued
## BRACING REQUIREMENTS BASED ON WIND SPEED

### EXPOSURE CATEGORY B
30-FOOT MEAN ROOF HEIGHT
10-FOOT WALL HEIGHT
2-BRADED WALL-LINES

<table>
<thead>
<tr>
<th>Ultimate Design Wind Speed (mph)</th>
<th>Story-Location</th>
<th>Braced Wall Line Spacing (feet)</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Methods DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP, ABW, PFH, PFQ, CS-SFB&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Methods CS-WSP, CS-G, CS-PF</th>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

a. Linear interpolation shall be permitted.

b. Method LIB shall have gypsum board fastened to not less than one side with nails or screws in accordance with Table R602.3(1) for exterior sheathing or Table R702.3.5 for interior gypsum board. Spacing of fasteners at panel edges shall not exceed 8 inches.

c. Where a braced wall line has parallel braced wall lines on one or both sides of differing dimensions, the average dimension shall be permitted to be used for braced wall line spacing.

### TABLE R602.10.3(2)
WIND ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

<table>
<thead>
<tr>
<th>ITEM NUMBER</th>
<th>ADJUSTMENT BASED ON</th>
<th>STORY/SUPPORTING</th>
<th>CONDITION</th>
<th>ADJUSTMENT FACTOR&lt;sup&gt;a,b&lt;/sup&gt; [multiply length from Table]</th>
<th>APPLICABLE METHODS</th>
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2018 North Carolina Residential Code
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<th>Exposure Category</th>
<th>One-story Structure</th>
<th>R602.10.3(1) by this factor</th>
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<th>All Methods</th>
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<td>Roof + 2-floors</td>
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<td>Fastened to the end studs of each braced wall panel and to the foundation or framing below</td>
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<table>
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<th>Interior Gypsum Board Finish (or Equivalent)</th>
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<td>Story Location</td>
<td>Braced Wall Line Length (feet)</td>
<td>Method LIB</td>
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<td>----------------</td>
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<td>------------</td>
</tr>
<tr>
<td>7</td>
<td>Gypsum board fastening</td>
<td>Any story</td>
<td>4 inches o.c. at panel edges, including top and bottom plates, and all horizontal joints blocked</td>
</tr>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.48 N.
a. Linear interpolation shall be permitted.
b. The total adjustment factor is the product of all applicable adjustment factors.
c. The adjustment factor is permitted to be 1.0 when determining bracing amounts for intermediate braced wall lines provided the bracing amounts on adjacent braced wall lines are based on a spacing and number that neglects the intermediate braced wall line.

### TABLE R602.10.3(3) BRACING REQUIREMENTS BASED ON SEISMIC DESIGN CATEGORY

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<tr>
<th>SOIL CLASS D</th>
<th>WALL HEIGHT = 10 FEET</th>
<th>MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE a</th>
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<td>10 PSF FLOOR DEAD LOAD</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.48 N.
a. Linear interpolation shall be permitted.
b. The total adjustment factor is the product of all applicable adjustment factors.
c. The adjustment factor is permitted to be 1.0 when determining bracing amounts for intermediate braced wall lines provided the bracing amounts on adjacent braced wall lines are based on a spacing and number that neglects the intermediate braced wall line.
### Table R602.10.3(3)—continued
**Bracing Requirements Based on Seismic Design Category**

<table>
<thead>
<tr>
<th>Soil Class D</th>
<th>Story Location</th>
<th>Seismic Design Category</th>
<th>Braced Wall Line Length (feet)</th>
<th>Method LIB</th>
<th>Method GB</th>
<th>Methods DWB, SFB, PBS, PCP, HPS, CS, SFB</th>
<th>Method WSP</th>
<th>Methods CS, WSP, CS-G</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td>NP</td>
<td>8.3</td>
<td>6.0</td>
<td>4.0</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>NP</td>
<td>11.0</td>
<td>9.0</td>
<td>6.0</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50</td>
<td>NP</td>
<td>13.8</td>
<td>12.0</td>
<td>10.0</td>
<td>8.5</td>
</tr>
</tbody>
</table>

(continued)
### Table R602.10.3(4)

SEISMIC ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

<table>
<thead>
<tr>
<th>ITEM NUMBER</th>
<th>ADJUSTMENT BASED ON:</th>
<th>STORY</th>
<th>CONDITION</th>
<th>ADJUSTMENT FACTOR [Multiply length from Table]</th>
<th>APPLICABLE METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NP</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Linear interpolation shall be permitted.

b. Wall bracing lengths are based on a soil site class "D." Interpolation of bracing length between the $S_{ds}$ values associated with the seismic design categories shall be permitted when a site-specific $S_{ds}$ value is determined in accordance with Section 1613.3 of the International Building Code.

c. Where the braced wall line length is greater than 50 feet, braced wall lines shall be permitted to be divided into shorter segments having lengths of 50 feet or less, and the amount of bracing within each segment shall be in accordance with this table.

d. Method LIB shall have gypsum board fastened to not less than one side with nails or screws in accordance with Table R602.3(1) for exterior sheathing or Table R702.3.5 for interior gypsum board. Spacing of fasteners at panel edges shall not exceed 8 inches.

e. Method CS-SFB does not apply in Seismic Design Categories D₀, D₁, and D₂.

Cripple wall below one- or two-story dwelling

<table>
<thead>
<tr>
<th>ITEM NUMBER</th>
<th>ADJUSTMENT BASED ON:</th>
<th>STORY</th>
<th>CONDITION</th>
<th>ADJUSTMENT FACTOR [Multiply length from Table]</th>
<th>APPLICABLE METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NP</td>
</tr>
<tr>
<td></td>
<td>Story height (Section 301.3)</td>
<td>Any story</td>
<td>R602.10.3(3) by this factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------</td>
<td>-----------</td>
<td>---------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>≤10 feet</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;10 feet and ≤12 feet</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Braced wall line spacing, townhouses in SDC C</td>
<td>≤35 feet</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;35 feet and ≤50 feet</td>
<td>1.43</td>
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</tr>
<tr>
<td>3</td>
<td>Braced wall line spacing, in SDC D₀, D₁, D₂</td>
<td>≥25 feet and ≤30 feet</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;30 feet and ≤35 feet</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All methods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Wall dead load</td>
<td>&gt;8 psf and ≤15 psf</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;8 psf</td>
<td>0.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Roof/ceiling dead load for wall supporting</td>
<td>1-, 2- or 3-story building</td>
<td>≤15 psf</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2- or 3-story building</td>
<td>&gt;15 psf and ≤25 psf</td>
<td>1.1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>1-story building</td>
<td>&gt;15 psf and ≤25 psf</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Walls with stone or masonry veneer, townhouses in SDC C</td>
<td>All methods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Walls with stone or masonry veneer, detached one- and two-family dwellings in SDC D₀, D₁, D₂</td>
<td>Any story</td>
<td>See Table R602.10.6.5</td>
<td>BV-WSP</td>
<td></td>
</tr>
</tbody>
</table>
8

Interior gypsum
board
finish (or
equivalent)

Any story

Omitted from
inside face of
braced
wall panels

1.5

DWB, WSP,
SFB, PBS,
PCP,
HPS,
CS-WSP, CS-
G,
CS-SEB

For SI: 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. Linear interpolation shall be permitted.
b. The total length of bracing required for a given wall line is the product of all applicable adjustment factors.
c. The length-to-width ratio for the floor/roof diaphragm shall not exceed 3:1. The top plate lap splice nailing shall be in accordance with Table R602.3(1), Item 13.
d. Applies to stone or masonry veneer exceeding the first story height.
e. The adjustment factor for stone or masonry veneer shall be applied to all exterior braced wall lines and all braced wall lines on the interior of the building, backing or perpendicular to and laterally supported veneered walls.
f. See Section R602.10.6.5 for requirements where stone or masonry veneer does not exceed the first story height.

R602.10.4 Construction methods for braced wall panels.
Intermittent and continuously sheathed braced wall panels shall be constructed in accordance with this section and the methods listed in Table R602.10.4.

<table>
<thead>
<tr>
<th>TABLE R602.10.4 BRACING METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td>METHODS, MATERIAL</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>LIB</td>
</tr>
<tr>
<td>intermittent</td>
</tr>
<tr>
<td>bracing method</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWB</td>
<td>Diagonal wood boards</td>
<td>3/4&quot; (1&quot; nominal) for maximum 24&quot; stud spacing 2-8d 1/2&quot; long or 3/4&quot; long staples per stud</td>
</tr>
<tr>
<td>WSP</td>
<td>Wood structural panel (See Section R604)</td>
<td>3/8&quot; 6&quot; edges 12&quot; field Per stud</td>
</tr>
<tr>
<td>BV-WSP</td>
<td>Wood structural panels with stone or masonry veneer (See Section R602.10.6.5)</td>
<td>7/16&quot; See Figure R602.10.6.5 8d common 1/2&quot; long 4&quot; at panel edges 12&quot; at intermediate supports 4&quot; at braced wall panel end posts</td>
</tr>
<tr>
<td>SFB</td>
<td>Structural fiberboard sheathing</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>1/2&quot; or 25/32&quot; for maximum 16&quot; stud spacing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/2&quot; or 1 1/4&quot; long, 0.12&quot; dia. (for 1/2&quot; thick sheathing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 1/4&quot; long, 0.12&quot; dia. (for 25/32&quot; thick sheathing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galvanized roofing nails or 8d common</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&quot; edges, 6&quot; field</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GB</th>
<th>Gypsum board</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td></td>
</tr>
<tr>
<td>Nails or screws per Table R602-3(1) for exterior locations</td>
<td></td>
</tr>
<tr>
<td>For all braced wall panel locations: 7&quot; edges (including top and bottom plates), 7&quot; field</td>
<td></td>
</tr>
<tr>
<td>PBS Particleboard sheathing (See Section R605)</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>3/8&quot; or 1/2&quot; for maximum 16&quot; stud spacing</td>
</tr>
<tr>
<td>PCP Portland cement plaster</td>
<td>See Section R703.6 for maximum 16&quot; stud spacing</td>
</tr>
<tr>
<td>METHODS, MATERIAL</td>
<td>MINIMUM THICKNESS</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Intermittent Bracing Methods</strong></td>
<td></td>
</tr>
<tr>
<td>PFH</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>PORTAL FRAME with hold-downs</td>
<td></td>
</tr>
<tr>
<td>PFG</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>PORTAL FRAME at garage</td>
<td></td>
</tr>
<tr>
<td><strong>Continuous Sheathing Methods</strong></td>
<td></td>
</tr>
<tr>
<td>CS-WSP</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>Continuously sheathed wood structural panel</td>
<td></td>
</tr>
<tr>
<td>Sheathing Type</td>
<td>Fastener Spacing</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>CS-G &lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>Continuously sheathed wood structural panel adjacent to garage openings</td>
<td></td>
</tr>
<tr>
<td>CS-PE &lt;sup&gt;c&lt;/sup&gt;</td>
<td>7/16&quot;</td>
</tr>
<tr>
<td>Continuously sheathed portal frame</td>
<td></td>
</tr>
</tbody>
</table>

Interior sheathing per Table R602.3(1) or R602.3(2)

Varies by fastener
Elevated seismically-induced lateral forces shall be resisted by means of the following:

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Thickness</th>
<th>Diameter</th>
<th>Nails</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS-SFB</td>
<td>Continuously sheathed structural fiberboard</td>
<td>1/2&quot; or 25/32&quot;</td>
<td>1/2&quot;</td>
<td>8d common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum 16&quot; stud-spacing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3" edges 6" field

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad, 1 pound per square foot = 47.8 N/m², 1 mile per hour = 0.447 m/s.

a. Adhesive attachment of wall sheathing, including Method GB, shall not be permitted in Seismic Design Categories C, D₀, D₁, and D₂.

b. Applies to panels next to garage door opening where supporting gable end wall or roof load only. Shall only be used on one wall of the garage. In Seismic Design Categories D₀, D₁, and D₂, roof covering dead load shall not exceed 3 psf.

c. Garage openings adjacent to a Method CS-G panel shall be provided with a header in accordance with Table R502.5(1). A full-height clear opening shall not be permitted adjacent to a Method CS-G panel.

d. Method CS-SFB does not apply in Seismic Design Categories D₀, D₁, and D₂.

e. Method applies to detached one- and two-family dwellings in Seismic Design Categories D₀ through D₂ only.

R602.10.4.1 Mixing methods.
Mixing of bracing methods shall be permitted as follows:
1. Mixing intermittent bracing and continuous sheathing methods from story to story shall be permitted.

2. Mixing intermittent bracing methods from braced wall line to braced wall line within a story shall be permitted. In regions within Seismic Design Categories A, B and C or where the ultimate design wind speed is less than or equal to 130 mph (58m/s), mixing of intermittent bracing and continuous sheathing methods from braced wall line to braced wall line within a story shall be permitted.

3. Mixing intermittent bracing methods along a braced wall line shall be permitted in Seismic Design Categories A and B, and detached dwellings in Seismic Design Category C, provided the length of required bracing in accordance with Table R602.10.3(1) or R602.10.3(3) is the highest value of all intermittent bracing methods used.

4. Mixing of continuous sheathing methods CS-WSP, CS-G and CS-PF along a braced wall line shall be permitted. Intermittent methods ABW, PFH and PFG shall be permitted to be used along a braced wall line with continuous sheathed methods.

5. In Seismic Design Categories A and B, and for detached one- and two-family dwellings in Seismic Design Category C, mixing of intermittent bracing methods along the interior portion of a braced wall line with continuous sheathing methods CS-WSP, CS-G and CS-PF along the exterior portion of the same braced wall line shall be permitted. The length of required bracing shall be the highest value of all intermittent bracing methods used in accordance with Table R602.10.3(1) or R602.10.3(3) as adjusted by Tables R602.10.3(2) and R602.10.3(4), respectively. The requirements of Section R602.10.7 shall apply to each end of the continuously sheathed portion of the braced wall line.

R602.10.4.2 Continuous sheathing methods.
Continuous sheathing methods require structural panel sheathing to be used on all sheathable surfaces on one side of a braced wall line including areas above and below openings and gable end walls and shall meet the requirements of Section R602.10.7.

R602.10.4.3 Braced wall panel interior finish material.
Braced wall panels shall have gypsum wall board installed on the side of the wall opposite the bracing material. Gypsum wall board shall be not less than \( \frac{1}{2} \) inch (12.7 mm) in thickness and be fastened with nails or screws in accordance with Table R602.3(1) for exterior sheathing or Table R702.3.5 for interior gypsum wall board. Spacing of fasteners at panel edges for gypsum wall board opposite Method LIB bracing shall not exceed 8 inches (203 mm). Interior finish material shall not be glued in Seismic Design Categories D0, D1 and D2.

Exceptions:

1. Interior finish material is not required opposite wall panels that are braced in accordance with Methods GB, BV-WSP, ABW, PFH, PFG and CS-PF, unless otherwise required by Section R302.6.
2. An approved interior finish material with an in-plane shear resistance equivalent to gypsum board shall be permitted to be substituted, unless otherwise required by Section R302.6.

3. Except for Method LIB, gypsum wall board is permitted to be omitted provided the required length of bracing in Tables R602.10.3(1) and R602.10.3(3) is multiplied by the appropriate adjustment factor in Tables R602.10.3(2) and R602.10.3(4), respectively, unless otherwise required by Section R302.6.

R602.10.5 Minimum length of a braced wall panel.
The minimum length of a braced wall panel shall comply with Table R602.10.5. For Methods CS-WSP and CS-SFB, the minimum panel length shall be based on the adjacent clear opening height in accordance with Table R602.10.5 and Figure R602.10.5. Where a panel has an opening on either side of differing heights, the taller opening height shall be used to determine the panel length.

<table>
<thead>
<tr>
<th>METHOD (See Table R602.10.4)</th>
<th>MINIMUM LENGTH a (inches)</th>
<th>CONTRIBUTING LENGTH b (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wall Height</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8-feet</td>
<td>9-feet</td>
</tr>
<tr>
<td>DWB, WSP, SEB, PBS, PCP, HPS, BV, WSP</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>GB</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIB</td>
<td>55</td>
<td>62</td>
</tr>
<tr>
<td>ABW SDC A, B and C, ultimate design wind speed &lt; 140 mph</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>ABW SDC D, D, and D, ultimate design wind speed &lt; 140 mph</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>PFH Supporting roof only</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>PFH Supporting one story and roof</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>PFG</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>CS-G</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>CS-PE SDC A, B and C</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>CS-PE SDC D, D, and D</td>
<td>16</td>
<td>18</td>
</tr>
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</table>
Adjacent clear opening height (inches) | 24 | 27 | 30 | 33 | 36 |
<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>≤ 64</td>
<td>24</td>
<td>27</td>
<td>30</td>
<td>33</td>
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<td>72</td>
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<td>144</td>
<td>46</td>
<td>46</td>
<td>46</td>
<td>46</td>
<td>46</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.
NP = Not Permitted.
a. Linear interpolation shall be permitted.
b. Use the actual length where it is greater than or equal to the minimum length.
c. Maximum header height for PFH is 10 feet in accordance with Figure R602.10.6.2, but wall height shall be permitted to be increased to 12 feet with pony wall.
d. Maximum opening height for PFG is 10 feet in accordance with Figure R602.10.6.3, but wall height shall be permitted to be increased to 12 feet with pony wall.
e. Maximum opening height for CS-PF is 10 feet in accordance with Figure R602.10.6.4, but wall height shall be permitted to be increased to 12 feet with pony wall.

**FIGURE R602.10.5**
BRACED WALL PANELS WITH CONTINUOUS SHEATHING

**R602.10.5.1 Contributing length.**
For purposes of computing the required length of bracing in Tables R602.10.3(1) and R602.10.3(3), the contributing length of each braced wall panel shall be as specified in Table R602.10.5.
R602.10.5.2 Partial credit.
For Methods DWB, WSP, SFB, PBS, PCP and HPS in Seismic Design Categories A, B and C, panels between 36 inches and 48 inches (914 mm and 1219 mm) in length shall be considered a braced wall panel and shall be permitted to partially contribute toward the required length of bracing in Tables R602.10.3(1) and R602.10.3(3), and the contributing length shall be determined from Table R602.10.5.2.

### TABLE R602.10.5.2
PARTIAL CREDIT FOR BRACED WALL PANELS LESS THAN 48 INCHES IN ACTUAL LENGTH

<table>
<thead>
<tr>
<th>ACTUAL LENGTH OF BRACED WALL PANEL (inches)</th>
<th>CONTRIBUTING LENGTH OF BRACED WALL PANEL (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>42</td>
<td>36</td>
</tr>
<tr>
<td>36</td>
<td>27</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm. N/A = Not Applicable.
a. Linear interpolation shall be permitted.

R602.10.6 Construction of Methods ABW, PFH, PFG, CS-PF and BV-WSP.
Methods ABW, PFH, PFG, CS-PF and BV-WSP shall be constructed as specified in Sections R602.10.6.1 through R602.10.6.5.

R602.10.6.1 Method ABW: Alternate braced wall panels.
Method ABW braced wall panels shall be constructed in accordance with Figure R602.10.6.1. The hold-down force shall be in accordance with Table R602.10.6.1.

### TABLE R602.10.6.1
MINIMUM HOLD-DOWN FORCES FOR METHOD ABW BRACED WALL PANELS

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY AND WIND SPEED</th>
<th>SUPPORTING/STORY</th>
<th>HOLD-DOWN FORCE (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height of Braced Wall Panel</td>
<td>8 feet</td>
</tr>
<tr>
<td>SDC A, B and C</td>
<td>One story</td>
<td>1,800</td>
</tr>
<tr>
<td>Ultimate design wind speed &lt; 140 mph</td>
<td>First of two stories</td>
<td>3,000</td>
</tr>
<tr>
<td>SDC D 0, 1 and D 2</td>
<td>One story</td>
<td>1,800</td>
</tr>
<tr>
<td>Ultimate design wind speed &lt; 140 mph</td>
<td>First of two stories</td>
<td>3,000</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.45 N, 1 mile per hour = 0.447 m/s. NP = Not Permitted.
**FIGURE R602.10.6.1**  
**METHOD ABW—ALTERNATE BRACED WALL PANEL**

**R602.10.6.2 Method PFH: Portal frame with hold-downs.**  
Method PFH braced wall panels shall be constructed in accordance with Figure R602.10.6.2.
FIGURE R602.10.6.2
METHOD PFH—PORTAL FRAME WITH HOLD-DOWNS

R602.10.6.3 Method PFG: Portal frame at garage door openings in Seismic Design Categories A, B and C.
Where supporting a roof or one story and a roof, a Method PFG braced wall panel constructed in accordance with Figure R602.10.6.3 shall be permitted on either side of garage door openings.

FIGURE R602.10.6.3
METHOD PFG—PORTAL FRAME AT GARAGE DOOR OPENINGS IN SEISMIC DESIGN CATEGORIES A, B AND C

R602.10.6.4 Method CS-PF: Continuously sheathed portal frame.
Continuously sheathed portal frame braced wall panels shall be constructed in accordance with Figure R602.10.6.4 and Table R602.10.6.4. The number of continuously sheathed portal frame panels in a single braced wall line shall not exceed four.

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FIGURE R602.10.6.4
METHOD CS-PF—CONTINUOUSLY SHEATHED PORTAL FRAME PANEL CONSTRUCTION

TABLE R602.10.6.4
TENSION STRAP CAPACITY FOR RESISTING WIND PRESSURES PERPENDICULAR TO METHODS PFH, PFG AND CS-PF BRACED WALL PANELS

<table>
<thead>
<tr>
<th>MINIMUM WALL STUD FRAMING NOMINAL SIZE AND GRADE</th>
<th>MAXIMUM PONY WALL HEIGHT (feet)</th>
<th>MAXIMUM TOTAL WALL HEIGHT (feet)</th>
<th>MAXIMUM OPENING WIDTH (feet)</th>
<th>TENSION STRAP CAPACITY REQUIRED (pounds)</th>
<th>Ultimate Design Wind Speed Vult (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. 2 Grade</td>
<td></td>
<td></td>
<td>a, b</td>
<td>110</td>
</tr>
<tr>
<td>2 x 4</td>
<td>0</td>
<td>10</td>
<td>18</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10</td>
<td>18</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>10</td>
<td>18</td>
<td>2,050</td>
<td>2,075</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>18</td>
<td>2,375</td>
<td>2,400</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>10</td>
<td>9</td>
<td>4,725</td>
<td>4,750</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
R602.10.6.5 Wall bracing for dwellings with stone and masonry veneer in Seismic Design Categories D0, D1, and D2.

Where stone and masonry veneer are installed in accordance with Section R703.8, wall bracing on exterior braced wall lines and braced wall lines on the interior of the building, backing or perpendicular to and laterally supporting veneered walls shall comply with this section.

Where dwellings in Seismic Design Categories D0, D1 and D2 have stone or masonry veneer installed in accordance with Section R703.7, and the veneer does not exceed the first-story height, wall bracing shall be in accordance with Section R602.10.3.

Where detached one- or two-family dwellings in Seismic Design Categories D0, D1 and D2 have stone or masonry veneer installed in accordance with Section R703.7, and the veneer exceeds the first-story height, wall bracing at exterior braced wall lines and braced wall lines on the interior of the building shall be constructed using Method BV-WSP in accordance with this section and Figure R602.10.6.5. Cripple walls shall not be permitted, and required interior braced wall lines shall be supported on continuous foundations.

Townhouses in Seismic Design Categories D0, D1 and D2 with stone or masonry veneer exceeding the first-story height shall be designed in accordance with accepted engineering practice.

### TABLE R602.10.6.5
**METHOD BV-WSP WALL BRACING REQUIREMENTS**

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>STORY</th>
<th>BRACED WALL LINE LENGTH (FEET)</th>
<th>SINGLE STORY HOLD-DOWN</th>
<th>CUMULATIVE HOLD-DOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>2×6 Stud-Grade</td>
<td>2</td>
<td>18</td>
<td>2,075</td>
<td>2,500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>1,150</td>
<td>1,500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>2,875</td>
<td>3,375</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>3,425</td>
<td>3,975</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>9</td>
<td>2,275</td>
<td>2,750</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>3,225</td>
<td>3,775</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>3,225</td>
<td>3,775</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>3,425</td>
<td>3,975</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. DR = Design Required.

b. Straps shall be installed in accordance with manufacturer’s recommendations.
<table>
<thead>
<tr>
<th></th>
<th>Minimum Total Length (feet) of Braced-Wall Panels Required Along each Braced Wall Line</th>
<th>FORCE (pounds) (^a)</th>
<th>FORCE (pounds) (^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(D_0)</td>
<td></td>
<td>4.0 7.0 10.5 14.0 17.5</td>
<td>N/A —</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0 7.0 10.5 14.0 17.5</td>
<td>1900 —</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.5 9.0 13.5 18.0 22.5</td>
<td>3500 5400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.0 12.0 18.0 24.0 30.0</td>
<td>3500 8900</td>
</tr>
<tr>
<td>(D_1)</td>
<td></td>
<td>4.5 9.0 13.5 18.0 22.5</td>
<td>2100 —</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.5 9.0 13.5 18.0 22.5</td>
<td>3700 5800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.0 12.0 18.0 24.0 30.0</td>
<td>3700 9500</td>
</tr>
<tr>
<td>(D_2)</td>
<td></td>
<td>5.5 11.0 16.5 22.0 27.5</td>
<td>2300 —</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.5 11.0 16.5 22.0 27.5</td>
<td>3900 6200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NP NP NP NP N/A</td>
<td>N/A N/A</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.479 kPa, 1 pound-force = 4.448 N.
NP = Not Permitted.
N/A = Not Applicable.

\(^a\) Hold-down force is minimum allowable stress design load for connector providing uplift tie from wall framing at end of braced wall panel at the noted story to wall framing at end of braced wall panel at the story below, or to

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foundation or foundation wall. Use single-story hold-down force where edges of braced wall panels do not align; a continuous load path to the foundation shall be maintained.

b. Where hold-down connectors from stories above align with stories below, use cumulative hold-down force to size middle- and bottom-story hold-down connectors.

**FIGURE R602.10.6.5**

**METHOD BV-WSP—WALL BRACING FOR DWELLINGS WITH STONE AND MASONRY VENEER IN SEISMIC DESIGN CATEGORIES**

**R602.10.6.5.1 Length of bracing.**

The length of bracing along each braced wall line shall be the greater of that required by the ultimate design wind speed and braced wall line spacing in accordance with Table R602.10.3(1) as adjusted by the factors in Table R602.10.3(2) or the seismic design category and braced wall line length in accordance with Table R602.10.6.5. Angled walls shall be permitted to be counted in accordance with Section R602.10.1.4, and braced wall panel location shall be in accordance with Section R602.10.2.2. Spacing between braced wall lines shall be in accordance with Table R602.10.1.3. The seismic adjustment factors in Table R602.10.3(4) shall not be applied to the length of bracing determined using Table R602.10.6.5, except that the bracing amount increase for braced wall line spacing greater than 25 feet (7620 mm) in accordance with Table R602.10.1.3 shall be required. The minimum total length of bracing in a braced wall line, after all adjustments have been taken, shall not be less than 48 inches (1219 mm) total.

**R602.10.7 Ends of braced wall lines with continuous sheathing.** Each end of a braced wall line with continuous sheathing shall have one of the conditions shown in Figure R602.10.7.
FIGURE R602.10.7
END CONDITIONS FOR BRACED WALL LINES WITH CONTINUOUS SHEATHING

R602.10.8 Braced wall panel connections.

*Braced wall panels* shall be connected to floor framing or foundations as follows:

1. Where joists are perpendicular to a *braced wall panel* above or below, a rim joist, band joist or blocking shall be provided along the entire length of the *braced wall panel* in accordance with Figure R602.10.8(1). Fastening of top and bottom wall plates to framing, rim joist, band joist and/or blocking shall be in accordance with Table R602.3(1).

2. Where joists are parallel to a *braced wall panel* above or below, a rim joist, end joist or other parallel framing member shall be provided directly above and below the *braced wall panel* in accordance with Figure R602.10.8(2). Where a parallel framing member cannot be located directly above and below the panel, full-depth blocking at 16-inch (406 mm) spacing shall be provided between the parallel framing members to each side of the *braced wall panel* in accordance with Figure R602.10.8(2). Fastening of blocking and wall plates shall be in accordance with Table R602.3(1) and Figure R602.10.8(2).

3. Connections of *braced wall panels* to concrete or masonry shall be in accordance with Section R403.1.6.
FIGURE R602.10.8(1)
BRACED WALL PANEL CONNECTION WHEN PERPENDICULAR TO FLOOR/CEILING FRAMING

FIGURE R602.10.8(2)
BRACED WALL PANEL CONNECTION WHEN PARALLEL TO FLOOR/CEILING FRAMING

R602.10.8.1 Braced wall panel connections for Seismic Design Categories D0, D1 and D2.
Braced wall panels shall be fastened to required foundations in accordance with Section R602.11.1, and top plate lap splices shall be face-nailed with not less than eight 16d nails on each side of the splice.

R602.10.8.2 Connections to roof framing.
Top plates of exterior braced wall panels shall be attached to rafters or roof trusses above in accordance with Table R602.3(1) and this section. Where required by this section, blocking between rafters or roof trusses shall be attached to top plates of braced wall panels and to rafters and roof trusses in accordance with Table R602.3(1). A continuous band, rim or header joist or roof truss parallel to the braced wall panels shall be permitted to replace the blocking required by this section. Blocking shall not be required over openings in continuously sheathed braced wall lines. In addition to the requirements of this section, lateral support shall be provided for rafters and ceiling joists in accordance with Section R802.8 and for trusses in accordance with Section R802.10.3. Roof ventilation shall be provided in accordance with Section R806.1.

1. For Seismic Design Categories A, B and C where the distance from the top of the braced wall panel to the top of the rafters or roof trusses above is 9\(\frac{1}{4}\) inches (235 mm) or less, blocking between rafters or roof trusses shall not be required. Where the distance from the top of the braced wall panel to the top of the rafters or roof trusses above is between 9\(\frac{1}{4}\) inches (235 mm) and 15\(\frac{1}{4}\) inches (387 mm), blocking between rafters or roof trusses shall be provided above the braced wall panel in accordance with Figure R602.10.8.2(1).

   Exception: Where the outside edge of truss vertical web members aligns with the outside face of the wall studs below, wood structural panel sheathing extending above the top plate as shown in Figure R602.10.8.2(3) shall be permitted to be fastened to each truss web with three 8d nails (2\(\frac{1}{2}\) inches × 0.131 inch) and blocking between the trusses shall not be required.

2. For Seismic Design Categories D0, D1 and D2, where the distance from the top of the braced wall panel to the top of the rafters or roof trusses is 15\(\frac{1}{4}\) inches (387 mm) or less, blocking between rafters or roof trusses shall be provided above the braced wall panel in accordance with Figure R602.10.8.2(1).

3. Where the distance from the top of the braced wall panel to the top of rafters or roof trusses exceeds 15\(\frac{1}{4}\) inches (387 mm), the top plates of the braced wall panel shall be connected to perpendicular rafters or roof trusses above in accordance with one or more of the following methods:
3.1. Soffit blocking panels constructed in accordance with Figure R602.10.8.2(2).

3.2. Vertical blocking panels constructed in accordance with Figure R602.10.8.2(3).

3.3. Blocking panels provided by the roof truss manufacturer and designed in accordance with Section R802.

3.4. Blocking, blocking panels or other methods of lateral load transfer designed in accordance with the AWC WFCM or accepted engineering practice.

For SI: 1 inch = 25.4 mm.

**FIGURE R602.10.8.2(1)**
BRACED WALL PANEL CONNECTION
TO PERPENDICULAR RAFTERS
Methods of bracing shall be as described in Section R602.10.4.

**FIGURE R602.10.8.2(2)**
**BRACED WALL PANEL CONNECTION OPTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES**

**FIGURE R602.10.8.2(3)**
WHERE AIR GAP AT TOP IS NOT USED, CENTER W/3 AVAILABLE FOR VENT HOLES
BRACED WALL PANEL CONNECTION OPTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES

R602.10.9 Braced wall panel support.
Braced wall panel support shall be provided as follows:

1. Cantilevered floor joists complying with Section R502.3.3 shall be permitted to support braced wall panels.

2. Raised floor system post or pier foundations supporting braced wall panels shall be designed in accordance with accepted engineering practice.

3. Masonry stem walls with a length of 48 inches (1219 mm) or less supporting braced wall panels shall be reinforced in accordance with Figure R602.10.9. Masonry stem walls with a length greater than 48 inches (1219 mm) supporting braced wall panels shall be constructed in accordance with Section R403.1. Methods ABW and PFH shall not be permitted to attach to masonry stem walls.

4. Concrete stem walls with a length of 48 inches (1219 mm) or less, greater than 12 inches (305 mm) tall and less than 6 inches (152 mm) thick shall have reinforcement sized and located in accordance with Figure R602.10.9.
FIGURE R602.10.9
MASONRY STEM WALLS SUPPORTING BRACED WALL PANELS

R602.10.9.1 Braced wall panel support for Seismic Design Categories D0, D1 and D2.
In Seismic Design Categories D0, D1, and D2, braced wall panel footings shall be as specified in Section R403.1.2.

R602.10.10 Panel joints.
Vertical joints of panel sheathing shall occur over and be fastened to, common studs.
Horizontal joints in braced wall panels shall occur over and be fastened to, common blocking of a minimum $\frac{1}{2}$ inch (38 mm) thickness.

Exceptions:

1. Vertical joints of panel sheathing shall be permitted to occur over double studs, where adjoining panel edges are attached to separate studs with the required panel edge fastening schedule, and the adjacent studs are attached together with two rows of 10d box nails [3 inches by 0.128 inch (76.2 mm by 3.25 mm)] at 10 inches o.c. (254 mm).

2. Blocking at horizontal joints shall not be required in wall segments that are not counted as braced wall panels.

3. Where the bracing length provided is not less than twice the minimum length required by Tables R602.10.3(1) and R602.10.3(3), blocking at horizontal joints shall not be required in braced wall panels constructed using Methods WSP, SFB, GB, PBS or HPS.

4. Where Method GB panels are installed horizontally, blocking of horizontal joints is not required.

R602.10.11 Cripple wall bracing.
Cripple walls shall be constructed in accordance with Section R602.9 and braced in accordance with this section. Cripple walls shall be braced with the length and method of bracing used for the wall above in accordance with Tables R602.10.3(1) and R602.10.3(3), and the applicable adjustment factors in Table R602.10.3(2) or R602.10.3(4), respectively, except that the length of cripple wall bracing shall be multiplied by a factor of 1.15. Where gypsum wallboard is not used on the inside of the cripple wall bracing, the length adjustments for the elimination of the gypsum wallboard, or equivalent, shall be applied as directed in Tables R602.10.3(2) and R602.10.3(4) to the length of cripple wall bracing required. This adjustment shall be taken in addition to the 1.15 increase.

R602.10.11.1 Cripple wall bracing for Seismic Design Categories D0 and D1 and townhouses in Seismic Design Category C.
In addition to the requirements in Section R602.10.11, the distance between adjacent
edges of braced wall panels for cripple walls along a braced wall line shall be 14 feet (4267 mm) maximum.

Where braced wall lines at interior walls are not supported on a continuous foundation below, the adjacent parallel cripple walls, where provided, shall be braced with Method WSP or Method CS-WSP in accordance with Section R602.10.4. The length of bracing required in accordance with Table R602.10.3(3) for the cripple walls shall be multiplied by 1.5. Where the cripple walls do not have sufficient length to provide the required bracing, the spacing of panel edge fasteners shall be reduced to 4 inches (102 mm) on center and the required bracing length adjusted by 0.7. If the required length can still not be provided, the cripple wall shall be designed in accordance with accepted engineering practice.

R602.10.11.2 Cripple wall bracing for Seismic Design Category D2.
In Seismic Design Category D2, cripple walls shall be braced in accordance with Tables R602.10.3(3) and R602.10.3(4).

R602.10.11.3 Redesignation of cripple walls.
Where all cripple wall segments along a braced wall line do not exceed 48 inches (1219 mm) in height, the cripple walls shall be permitted to be redesignated as a first-story wall for purposes of determining wall bracing requirements. Where any cripple wall segment in a braced wall line exceeds 48 inches (1219 mm) in height, the entire cripple wall shall be counted as an additional story. If the cripple walls are redesignated, the stories above the redesignated story shall be counted as the second and third stories, respectively.

R602.10 Wall bracing.
Buildings, and portions thereof, shall be braced in accordance with one or more of the following sections using bracing materials and methods complying with Section R602.10.1 and load path detailing in accordance with Section R602.10.4:

1. Isolated panel bracing in accordance with Section R602.10.2.

2. Continuous sheathing in accordance with Section R602.10.3.

3. Engineered design in accordance with Section R602.10.5, or


Where a building, or portion thereof, does not comply with Section R602.10.2, Section R602.10.3, or Section R602.10.4, those portions shall be designed and constructed in accordance with Section R602.10.5.

R602.10.1 Bracing materials and methods.
Wall bracing materials and methods shall comply with Table R602.10.1.

**TABLE R602.10.1**  
**BRACING METHODS**

<table>
<thead>
<tr>
<th>Method</th>
<th>Minimum Brace Material Thickness or Size</th>
<th>Minimum Brace Panel Length or Brace Angle</th>
<th>Connection Criteria</th>
<th>Figure of Bracing Method, not Necessarily Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIB</td>
<td>1x4 wood brace (or approved metal brace installed per manufacturer instructions)</td>
<td>45° angle for maximum 16&quot;oc stud spacing</td>
<td>2-8d common nails or 3-8d (2-1/2&quot; long x 0.113&quot; dia.) nails</td>
<td><img src="image1.png" alt="Diagram" /></td>
</tr>
<tr>
<td>DWB</td>
<td>½&quot; (1&quot; nominal)</td>
<td>48&quot;</td>
<td>2-8d (2-1/2&quot; long x 0.113&quot; diameter) or 2 – 1-3/4&quot; long staples</td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
<tr>
<td>WSP</td>
<td>3/8&quot;</td>
<td>48⁴</td>
<td>6d common nail or 8d (2-1/2&quot; long x 0.113&quot; diameter) nail (See Table R602.3(3))</td>
<td><img src="image3.png" alt="Diagram" /></td>
</tr>
<tr>
<td>SFB</td>
<td>½&quot;</td>
<td>48⁴</td>
<td>1-1/2&quot; long x 0.120&quot; dia. Galvanized roofing nails</td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
<tr>
<td>GB</td>
<td>½&quot;</td>
<td>96° for use with R602.10.2 48° for use with R602.10.3</td>
<td>Min. 5d cooler nails or #6 screws</td>
<td><img src="image5.png" alt="Diagram" /></td>
</tr>
<tr>
<td>PCP</td>
<td>½&quot; (maximum 16&quot;oc stud spacing)</td>
<td>48&quot;</td>
<td>1-1/2&quot; long, 11 gage, 7/16&quot; diameter head nails or 7/8&quot; long, 16 gage staples</td>
<td><img src="image6.png" alt="Diagram" /></td>
</tr>
<tr>
<td>CS-WSP⁵,⁹</td>
<td>3/8&quot;</td>
<td>24° adjacent to window not more than 67% of wall height; 30° adjacent to door or window greater than 67% and less than 85% of wall height. 48° for taller</td>
<td>Same as WSP</td>
<td><img src="image7.png" alt="Diagram" /></td>
</tr>
<tr>
<td>CS-SFB⁵,⁹</td>
<td>½&quot;</td>
<td>Same as SFB</td>
<td>Same as SFB</td>
<td><img src="image8.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>
Table Notes:
1. Alternative bracing materials and methods shall comply with Section 105 of the North Carolina Administrative Code and Policies, and shall be permitted to be used as a substitute for any of the bracing materials listed in Table R602.10.1 provided at least equivalent performance is demonstrated. Where the tested bracing strength or stiffness differs from tabulated materials, the bracing amount required for the alternative material shall be permitted to be factored to achieve equivalence.
2. All edges of panel-type wall bracing required from Tables R602.10.1 and R602.10.3 shall be attached to framing or blocking, except GB bracing horizontal joints shall not be required to be blocked when joints are finished.
3. Two LIB braces installed at a 60° angle shall be permitted to be substituted for each 45° angle LIB brace.
4. For 8-foot (2483 mm) or 9-foot (2743 mm) wall height, brace panel minimum length shall be permitted to be reduced to 36-inch (914 mm) or 42-inch length (1067 mm), respectively, where not located adjacent to a door opening. A braced wall panel shall be permitted to be reduced to a 32-inch (813 mm) length when studs at each end of the braced wall panel are anchored to foundation or framing below using hold-down device with minimum 2,800 lbs. design tension capacity. For detached single story garages and attached garages supporting roof only, a minimum 24-inch (610 mm) brace panel length shall be permitted on one wall containing one or more garage door openings.
5. Bracing methods designated CS-WSP and CS-SFB shall have sheathing installed on all sheathable surfaces above, below, and between wall openings.
6. For purposes of bracing in accordance with Section R602.10.2, two portal frame brace panels with wood structural panel sheathing applied to the exterior face of each brace panel as shown in Figure R602.10.1 shall be considered equivalent to one braced wall panel.
7. Structural fiberboard (SFB) shall not be used in portal frame construction.
8. No more than three portal frames shall be used in a single building elevation.
9. CS-WSP and CS-SFB cannot be mixed on the same story. Gable ends shall match the panel type of the wall below.
R602.10.2. Isolated Panel Bracing.

**R602.10.2.1 Limitations.**
The conventional bracing requirements of Section R602.10.2.2 shall be limited to the following conditions of use:

1. Ultimate design wind speed shall not exceed 120 mph (53 m/s), Exposure Category B.

2. Bracing methods shall be LIB, DWB, WSP, SFB, GB, PCP, and PF in accordance with Table R602.10.1.

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 lb = 4.45 N
3. Length of the house is limited to 75 feet (22.9 m). Overall plan length shall not exceed 3 times the overall plan width. The multiple circumscribed rectangle method from R602.10.3.2 may be applied to the method set forth in this section.

4. Wall height at each story level shall not exceed 10 feet (3048 mm).

5. Roof eave-to-ridge height shall not exceed 10 feet (3048 mm) unless the roof is considered as an additional story for the purpose of determining bracing amounts required.

6. Except when used for bracing method GB, the interior side of exterior walls and both sides of interior walls shall be sheathed continuously with minimum ½-inch (12.7 mm) thick gypsum wall board interior finish fastened in accordance with Table R702.3.5, or approved interior finish of equivalent or greater shear resistance.

7. Floors shall not cantilever more than 24 inches (610 mm) beyond the foundation or bearing wall below.

8. Townhouses shall be stabilized independently of adjacent units unless a design is provided to permit lateral load transfer between adjacent units.

9. Townhouses in Seismic Design Category C shall be designed in accordance with Section R602.10.5 or the 2015 International Residential Code.

R602.10.2.2 Requirements.
Braced wall panels shall be constructed of bracing methods, materials, and minimum braced panel lengths complying with Table R602.10.1. The number of braced wall panels required for each side of a building (elevation view) at each story level of the building shall comply with Table R602.10.2. The following additional requirements shall apply:

1. In no case shall the amount of bracing be less than two braced wall panels on exterior walls comprising each side of the floor plan (or plan elevation) for each story level of the building.

2. A braced wall panel shall be located within 12 feet (3658 mm) of both ends of each elevation view of the house. Braced wall panels on exterior walls shall be installed such that the edge-to-edge distance between braced wall panels does not exceed 21 feet (6401 mm). See Figures R602.10.2.2(1) and R602.10.2.2(2).
3. No more than one-half of bracing on parallel exterior walls shall be permitted to be relocated to interior walls oriented in the same plan direction and within one-half the floor plan dimension perpendicular to the exterior wall. See Figure R602.10.2.2(3).
4. Use of multiple bracing methods and materials complying with Table R602.10.1 shall be permitted.

5. Detached garages or storage buildings connected to the house with a covered walk-way shall be considered separate buildings. Houses with skewed wings shall be designed in accordance with Section R602.10.3, Section R602.10.5, or the 2015 International Residential Code.

6. Garage door openings supporting a floor load above shall be braced using the portal frame method (PF) unless the building plan level containing the garage opening wall complies with all the bracing requirements of this section.

### TABLE R602.10.2
NUMBER OF BRACED WALL PANELS REQUIRED FOR EACH HOUSE ELEVATION (BUILDING SIDE) AT EACH STORY LEVEL

<table>
<thead>
<tr>
<th>Wind Speed</th>
<th>Story Level Supporting:</th>
<th>Longest Overall Dimension of Floor Plan for a Given Story Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25'</td>
</tr>
<tr>
<td>115 mph</td>
<td>Roof Only</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Roof + 1 Story</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Roof + 2 Stories</td>
<td>3</td>
</tr>
<tr>
<td>120 mph</td>
<td>Roof Only</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Roof + 1 Story</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Roof + 2 Stories</td>
<td>4</td>
</tr>
</tbody>
</table>
1. Interpolation between dimensions is permitted. Extrapolation is prohibited. Fractions of panels shall be rounded to the nearest whole panel.

**R602.10.3 Continuous Sheathing.**

**R602.10.3.1 Limitations.**
The continuous sheathing requirements of Section R602.10.3 shall be limited to bracing methods CS-WSP and CS-SFB in accordance with Table R602.10.1 with the following conditions of use:

1. Ultimate design wind speed shall not exceed 130 mph (58 m/s).
2. Wall height at each story level shall not exceed 12 feet (3658 mm).
3. Eave to ridge height shall not exceed 20 feet (6096 mm).
4. Exterior walls shall be sheathed on all sheathable surfaces including infill areas between braced wall panels, above and below wall openings, and on gable end walls.
5. Except when used for bracing method GB, the interior side of exterior walls and both sides of interior walls shall be sheathed continuously with minimum ½-inch (12.7 mm) thick gypsum wall board interior finish fastened in accordance with Table R702.3.5, or approved interior finish of equivalent or greater shear resistance. Unless required for fire separation by Section R302.6, gypsum board shall be permitted to be omitted where the required length of bracing, as determined in Table R602.10.3, is multiplied by 1.40.
6. Floors shall not cantilever more than 24 inches (610 mm) beyond the foundation or bearing wall below.
7. Townhouses in Seismic Design Category C shall be designed in accordance with Section R602.10.5 or the 2015 *International Residential Code*.
8. Townhouses shall be stabilized independently of adjacent units, unless a design is provided to permit lateral load transfer between adjacent units.
9. CS-WSP and CS-SFB cannot be mixed on the same story. Gable ends shall match the panel type of the wall below.

**R602.10.3.2 Requirements.**
The required length of bracing for each side of a rectangle circumscribed around the plan or a portion of the plan at each story level shall be determined using Table
R602.10.3 and Figure R602.10.3(1). The cumulative contributing length of braced wall panels assigned to a rectangle side shall be greater than or equal to the required length of bracing specified in Table R602.10.3. The following additional requirements shall apply.

1. Braced wall panels on exterior or interior walls shall be assigned to the nearest rectangle side as shown in Figure R602.10.3(2) for each story level floor plan.

2. Braced wall panels shall be distributed and installed in accordance with Figures R602.10.3(3), R602.10.3(4), and R602.10.3(5).

3. A minimum of one-half the required bracing amount for each rectangle side should be located on exterior walls within 8 feet (2438 mm) of the location of the rectangle side.

4. Interior braced wall panels using method GB shall be assigned to the closest parallel rectangle side and shall contribute 0.5 times their actual length.

5. The bracing amount provided on an upper story building side shall be deemed-to-comply where it equals or exceeds the amount of bracing required for the story immediately below.

6. Where the bracing amount provided on an upper story equals or exceeds the amount of bracing required for the story below, an analysis of bracing shall not be required for the upper story.

**FIGURE R602.10.3(1)**
**CIRCUMSCRIBED RECTANGLES**

**Figure Notes:**

1. Each floor plan level shall be circumscribed with one or more rectangles around the floor plan or portions of the plan at the floor level under consideration as shown in Figure R602.10.3(1).

2. Rectangles shall surround all enclosed offsets and projections such as sunrooms and attached garages for a given story level floor plan. Chimneys, partial height projections, and open structures, such as carports and decks, shall be excluded from the rectangle.

3. Each rectangle shall have no side greater than 80 feet (24.4 m) with a maximum rectangle length-to-width ratio of 3.1. Rectangles shall be permitted to be skewed to accommodate diagonal walls.

**TABLE R602.10.3**
**REQUIRED LENGTH OF BRACING ALONG EACH SIDE**

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>WIND SPEED</th>
<th>EAVE-TO-RIDGE HEIGHT (FEET)</th>
<th>REQUIRED LENGTH OF BRACING ON ANY SIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Roof Only</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>Roof Only</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Roof + 1 Story</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Roof + 2 Stories</td>
<td>4.5</td>
</tr>
<tr>
<td>15</td>
<td>Roof Only</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Roof + 1 Story</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Roof + 2 Stories</td>
<td>5.0</td>
</tr>
<tr>
<td>20</td>
<td>Roof Only</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Roof + 1 Story</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Roof + 2 Stories</td>
<td>5.0</td>
</tr>
</tbody>
</table>

For SI: 1 ft = 304.8 mm

**a.** Interpolation shall be permitted; extrapolation shall be prohibited.

**b.** For Exposure Category C or D, multiply the required length of bracing by a factor of 1.3 or 1.6, respectively.

**c.** For wall heights other than 10 ft (3048 mm), multiply the required length of bracing by the following factors: 0.90 for 8 feet (2438 mm), 0.95 for 9 feet (2743 mm), 1.05 for 11 feet (3353 mm) and 1.10 for 12 feet (3658 mm).

2018 North Carolina Residential Code
d. Where minimum ½" gypsum wall board interior finish is not provided, the required bracing amount for the affected rectangle side shall be multiplied by 1.40.

e. A floor, habitable or otherwise, contained wholly within the roof rafters or roof trusses need not be considered a story for purposes of determining wall bracing provided the eave to ridge height does not exceed 20 feet (6096 mm) and the openings in the roof do not exceed 48 inches (1219 mm) in width.

f. Perpendicular sides to the front and rear sides are the left and right sides. Perpendicular sides to the left and right sides are the front and rear sides.
FIGURE R602.10.3(2)c

**FIGURE R602.10.3(2)**
**ASSIGNMENT OF BRACED WALL PANELS TO CIRCUMSCRIBED RECTANGLE SIDES**

**Figure Notes:**

1. Exterior braced wall panels shall be assigned to the closest parallel rectangle side and shall contribute their actual length.
2. Interior braced wall panels using method GB shall be assigned to the closest parallel rectangle side and shall contribute 0.5 times their actual length.
3. Projected contributing lengths of angled braced wall panels shall be assigned to the closest rectangle sides.
4. Portal frame braced wall panels shall contribute 1.5 times their actual length to their assigned rectangle side.
5. Where multiple rectangles share a common side or sides, as shown in Figure R602.10.3(2)(a), the required length of bracing shall equal the sum of the required lengths from each of the shared rectangle sides.
6. Braced wall panels located on a common wall where skewed rectangles intersect, as shown in Figure R602.10.3(2)(b), shall have their contributing length applied towards the required length of bracing for the parallel rectangle side and its projected contributing lengths towards the adjacent skewed rectangle sides. Where the common side of rectangle 2 as shown in Figure R602.10.3(2)c has no physical wall, the wall bracing required to stabilize this side of Rectangle 2 shall be determined from Table 602.10.3. This length of bracing shall be resolved into orthogonal projections, and the orthogonal projections shall be added to the length of bracing required for the walls of Rectangle 1 which connect to Rectangle 2 in the directions parallel to the projections.
**FIGURE R602.10.3(3) DISTRIBUTION OF BRACED WALL PANELS**

**Figure Notes:**

1. A braced wall panel shall be located on each elevation view within 12 feet (3658 mm) of the corners of circumscribed rectangles. Detached garages or storage buildings connected to the house with a covered walk-way shall be considered separate buildings.

2. The distance between adjacent edges of braced wall panels shall be no more than 21 feet (6401 mm).

3. Segments of exterior walls greater than 12 feet (3658 mm) in length shall have a minimum of one braced wall panel.

4. Segments of exterior wall 12 feet (3658 mm) or less in length shall be permitted to have no bracing provided a braced wall panel is located within 12 feet (3658 mm) from the rectangle corner.

5. Interior and exterior wall segments which contribute to the common sides of multiple rectangles shall be permitted to apply the distribution requirements given above to each wall segment independently.

6. See Figures R602.10.3(4) and R602.10.3(5) for end conditions for braced walls with continuous sheathing.
END CONDITIONS FOR BRACED WALLS WITH CONTINUOUS SHEATHING

<table>
<thead>
<tr>
<th>END CONDITION 3</th>
<th>END CONDITION 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONTINUOUSLY SHEATHED BRACED WALL LINE</strong></td>
<td><strong>CONTINUOUSLY SHEATHED BRACED WALL LINE</strong></td>
</tr>
<tr>
<td><strong>48” MINIMUM BRACED WALL PANEL AT END OF BRACED WALL LINE</strong></td>
<td><strong>12” MAX</strong></td>
</tr>
</tbody>
</table>

**END CONDITION 5**

<table>
<thead>
<tr>
<th>RETURN PANEL</th>
<th>FIRST BRACED WALL PANEL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HOLD DOWN DEVICE</strong></td>
<td><strong>12” MAX</strong></td>
</tr>
</tbody>
</table>

**END CONDITION 4**

<table>
<thead>
<tr>
<th>REQUIREMENTS</th>
</tr>
</thead>
</table>

**Return panel:**
- 24” for braced wall lines sheathed with wood structural panels
- 32” for braced wall lines sheathed with structural fiberboard

**Distance D:**
- 24” for braced wall lines sheathed with wood structural panels
- 32” for braced wall lines sheathed with structural fiberboard

**Hold-down device:**
- 800 lbs capacity fastened to the edge of the braced wall panel closest to the corner and to the foundation or floor framing below

---

**FIGURE R602.10.3(4)**

END CONDITIONS FOR BRACED WALLS WITH CONTINUOUS SHEATHING

---

2018 North Carolina Residential Code
FIGURE R602.10.3(5)
R602.10.4 Load path details.
Construction shall comply with applicable detailing requirements of this section to ensure an adequate continuous load path for transfer of bracing loads and uplift loads from the roof to the foundation.

R602.10.4.1 Wind uplift load path.
Framing connections to transfer roof uplift forces shall comply with Section R602.3.5 and Section R802.11. In the 130 mph (58 m/s) wind zone provide uplift anchorage in accordance with Section R4508 and Section R4504.1.

R602.10.4.2 Foundation anchorage.
Braced wall panels shall be connected to the foundation per Section R403.1.6, Section R602.11 and as required in Figure R602.10.1 for portal frames.

R602.10.4.3 Masonry or concrete pedestals.
Masonry or concrete stem walls with a length of 48 inches (1219 mm) or less supporting braced wall panels shall be reinforced in accordance with Figure R602.10.4.3. Concrete stem walls shall be 6 inches (152 mm) nominal minimum thickness. Continuous concrete stem walls shall be reinforced per Section R404.1.3.2.
FIGURE R602.10.4.3
MASONRY STEM WALLS SUPPORTING BRACED WALL PANELS

R602.10.4.4 Blocking of floor framing.
When perpendicular to floor framing, braced wall panels shall be connected to full-height solid blocking between floor framing in accordance with Figure R602.10.4.4(1). When parallel to floor framing, braced wall panels shall be connected to a band, rim or header joist, floor framing or perpendicular full-height solid blocking between floor framing at 16 inches (406 mm) on center in accordance with Figure R602.10.4.4(2). Attachments shall be in accordance with Table R602.3(1). Manufactured lumber or truss blocking panels shall be permitted to substitute for full-height solid blocking.
R602.10.4.4(1) **Braced Wall Panel Connection When Perpendicular to Floor/Ceiling Framing**

**Figure R602.10.4.4(1)**

- Full height blocking continuous along length of braced wall panel.
- 8d @ 6" O.C. along braced wall panel.
- 3-16d @ 16" O.C. along braced wall panel.
- Continuous rim or band joist.

**Figure R602.10.4.4(2)**

- Additional framing member directly above braced wall panel.
- Additional framing member directly below braced wall panel.
- 2-16d nails each side.
- Full height blocking @ 16" O.C. along braced wall panel.
- 8d @ 6" O.C. along braced wall panel.
- 3-16d @ 16" O.C. along braced wall panel.
- Continuous rim or end joist.

---

**R602.10.4.5 Blocking of Roof Framing**

When parallel to roof framing, braced wall panels shall be connected to a band, rim or header joist, or roof truss. When perpendicular to roof framing, the top plates of exterior...
braced wall panels shall be connected to the rafters or roof trusses above in accordance with Table R602.10.4.5 and fastened in accordance with Table R602.3(1).

**TABLE R602.10.4.5**
**BRACED WALL PANEL CONNECTIONS TO PERPENDICULAR ROOF FRAMING**

<table>
<thead>
<tr>
<th>DISTANCE FROM TOP OF BRACED WALL PANEL TO TOP OF RAFTER OR ROOF TRUSS, (in)</th>
<th>REQUIREMENT</th>
<th>REFERENCED FIGURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 9.25</td>
<td>No blocking required</td>
<td>NA</td>
</tr>
<tr>
<td>9.26 – 15.25</td>
<td>Solid 2x blocking between rafters or trusses</td>
<td>R602.10.4.5(1) or (2)</td>
</tr>
<tr>
<td>15.26 – 48</td>
<td>Vertical blocking panels</td>
<td>R602.10.4.5(2) or (3)</td>
</tr>
<tr>
<td>&gt; 48</td>
<td>Designed in accordance with accepted engineering practice</td>
<td>NA</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm

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**FIGURE R602.10.4.5(1)**
BRACED WALL PANEL CONNECTION TO PERPENDICULAR RAFTERS OR ROOF TRUSSES

**FIGURE R602.10.4.5(2)**
ALTERNATE TO FIGURE R602.10.4.5(1) OR FIGURE R602.10.4.5(3)

*Note: Provide ventilation per Section R806*
R602.10.4.6 Cripple walls and framed walls of walk-out basements.
The required length of bracing for cripple walls with a maximum height of 48 inches (1219 mm) or less along its entire length shall be equal to the bracing provided for the wall above. The required length of bracing for cripple walls with a height greater than 48 inches (1219 mm) at any location along its length and for framed walls of a walk-out basement shall be determined in accordance with Section R602.10.2 or R602.10.3, considering the cripple wall or walk-out basement as an additional story. As an alternative, the required length of bracing shall be permitted to equal to the bracing provided for the wall above multiplied by a factor of 1.15.

R602.10.4.7 Open elevated foundations.
Open elevated foundations, such as pile foundations, shall be constructed to transfer all lateral loads from the wall bracing system to the piles or open pier system, including shears, overturning, and uplift loads. Piles or open pier systems along with their foundations shall be sized and embedded to transfer all lateral loads imposed by the wall bracing system to the ground.

R602.10.4.8 Balloon frame wall bracing.
Balloon frame walls shall have a maximum height of two stories and a maximum length of 20 feet (6096 mm) unless constructed in accordance with an approved design. Wall framing shall be continuous from lowest floor to the wall top plate at the roof. Braced wall panels shall extend to the full-height of the balloon frame wall. All edges of sheathing shall be supported on and fastened to blocking or framing. The required brace wall panel length assigned to the balloon frame wall shall be based on the bracing required for the lowest floor level supporting the balloon frame wall as determined in accordance with Section R602.10.2 or R602.10.3. For balloon framed walls having a maximum height of two stories and a maximum length of 20 feet (6096 mm), braced wall panels shall be permitted to be placed both parallel and perpendicular to the balloon framed wall on each side and at each story adjacent to the balloon framed wall, and no bracing shall be required for the balloon frame wall portion. Bracing in the direction perpendicular to the balloon framed wall may be omitted when the opening dimension in the second floor perpendicular to the balloon framed wall created by the two story space is less than one half the least overall dimension of the house. See Figure R602.10.4.8.
R602.10.5 Wall bracing by engineered design. Design using bracing materials and methods listed in Table R602.10.1 or approved alternative materials and methods shall be permitted and shall comply with accepted engineering practice. Accepted engineering practice shall include the following:

1. Design in accordance with Section R301.

2. Design equivalent to the analysis basis of the provisions in Sections R602.10.2, R602.10.3, and R602.10.4, including determination of design loads, design unit shear values, and bracing amounts.

R602.11 Wall anchorage. 
Braced wall line sills shall be anchored to concrete or masonry foundations in accordance with Sections R403.1.6 and R602.11.1.

R602.11.1 Wall anchorage for all buildings in Seismic Design Categories D0, D1 and D2 and townhouses in Seismic Design Category C. Plate washers, not less than 0.229 inch by 3 inches by 3 inches (5.8 mm by 76 mm by 76 mm) in size, shall be provided between the foundation sill plate and the nut except where approved anchor straps are used. The hole in the plate washer is permitted to be diagonally slotted with a width of up to \( \frac{3}{16} \) inch (5 mm) larger than the bolt diameter and a slot length not to exceed \( \frac{3}{4} \) inches (44 mm), provided a standard cut washer is placed between the plate washer and the nut.

R602.11.2 Stepped foundations in Seismic Design Categories D0, D1 and D2. Deleted. In all buildings located in Seismic Design Categories D0, D1 and D2, where the height of a required braced wall line that extends from foundation to floor above varies more than 4 feet (1219 mm), the braced wall line shall be constructed in accordance with the following:
1. Where the lowest floor framing rests directly on a sill bolted to a foundation not less than 8 feet (2440 mm) in length along a line of bracing, the line shall be considered as braced. The double plate of the cripple stud wall beyond the segment of footing that extends to the lowest framed floor shall be spliced by extending the upper top plate not less than 4 feet (1219 mm) along the foundation. Anchor bolts shall be located not more than 1 foot and 3 feet (305 and 914 mm) from the step in the foundation. See Figure R602.11.2.

2. Where cripple walls occur between the top of the foundation and the lowest floor framing, the bracing requirements of Sections R602.10.11, R602.10.11.1 and R602.10.11.2 shall apply.

3. Where only the bottom of the foundation is stepped and the lowest floor framing rests directly on a sill bolted to the foundations, the requirements of Sections R403.1.6 and R602.11.1 shall apply.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

Note: Where footing Section “A” is less than 8 feet long in a 25-foot-long wall, install bracing at cripple stud wall.

FIGURE R602.11.2
STEPPEP FOUNDATION CONSTRUCTION

R602.12 Simplified wall bracing. Deleted.
Buildings meeting all of the conditions listed below shall be permitted to be braced in accordance with this section as an alternate to the requirements of Section R602.10. The entire building shall be braced in accordance with this section; the use of other bracing provisions of Section R602.10, except as specified herein, shall not be permitted.

1. There shall be not more than three stories above the top of a concrete or masonry foundation or basement wall. Permanent wood foundations shall not be permitted.

2. Floors shall not cantilever more than 24 inches (607 mm) beyond the foundation or bearing wall below.
3. Wall height shall not be greater than 10 feet (3048 mm).

4. The building shall have a roof eave-to-ridge height of 15 feet (4572 mm) or less.

5. Exterior walls shall have gypsum board with a minimum thickness of \( \frac{\frac{1}{2}}{\text{inch}} \) (12.7 mm) installed on the interior side fastened in accordance with Table R702.3.5.

6. The structure shall be located where the ultimate design wind speed is less than or equal to 130 mph (58 m/s), and the exposure category is B or C.

7. The structure shall be located in Seismic Design Category A, B or C for detached one- and two-family dwellings or Seismic Design Category A or B for townhouses.


R602.12.1 Circumscribed rectangle.
The bracing required for each building shall be determined by circumscribing a rectangle around the entire building on each floor as shown in Figure R602.12.1. The rectangle shall surround all enclosed offsets and projections such as sunrooms and attached garages. Open structures, such as carports and decks, shall be permitted to be excluded. The rectangle shall not have a side greater than 60 feet (18 288 mm), and the ratio between the long side and short side shall be not greater than 3:1.

![Figure R602.12.1](image)

**FIGURE R602.12.1**
RECTANGLE CIRCUMSCRIBING AN ENCLOSED BUILDING

R602.12.2 Sheathing materials.
The following sheathing materials installed on the exterior side of exterior walls shall be used to construct a bracing unit as defined in Section R602.12.3. Mixing materials is prohibited.
1. Wood structural panels with a minimum thickness of $\frac{3}{8}$ inch (9.5 mm) fastened in accordance with Table R602.3(3).

2. Structural fiberboard sheathing with a minimum thickness of $\frac{1}{2}$ inch (12.7 mm) fastened in accordance with Table R602.3(1).

**R602.12.3 Bracing unit.**
A bracing unit shall be a full-height sheathed segment of the exterior wall without openings or vertical or horizontal offsets and a minimum length as specified herein. Interior walls shall not contribute toward the amount of required bracing. Mixing of Items 1 and 2 is prohibited on the same story.

1. Where all framed portions of all exterior walls are sheathed in accordance with Section R602.12.2, including wall areas between bracing units, above and below openings and on gable end walls, the minimum length of a bracing unit shall be 3 feet (914 mm).

2. Where the exterior walls are braced with sheathing panels in accordance with Section R602.12.2 and areas between bracing units are covered with other materials, the minimum length of a bracing unit shall be 4 feet (1219 mm).

**R602.12.3.1 Multiple bracing units.**
Segments of wall compliant with Section R602.12.3 and longer than the minimum bracing unit length shall be considered as multiple bracing units. The number of bracing units shall be determined by dividing the wall segment length by the minimum bracing unit length. Full-height sheathed segments of wall narrower than the minimum bracing unit length shall not contribute toward a bracing unit except as specified in Section R602.12.6.

**R602.12.4 Number of bracing units.**
Each side of the circumscribed rectangle, as shown in Figure R602.12.1, shall have, at a minimum, the number of bracing units in accordance with Table R602.12.4 placed on the parallel exterior walls facing the side of the rectangle. Bracing units shall then be placed using the distribution requirements specified in Section R602.12.5.

**TABLE R602.12.4**

| MINIMUM NUMBER OF BRACING UNITS ON EACH SIDE OF THE CIRCUMSCRIBED RECTANGLE |
**R602.12.5 Distribution of bracing units.**
The placement of bracing units on exterior walls shall meet all of the following requirements as shown in Figure R602.12.5.

1. A bracing unit shall begin not more than 12 feet (3658 mm) from any wall corner.

2. The distance between adjacent edges of bracing units shall be not greater than 20 feet (6096 mm).

3. Segments of wall greater than 8 feet (2438 mm) in length shall have not less than one bracing unit.
R602.12.5 Narrow panels.
The bracing methods referenced in Section R602.10 and specified in Sections R602.12.6.1 through R602.12.6.3 shall be permitted when using simplified wall bracing.

R602.12.6.1 Method CS-G.
Braced wall panels constructed as Method CS-G in accordance with Tables R602.10.4 and R602.10.5 shall be permitted for one-story garages where all framed portions of all exterior walls are sheathed with wood structural panels. Each CS-G panel shall be equivalent to 0.5 of a bracing unit. Segments of wall that include a Method CS-G panel shall meet the requirements of Section R602.10.4.2.

R602.12.6.2 Method CS-PF.
Braced wall panels constructed as Method CS-PF in accordance with Section R602.10.6.4 shall be permitted where all framed portions of all exterior walls are sheathed with wood structural panels. Each CS-PF panel shall equal 0.75 bracing units. Not more than four CS-PF panels shall be permitted on all segments of walls parallel to each side of the circumscribed rectangle. Segments of wall that include a Method CS-PF panel shall meet the requirements of Section R602.10.4.2.

R602.12.6.3 Methods ABW, PFH and PFG.
Braced wall panels constructed as Method ABW, PFH and PFG shall be permitted where bracing units are constructed using wood structural panels applied either continuously or intermittently. Each ABW and PFH panel shall equal one bracing unit and each PFG panel shall be equal to 0.75 bracing unit.

R602.12.7 Lateral support.
For bracing units located along the eaves, the vertical distance from the outside edge of the top wall plate to the roof sheathing above shall not exceed 9.25 inches (235 mm) at the location of a bracing unit unless lateral support is provided in accordance with Section R602.10.8.2.

R602.12.8 Stem walls.
Masonry stem walls with a height and length of 48 inches (1219 mm) or less supporting a bracing unit or a Method CS-G, CS-PF or PFG braced wall panel shall be constructed in accordance with Figure R602.10.9. Concrete stem walls with a length of 48 inches (1219 mm) or less, greater than 12 inches (305 mm) tall and less than 6 inches (152 mm) thick shall be reinforced sized and located in accordance with Figure R602.10.9.

SECTION R603
COLD-FORMED STEEL WALL FRAMING
Deleted

R603.1 General.
Elements shall be straight and free of any defects that would significantly affect structural...
performance. Cold-formed steel wall framing members shall be in accordance with the requirements of this section.

R603.1.1 Applicability limits.
The provisions of this section shall control the construction of exterior cold-formed steel wall framing and interior load-bearing cold-formed steel wall framing for buildings not more than 60 feet (18,288 mm) long perpendicular to the joist or truss span, not more than 40 feet (12,192 mm) wide parallel to the joist or truss span, and less than or equal to three stories above grade plane. Exterior walls installed in accordance with the provisions of this section shall be considered as load-bearing walls. Cold-formed steel walls constructed in accordance with the provisions of this section shall be limited to sites where the ultimate design wind speed is less than 139 miles per hour (62 m/s), Exposure Category B or C, and the ground snow load is less than or equal to 70 pounds per square foot (3.35 kPa).

R603.1.2 In-line framing.
Load-bearing cold-formed steel studs constructed in accordance with Section R603 shall be located in line with joists, trusses and rafters in accordance with Figure R603.1.2 and the tolerances specified as follows:

1. The maximum tolerance shall be $\frac{3}{4}$ inch (19 mm) between the centerline of the horizontal framing member and the centerline of the vertical framing member.

2. Where the centerline of the horizontal framing member and bearing stiffener is located to one side of the centerline of the vertical framing member, the maximum tolerance shall be $\frac{1}{8}$ inch (3 mm) between the web of the horizontal framing member and the edge of the vertical framing member.
FIGURE R603.1.2
IN-LINE FRAMING

R603.2 Structural framing.
Load-bearing cold-formed steel wall framing members shall be in accordance with this section.

R603.2.1 Material.
Load-bearing cold-formed steel framing members shall be cold formed to shape from structural-quality sheet steel complying with the requirements of ASTM A 1003: Structural Grades 33 Type H and 50 Type H.

R603.2.2 Corrosion protection.
Load-bearing cold-formed steel framing shall have a metallic coating complying with ASTM A 1003 and one of the following:

1. A minimum of G 60 in accordance with ASTM A 653.

2. A minimum of AZ 50 in accordance with ASTM A 792.

R603.2.3 Dimension, thickness and material grade.
Load-bearing cold-formed steel wall framing members shall comply with Figure R603.2.3(1) and with the dimensional and thickness requirements specified in Table R603.2.3. Additionally, C-shaped sections shall have a minimum flange width of \(1\frac{5}{8}\) inches (41 mm) and a maximum flange width of 2 inches (51 mm). The minimum lip size for C-shaped sections shall be \(\frac{1}{2}\) inch (12.7 mm). Track sections shall comply with Figure R603.2.3(2) and shall have a minimum flange width of \(1\frac{1}{4}\) inches (32 mm). Minimum Grade 33 ksi steel shall be used wherever 33 mil and 43 mil thicknesses are specified. Minimum Grade 50 ksi steel shall be used wherever 54 and 68 mil thicknesses are specified.
FIGURE R603.2.3(1)
C-SHAPED SECTION
Table R603.2.3

<table>
<thead>
<tr>
<th>Member Designation</th>
<th>Web Depth (inches)</th>
<th>Minimum Base Steel Thickness (mil, inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>350S162-t</td>
<td>3.5</td>
<td>33 (0.0329), 43 (0.0428), 54 (0.0538)</td>
</tr>
<tr>
<td>550S162-t</td>
<td>5.5</td>
<td>33 (0.0329), 43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 mil = 0.0254 mm.

a. The member designation is defined by the first number representing the member depth in hundredths of an inch, "S" representing a stud or joist member, the second number representing the flange width in hundredths of an inch, and the letter "t" shall be a number representing the minimum base metal thickness in mils.

R603.2.4 Identification.

Load-bearing cold-formed steel framing members shall have a legible label, stencil, stamp or embossment with the following information as a minimum:
1. Manufacturer's identification.

2. Minimum base steel thickness in inches (mm).


4. Minimum yield strength, in kips per square inch (ksi) (MPa).

R603.2.5 Fastening.
Screws for steel-to-steel connections shall be installed with a minimum edge distance and center-to-center spacing of \( \frac{1}{2} \) inch (12.7 mm), shall be self-drilling tapping and shall conform to ASTM C 1513. Structural sheathing shall be attached to cold-formed steel studs with minimum No. 8 self-drilling tapping screws that conform to ASTM C 1513. Screws for attaching structural sheathing to cold-formed steel wall framing shall have a minimum head diameter of 0.292 inch (7.4 mm) with countersunk heads and shall be installed with a minimum edge distance of \( \frac{3}{8} \) inch (9.5 mm). Gypsum board shall be attached to cold-formed steel wall framing with minimum No. 6 screws conforming to ASTM C 954 or ASTM C 1513 with a bugle-head style and shall be installed in accordance with Section R702. For connections, screws shall extend through the steel a minimum of three exposed threads. Fasteners shall have rust-inhibitive coating suitable for the installation in which they are being used, or be manufactured from material not susceptible to corrosion.

R603.2.6 Web holes, web hole reinforcing and web hole patching.
Web holes, web hole reinforcing and web hole patching shall be in accordance with this section.

R603.2.6.1 Web holes.
Web holes in wall studs and other structural members shall comply with all of the following conditions:

1. Holes shall conform to Figure R603.2.6.1.

2. Holes shall be permitted only along the centerline of the web of the framing member.

3. Holes shall have a center-to-center spacing of not less than 24 inches (610 mm).

4. Holes shall have a web hole width not greater than 0.5 times the member depth, or \( 1 \frac{1}{2} \) inches (38 mm).

5. Holes shall have a web hole length not exceeding \( 4 \frac{1}{2} \) inches (114 mm).

6. Holes shall have a minimum distance between the edge of the bearing surface and the edge of the web hole of not less than 10 inches (254 mm).
Framing members with web holes not conforming to the above requirements shall be reinforced in accordance with Section R603.2.6.2, patched in accordance with Section R603.2.6.3 or designed in accordance with accepted engineering practice.

For SI: 1 inch = 25.4 mm.

FIGURE R603.2.6.1
WALL STUD WEB HOLES

R603.2.6.2 Web hole reinforcing.
Web holes in gable endwall studs not conforming to the requirements of Section R603.2.6.1 shall be permitted to be reinforced if the hole is located fully within the center 40 percent of the span and the depth and length of the hole does not exceed 65 percent of the flat width of the web. The reinforcing shall be a steel plate or C-shape section with a hole that does not exceed the web hole size limitations of Section R603.2.6.1 for the member being reinforced. The steel reinforcing shall be the same thickness as the receiving member and shall extend not less than 1 inch (25 mm) beyond all edges of the hole. The steel reinforcing shall be fastened to the web of the receiving member with No. 8 screws spaced not more than 1 inch (25 mm) center-to-center along the edges of the patch with minimum edge distance of \( \frac{1}{2} \) inch (12.7 mm).

R603.2.6.3 Hole patching.
Web holes in wall studs and other structural members not conforming to the requirements in Section R603.2.6.1 shall be permitted to be patched in accordance with either of the following methods:
1. Framing members shall be replaced or designed in accordance with accepted engineering practice where web holes exceed the following size limits:

1.1. The depth of the hole, measured across the web, exceeds 70 percent of the flat width of the web—or

1.2. The length of the hole measured along the web exceeds 10 inches (254 mm) or the depth of the web, whichever is greater.

2. Web holes not exceeding the dimensional requirements in Section R603.2.6.3, Item 1, shall be patched with a solid steel plate, stud section or track section in accordance with Figure R603.2.6.3. The steel patch shall, as a minimum, be the same thickness as the receiving member and shall extend not less than 1 inch (25 mm) beyond all edges of the hole. The steel patch shall be fastened to the web of the receiving member with No. 8 screws spaced not more than 1 inch (25 mm) center-to-center along the edges of the patch with a minimum edge distance of \( \frac{1}{2} \) inch (12.7 mm).

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R603.3 Wall construction.
Exterior cold-formed steel framed walls and interior load-bearing cold-formed steel framed walls shall be constructed in accordance with the provisions of this section.
R603.3.1 Wall to foundation or floor connection.
Cold-formed steel framed walls shall be anchored to foundations or floors in accordance with Table R603.3.1 and Figure R603.3.1(1), R603.3.1(2), R603.3.1(3) or R603.3.1(4). Anchor bolts shall be located not more than 12 inches (305 mm) from corners or the termination of bottom tracks. Anchor bolts shall extend not less than 15 inches (381 mm) into masonry or 7 inches (178 mm) into concrete. Foundation anchor straps shall be permitted, in lieu of anchor bolts, if spaced as required to provide equivalent anchorage to the required anchor bolts and installed in accordance with manufacturer’s requirements.

**TABLE R603.3.1**
WALL TO FOUNDATION OR FLOOR CONNECTION REQUIREMENTS

<table>
<thead>
<tr>
<th>FRAMING CONDITION</th>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>(mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>115 B</td>
<td>126 B or 110 C</td>
</tr>
<tr>
<td>Wall bottom track to floor per Figure R603.3.1(1)</td>
<td>1-No. 8 screw at 12” o.c.</td>
<td>1-No. 8 screw at 12” o.c.</td>
</tr>
<tr>
<td>Wall bottom track to foundation per Figure R603.3.1(2)</td>
<td>1/2 minimum diameter anchor bolt at 6’ o.c.</td>
<td>1/2 minimum diameter anchor bolt at 4’ o.c.</td>
</tr>
<tr>
<td>Wall bottom track to wood sill per Figure R603.3.1(3)</td>
<td>Steel plate spaced at 4’ o.c., with 4-10d or 6-8d common nails</td>
<td>Steel plate spaced at 3’ o.c., with 4-10d or 6-8d common nails</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stud Spacing (inches)</th>
<th>Roof Span (feet)</th>
<th>Wind uplift connector strength c, e (lb)</th>
<th>16</th>
<th>24</th>
<th>28</th>
<th>32</th>
<th>36</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>36</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>36</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s, 1 foot = 304.8 mm, 1 pound = 4.45 N.

a.—Anchor bolts are to be located not more than 12 inches from corners or the termination of bottom tracks such as at door openings or corners. Bolts are to extend not less than 15 inches into masonry or 7 inches into concrete.
b.—All screw sizes shown are minimum.
c.—NR = Uplift connector not required.
d. Foundation anchor straps are permitted in place of anchor bolts, if spaced as required to provide equivalent anchorage to the required anchor bolts and installed in accordance with manufacturer’s requirements.

e. See Figure R603.3.1(4) for details.
FIGURE R603.3.1(2)
WALL TO FOUNDATION CONNECTION

FIGURE R603.3.1(3)
WALL TO WOOD SILL CONNECTION
Gable endwalls.
Gable endwalls with heights greater than 10 feet (3048 mm) shall be anchored to foundations or floors in accordance with Table R603.3.1.1(1) or R603.3.1.1(2).

**TABLE R603.3.1.1(1)**

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED (mph)</th>
<th>WALL BOTTOM TRACK TO FLOOR JOIST OR TRACK CONNECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure Category</td>
<td>Stud height, h (feet)</td>
</tr>
<tr>
<td></td>
<td>10 &lt; h ≤ 14</td>
</tr>
<tr>
<td></td>
<td>14 &lt; h ≤ 18</td>
</tr>
<tr>
<td></td>
<td>18 &lt; h ≤ 22</td>
</tr>
<tr>
<td>B</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>&lt;139</td>
</tr>
<tr>
<td></td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>&lt;139</td>
</tr>
<tr>
<td></td>
<td>1- No. 8 screw @ 12&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>1- No. 8 screw @ 12&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>2- No. 8 screws @ 12&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>2- No. 8 screws @ 8&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>5- 6&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>6-10&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>5-10&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>6-0&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>6-0&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>5-2&quot; o.c.</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s, 1 foot = 304.8 mm.

a. Refer to Table R603.3.1.1(2) for gable endwall bottom track to foundation connections.
b. Where attachment is not given, special design is required.
c. Stud height, h, is measured from wall bottom track to wall top track or brace connection height.

d. Foundation anchor straps are permitted in place of anchor bolts if spaced as required to provide equivalent anchorage to the required anchor bolts and installed in accordance with manufacturer's requirements.

**TABLE R603.3.1.1(2)**

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED (mph)</th>
<th>MINIMUM SPACING FOR $\frac{1}{2}$-inch-diameter anchor bolts d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure Category</td>
<td>Stud height, h (feet)</td>
</tr>
<tr>
<td></td>
<td>10 &lt; h ≤ 14</td>
</tr>
<tr>
<td></td>
<td>14 &lt; h ≤ 18</td>
</tr>
<tr>
<td></td>
<td>18 &lt; h ≤ 22</td>
</tr>
<tr>
<td>B</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>&lt;139</td>
</tr>
<tr>
<td></td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>&lt;139</td>
</tr>
<tr>
<td></td>
<td>1- 6&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>5- 7&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>6-7&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>6-0&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>6-0&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td>5-2&quot; o.c.</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s, 1 foot = 304.8 mm.

a. Refer to Table R603.3.1.1(1) for gable endwall bottom track to floor joist or track connection connections.
b. Where attachment is not given, special design is required.
c. Stud height, h, is measured from wall bottom track to wall top track or brace connection height.
d. Foundation anchor straps are permitted in place of anchor bolts if spaced as required to provide equivalent anchorage to the required anchor bolts and installed in accordance with manufacturer's requirements.

R603.3.2 Minimum stud sizes.
Cold-formed steel walls shall be constructed in accordance with Figure R603.3.1(1),
Exterior wall stud size and thickness shall be determined in accordance with the limits set forth in Tables R603.3.2(2) through R603.3.2(16). Interior load-bearing wall stud size and thickness shall be determined in accordance with the limits set forth in Tables R603.3.2(2) through R603.3.2(16) based upon an ultimate design wind speed of 115 miles per hour (51 m/s), Exposure Category B, and the building width, stud spacing and snow load, as appropriate. Fastening requirements shall be in accordance with Section R603.2.5 and Table R603.3.2(1). Top and bottom tracks shall have the same minimum thickness as the wall studs.

Exterior wall studs shall be permitted to be reduced to the next thinner size, as shown in Tables R603.3.2(2) through R603.3.2(16), but not less than 33 mils (0.84 mm), where both of the following conditions exist:

1. Minimum of $\frac{1}{2}$-inch (12.7 mm)-gypsum board is installed and fastened on the interior surface in accordance with Section R702.

2. Wood structural sheathing panels of minimum $\frac{7}{16}$-inch-thick (11.1 mm)-oriented strand board or $\frac{15}{32}$-inch-thick (12 mm)-plywood are installed and fastened in accordance with Section R603.9.1 and Table R603.3.2(1) on the outside surface.

Interior load-bearing walls shall be permitted to be reduced to the next thinner size, as shown in Tables R603.3.2(2) through R603.3.2(16), but not less than 33 mile (0.84 mm), where not less than $\frac{1}{2}$-inch (12.7 mm)-gypsum board is installed and fastened in accordance with Section R702 on both sides of the wall. The tabulated stud thickness for load-bearing walls shall be used when the attic load is 10 pounds per square foot (480 Pa) or less. A limited attic storage load of 20 pounds per square foot (960 Pa) shall be permitted provided that the next higher snow load column is used to select the stud size from Tables R603.3.2(2) through R603.3.2(16).

For two-story buildings, the tabulated stud thickness for walls supporting one floor, roof and ceiling shall be used when the second floor live load is 30 pounds per square foot (1440 Pa). Second-floor live loads of 40 psf (1920 Pa) shall be permitted provided that the next higher snow load column is used to select the stud size from Tables R603.3.2(2) through R603.3.2(16).

For three-story buildings, the tabulated stud thickness for walls supporting one or two floors, roof and ceiling shall be used when the third floor live load is 30 pounds per square foot (1440 Pa). Third-floor live loads of 40 pounds per square foot (1920 Pa) shall be permitted provided that the next higher snow load column is used to select the stud size from Tables R603.3.2(2) through R603.3.2(16).

**TABLE R603.3.2(1)**

**WALL FASTENING SCHEDULE**
<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENT</th>
<th>NUMBER AND SIZE OF FASTENERS&lt;sup&gt;a&lt;/sup&gt;</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall stud to top or bottom track</td>
<td>2-No. 8 screws</td>
<td>Each end of stud, one per flange</td>
</tr>
<tr>
<td>Structural sheathing to wall studs</td>
<td>No. 8 screws &lt;sup&gt;b&lt;/sup&gt;</td>
<td>6” o.c. on edges and 12” o.c. at intermediate supports</td>
</tr>
<tr>
<td>1/2” gypsum board to framing</td>
<td>No. 6 screws</td>
<td>12” o.c.</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

<sup>a</sup> All screw sizes shown are minimum.

<sup>b</sup> Screws for attachment of structural sheathing panels are to be bugle-head, flat-head, or similar head styles with a minimum head diameter of 0.29 inch.

---

**TABLE R603.3.2(2)**

24-FOOT-WIDE BUILDING SUPPORTING ROOF AND CEILING ONLY<sup>a,b,c,d</sup>

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (Inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
<th>8-foot Studs</th>
<th>9-foot Studs</th>
<th>10-foot Studs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ground Snow Load (psf)</td>
<td>20</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Exp. B</td>
<td>Exp. C</td>
<td>350S 162</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>115</td>
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<td>&lt; 139</td>
<td>115</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.

<sup>a</sup> Deflection criterion: L/240.

<sup>b</sup> Design load assumptions:
- Second-floor dead load is 10 psf.
- Second-floor live load is 30 psf.
- Roof/ceiling dead load is 12 psf.
Attic live load is 10 psf.

Building width is in the direction of horizontal framing members supported by the wall studs.

Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

**TABLE R603.3.2(3)**

28-FOOT-WIDE BUILDING SUPPORTING ROOF AND CEILING ONLY

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>8-foot Studs</td>
<td>9-foot Studs</td>
</tr>
<tr>
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<td></td>
<td>Ground Snow Load (psf)</td>
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<td>20  30  50  70  20  30  50  70</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.

a—Deflection criterion: \(L/240\).
b—Design load assumptions:
  - Second-floor dead load is 10 psf.
  - Second-floor live load is 30 psf.
  - Roof/ceiling dead load is 12 psf.
  - Attic live load is 10 psf.
c—Building width is in the direction of horizontal framing members supported by the wall studs.
d—Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

**TABLE R603.3.2(4)**

32-FOOT-WIDE BUILDING SUPPORTING ROOF AND CEILING ONLY

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<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>8-foot Studs</td>
<td>9-foot Studs</td>
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<tr>
<td></td>
<td></td>
<td>Ground Snow Load (psf)</td>
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<td>24  33  33  43  43  33  33</td>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.

a—Deflection criterion: \(L/240\).
b—Design load assumptions:
  - Second-floor dead load is 10 psf.
  - Second-floor live load is 30 psf.
  - Roof/ceiling dead load is 12 psf.
  - Attic live load is 10 psf.
c—Building width is in the direction of horizontal framing members supported by the wall studs.
d—Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.
b. Design load assumptions:
   - Second-floor dead load is 10 psf.
   - Second-floor live load is 30 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.
c. Building width is in the direction of horizontal framing members supported by the wall studs.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 51 and 68 mil thicknesses.

### TABLE R603.3.2(5)

<table>
<thead>
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<th>Ultimate Wind Speed (mph)</th>
<th>Member Size</th>
<th>Stud Spacing (inches)</th>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.
1 ksi = 1,000 psi = 6.895 MPa.
## TABLE R603.3.2(6) 40-FOOT-WIDE BUILDING SUPPORTING ROOF AND CEILING ONLY

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (Inches)</th>
<th>8-foot Studs</th>
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<th>10-foot Studs</th>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.

a.**Deflection criterion:** \( L/240 \).
b.**Design load assumptions:**
   - Second-floor dead load is 10 psf.
   - Second-floor live load is 30 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.
c.**Building width is in the direction of horizontal framing members supported by the wall studs.**
d.**Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.**
### TABLE R603.3.2(7)
#### 24-FOOT-WIDE BUILDING SUPPORTING ONE FLOOR, ROOF AND CEILING

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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.

1 ksi = 1,000 psi = 6.895 MPa.

b. Design load assumptions:
   - Second-floor dead load is 10 psf.
   - Second-floor live load is 30 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.
c. Building width is in the direction of horizontal framing members supported by the wall studs.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.
deflection criterion: L/240.

- Second-floor dead load is 10 psf.
- Second-floor live load is 30 psf.
- Roof/ceiling dead load is 12 psf.
- Attic live load is 10 psf.

building width is in the direction of horizontal framing members supported by the wall studs.

minimum grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. minimum grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (INCHES)</th>
<th>MINIMUM STUD THICKNESS (MILES)</th>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.

TABLE R603.3.2(8)

28-FOOT-WIDE BUILDING SUPPORTING ONE FLOOR, ROOF AND CEILING

2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa,
1 ksi = 1,000 psi = 6.895 MPa.

a.— Deflection criterion: L/240.
b.— Design load assumptions:
- Second-floor dead load is 10 psf.
- Second-floor live load is 30 psf.
- Roof/ceiling dead load is 12 psf.
- Attic live load is 10 psf.
c.— Building width is in the direction of horizontal framing members supported by the wall studs.
d.— Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

### TABLE R603.3.2(9)

<table>
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<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
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<th>9-foot Studs</th>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa,
1 ksi = 1,000 psi = 6.895 MPa.
a. Deflection criterion:
   \[ \frac{L}{240} \]

b. Design load assumptions:
   - Second-floor dead load is 10 psf.
   - Second-floor live load is 30 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.

c. Building width is in the direction of horizontal framing members supported by the wall studs.

d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

### TABLE R603.3.2(10)

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (Inches)</th>
<th>MINIMUM STUD THICKNESS (mil)</th>
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<tr>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.
1 ksi = 1,000 psi = 6.895 MPa.

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2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.

b. Design load assumptions:
   Second-floor dead load is 10 psf.
   Second-floor live load is 30 psf.
   Roof/ceiling dead load is 12 psf.
   Attic live load is 10 psf.
c. Building width is in the direction of horizontal framing members supported by the wall studs.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

**TABLE R603.3.2(11)**

40-FOOT-WIDE BUILDING SUPPORTING ONE FLOOR, ROOF AND CEILING

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
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</table>

b. Design load assumptions:
   - Second-floor dead load is 10 psf.
   - Second-floor live load is 30 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.

c. Building width is in the direction of horizontal framing members supported by the wall studs.

d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

**TABLE R603.3.2(12)**

24-FOOT-WIDE BUILDING SUPPORTING TWO FLOORS, ROOF AND CEILING a,b,c,d
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa,
1 ksi = 1,000 psi = 6.895 MPa.

b. Design load assumptions:
   - Top and middle-floor dead load is 10 psf.
   - Top-floor live load is 30 psf.
   - Middle-floor live load is 40 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.
c. Building width is in the direction of horizontal framing members supported by the wall studs.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

**TABLE R603.3.2(13)**

28-FOOT-WIDE BUILDING SUPPORTING TWO FLOORS, ROOF AND CEILING a, b, c, d
**Deflection criterion:** \( L/240 \).

**Design load assumptions:**
- Top- and middle-floor dead load is 10 psf.
- Top-floor live load is 30 psf.
- Middle-floor live load is 40 psf.
- Roof/ceiling dead load is 12 psf.
- Attic live load is 10 psf.

**Building width** is in the direction of horizontal framing members supported by the wall studs.

**Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.**

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**TABLE R603.3.2(14)**

32-FOOT-WIDE BUILDING SUPPORTING TWO FLOORS, ROOF AND CEILING^a,b,c,d^
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.


b. Design load assumptions:
   - Top- and middle-floor dead load is 10 psf.
   - Top-floor live load is 30 psf.
   - Middle-floor live load is 40 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.

c. Building width is in the direction of horizontal framing members supported by the wall studs.

d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

### TABLE R603.3.2(15)

**36-FOOT-WIDE BUILDING SUPPORTING TWO FLOORS, ROOF AND CEILING**

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (Inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
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2018 North Carolina Residential Code
b. Design load assumptions:
   - Top-floor dead load is 10 psf.
   - Top-floor live load is 30 psf.
   - Middle-floor live load is 40 psf.
   - Roof/ceiling dead load is 12 psf.
   - Attic live load is 10 psf.
c. Building width is in the direction of horizontal framing members supported by the wall studs.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

### TABLE R603.3.2(16)
40-FOOT-WIDE BUILDING SUPPORTING TWO FLOORS, ROOF AND CEILING

<table>
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<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
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<tr>
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<td>8-foot Studs</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.
### Deflection criterion:

\[ \frac{L}{240} \]

### Design load assumptions:
- Top and middle floor dead load is 10 psf.
- Top floor live load is 30 psf.
- Middle floor live load is 40 psf.
- Roof/ceiling dead load is 12 psf.
- Attic live load is 10 psf.

### Building width:
Is in the direction of horizontal framing members supported by the wall studs.

### Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

#### TABLE R603.3.2.1(1)

**ALL BUILDING WIDTHS GABLE ENDWALLS 8, 9 OR 10 FEET IN HEIGHT**

<table>
<thead>
<tr>
<th>Exp. B</th>
<th>Exp. C</th>
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<tbody>
<tr>
<td>115</td>
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<td>126</td>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa.

1 ksi = 1,000 psi = 6.895 MPa.

a. Deflection criterion: \( L/240 \).

b. Design load assumptions:
- Top and middle floor dead load is 10 psf.
- Top floor live load is 30 psf.
- Middle floor live load is 40 psf.
- Roof/ceiling dead load is 12 psf.
- Attic live load is 10 psf.

c. Building width is in the direction of horizontal framing members supported by the wall studs.

d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

**R603.3.2.1 Gable endwalls.**

The size and thickness of gable endwall studs with heights less than or equal to 10 feet (3048 mm) shall be permitted in accordance with the limits set forth in Table R603.3.2.1(1). The size and thickness of gable endwall studs with heights greater than 10 feet (3048 mm) shall be determined in accordance with the limits set forth in Table R603.3.2.1(2).

**TABLE R603.3.2.1(1)**

**ALL BUILDING WIDTHS GABLE ENDWALLS 8, 9 OR 10 FEET IN HEIGHT**

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>STUD MEMBER SIZE</th>
<th>STUD SPACING (inches)</th>
<th>8-foot Studs</th>
<th>9-foot Studs</th>
<th>10-foot Studs</th>
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<tr>
<td>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</td>
<td>MEMBER SIZE</td>
<td>STUD SPACING (inches)</td>
<td>MINIMUM STUD THICKNESS (mils)</td>
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</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.

a. Deflection criterion L/240.
b. Design load assumptions:
   - Ground snow load is 70 psf.
   - Roof/ceiling dead load is 12 psf.
   - Floor dead load is 10 psf.
   - Floor live load is 40 psf.
   - Attic dead load is 10 psf.
c. Building width is in the direction of horizontal framing members supported by the wall studs.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

### Table R603.3.2.1(2)
<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>MEMBER SIZE</th>
<th>STUD SPACING (inches)</th>
<th>MINIMUM STUD THICKNESS (mils)</th>
<th>Stud Height, h (feet)</th>
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<td>Exp. B</td>
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</table>
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 0.0479 kPa, 1 ksi = 1,000 psi = 6.895 MPa.

a—Deflection criterion L/240.
b—Design load assumptions:
  Ground snow load is 70 psf.
  Roof/ceiling dead load is 12 psf.
  Floor dead load is 10 psf.
  Floor live load is 40 psf.
  Attic dead load is 10 psf.
c—Building width is in the direction of horizontal framing members supported by the wall studs.
d—Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

<table>
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</tbody>
</table>
R603.3.3 Stud bracing.
The flanges of cold-formed steel studs shall be laterally braced in accordance with one of the following:

1. Gypsum board on both sides, structural sheathing on both sides, or gypsum board on one side and structural sheathing on the other side of load-bearing walls with gypsum board installed with minimum No. 6 screws in accordance with Section R702 and structural sheathing installed in accordance with Section R603.9 and Table R603.3.2(1).

2. Horizontal steel straps fastened in accordance with Figure R603.3.3(1) on both sides at mid-height for 8-foot (2438 mm) walls, and at one-third points for 9-foot and 10-foot (2743 mm and 3048 mm) walls. Horizontal steel straps shall be not less than 1\(\frac{1}{2}\) inches in width and 33 mils in thickness (38 mm by 0.84 mm). Straps shall be attached to the flanges of studs with one No. 8 screw. In-line blocking shall be installed between studs at the termination of straps and at 12-foot (3658 mm) intervals along the strap. Straps shall be fastened to the blocking with two No. 8 screws.

3. Sheathing on one side and strapping on the other side fastened in accordance with Figure R603.3.3(2). Sheathing shall be installed in accordance with Item 1. Steel straps shall be installed in accordance with Item 2.

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE R603.3.3(1)
STUD BRACING WITH STRAPPING ONLY
FIGURE R603.3.3(2)
STUD BRACING WITH STRAPPING AND SHEATHING MATERIAL

R603.3.4 Cutting and notching.
Flanges and lips of cold-formed steel studs and headers shall not be cut or notched.

R603.3.5 Splicing.
Steel studs and other structural members shall not be spliced. Tracks shall be spliced in accordance with Figure R603.3.5.
R603.4 Corner framing.
In exterior walls, corner studs and the top tracks shall be installed in accordance with Figure R603.4.

For SI: 1 inch = 25.4 mm.
R603.5 Exterior wall covering.
The method of attachment of exterior wall covering materials to cold-formed steel stud wall framing shall conform to the manufacturer's installation instructions.

R603.6 Headers.
Headers shall be installed above all wall openings in exterior walls and interior load-bearing walls. Box beam headers and back-to-back headers each shall be formed from two equal sized C-shaped members in accordance with Figures R603.6(1) and R603.6(2), respectively, and Tables R603.6(1) through R603.6(6). L-shaped headers shall be permitted to be constructed in accordance with AISI S230. Alternately, headers shall be permitted to be designed and constructed in accordance with AISI S100, Section D4.

For SI: 1 inch = 25.4 mm.
For SI: 1 inch = 25.4 mm.

**FIGURE R603.6(2)**
BACK-TO-BACK HEADER

**TABLE R603.6(1)**
BOX-BEAM AND BACK-TO-BACK HEADER SPANS

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>GROUND SNOW LOAD (20 psf)</th>
<th>GROUND SNOW LOAD (30 psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building width c (feet)</td>
<td>Building width c (feet)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>28</td>
</tr>
<tr>
<td>2-350S162-33</td>
<td>3'-3&quot;</td>
<td>2'-8&quot;</td>
</tr>
<tr>
<td>2-350S162-43</td>
<td>4'-2&quot;</td>
<td>3'-9&quot;</td>
</tr>
<tr>
<td>2-350S162-54</td>
<td>6'-2&quot;</td>
<td>5'-10&quot;</td>
</tr>
<tr>
<td>2-350S162-68</td>
<td>6'-7&quot;</td>
<td>6'-3&quot;</td>
</tr>
<tr>
<td>2-550S162-33</td>
<td>4'-8&quot;</td>
<td>4'-0&quot;</td>
</tr>
<tr>
<td>2-550S162-43</td>
<td>6'-0&quot;</td>
<td>5'-4&quot;</td>
</tr>
<tr>
<td>2-550S162-54</td>
<td>8'-9&quot;</td>
<td>8'-5&quot;</td>
</tr>
<tr>
<td>2-550S162-68</td>
<td>9'-5&quot;</td>
<td>9'-0&quot;</td>
</tr>
<tr>
<td>2-800S162-33</td>
<td>4'-5&quot;</td>
<td>3'-11&quot;</td>
</tr>
<tr>
<td>2-800S162-43</td>
<td>7'-3&quot;</td>
<td>6'-7&quot;</td>
</tr>
<tr>
<td>2-800S162-54</td>
<td>10'-10&quot;</td>
<td>10'-2&quot;</td>
</tr>
<tr>
<td>2-800S162-68</td>
<td>12'-8&quot;</td>
<td>11'-10&quot;</td>
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</table>

*Headers Supporting Roof and Ceiling Only*
### TABLE R603.6(2)

**Box-Beam and Back-to-Back Header Spans**

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>GROUND SNOW LOAD (50 psf)</th>
<th>GROUND SNOW LOAD (70 psf)</th>
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<tr>
<td></td>
<td>Building width (e) (feet)</td>
<td>Building width (e) (feet)</td>
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<tr>
<td></td>
<td>24</td>
<td>28</td>
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<tr>
<td>2-1000S162-43</td>
<td>7'│10&quot;</td>
<td>6'│10&quot;</td>
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<td>2-1000S162-64</td>
<td>12'│3&quot;</td>
<td>11'│5&quot;</td>
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<td>2-1000S162-68</td>
<td>14'│5&quot;</td>
<td>13'│5&quot;</td>
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<tr>
<td>2-1200S162-54</td>
<td>12'│11&quot;</td>
<td>11'│3&quot;</td>
</tr>
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<td>2-1200S162-68</td>
<td>15'│11&quot;</td>
<td>14'│10&quot;</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

- **a.** Deflection criteria: L/360 for live loads, L/240 for total loads.
- **b.** Design load assumptions:
  - Roof/ceiling dead load is 12 psf.
  - Attic dead load is 10 psf.
- **c.** Building width is in the direction of horizontal framing members supported by the header.
- **d.** Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.
### TABLE R603.6(3)
**BOX-BEAM AND BACK-TO-BACK HEADER SPANS**

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>GROUND SNOW LOAD (^{\text{c}}) (20 psf)</th>
<th>GROUND SNOW LOAD (^{\text{c}}) (30 psf)</th>
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<tr>
<td></td>
<td>Building width (^{\text{c}}) (feet)</td>
<td>Building width (^{\text{c}}) (feet)</td>
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<td>10'-1&quot; 9'-1&quot; 8'-3&quot; 7'-6&quot; 6'-10&quot;</td>
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<tr>
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<td>7'-8&quot; 6'-9&quot; 6'-1&quot; 5'-6&quot; 5'-0&quot; 5'-10&quot; 5'-1&quot; 4'-7&quot; 4'-1&quot; 3'-9&quot;</td>
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</tr>
<tr>
<td>2-1200S162-68</td>
<td>10'-4&quot; 9'-7&quot; 8'-11&quot;</td>
<td>9'-1&quot; 8'-3&quot; 7'-6&quot; 6'-10&quot;</td>
</tr>
</tbody>
</table>

- **For SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
- **a.** Deflection criteria: L/360 for live loads, L/240 for total loads.
- **b.** Design load assumptions:
  - Roof/ceiling dead load is 12 psf.
  - Attic dead load is 10 psf.
- **c.** Building width is in the direction of horizontal framing members supported by the header.
- **d.** Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.
**TABLE R603.6(4)**

**BOX-BEAM AND BACK-TO-BACK HEADER SPANS**

Headers Supporting One-Floor, Roof and Ceiling

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>GROUND SNOW LOAD (50 psf)</th>
<th>GROUND SNOW LOAD (70 psf)</th>
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</thead>
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<tr>
<td></td>
<td>Building width c (feet)</td>
<td>Building width c (feet)</td>
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<td></td>
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<td>28</td>
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<tr>
<td>2-350S162-33</td>
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<tr>
<td>2-350S162-43</td>
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<td>3'-5&quot;</td>
<td>3'-0&quot;</td>
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<tr>
<td>2-350S162-68</td>
<td>4'-6&quot;</td>
<td>4'-1&quot;</td>
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<tr>
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<tr>
<td>2-1200S162-68</td>
<td>9'-7&quot;</td>
<td>8'-8&quot;</td>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

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*Deflection criteria: L/360 for live loads, L/240 for total loads.*

*Design load assumptions:*
- Second-floor dead load is 10 psf.
- Roof/ceiling dead load is 12 psf.
- Second-floor live load is 30 psf.
- Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.
Attic dead load is 10 psf.
Building width is in the direction of horizontal framing members supported by the header.
Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

**TABLE R603.6(5)**

**BOX-BEAM AND BACK-TO-BACK HEADER SPANS**

Headers Supporting Two Floors, Roof and Ceiling

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>GROUND SNOW LOAD (20 psf)</th>
<th>GROUND SNOW LOAD (30 psf)</th>
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</thead>
<tbody>
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<tr>
<td>2-350S162-43</td>
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<td>—</td>
</tr>
<tr>
<td>2-350S162-54</td>
<td>2’-5”</td>
<td>2’-4”</td>
</tr>
<tr>
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<td>3’-6” 3’-0” 2’-6” 2’-1”</td>
<td>3’-5” 2’-11” 2’-6” 2’-0”</td>
</tr>
<tr>
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<tr>
<td>2-550S162-43</td>
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<td>=</td>
</tr>
<tr>
<td>2-550S162-54</td>
<td>3’-11” 3’-3” 2’-8” 2’-0”</td>
<td>3’-10” 3’-3” 2’-7” —</td>
</tr>
<tr>
<td>2-550S162-68</td>
<td>5’-1” 4’-5” 3’-10” 3’-3”</td>
<td>5’-0” 4’-4” 3’-9” 3’-3” 2’-9”</td>
</tr>
<tr>
<td>2-800S162-33</td>
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<td>—</td>
</tr>
<tr>
<td>2-800S162-43</td>
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<td>=</td>
</tr>
<tr>
<td>2-800S162-54</td>
<td>4’-7” 3’-10” 3’-1” 2’-5”</td>
<td>4’-6” 3’-9” 3’-0” 2’-4”</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>2-1000S162-54</td>
<td>5’-0” 4’-4” 3’-6” 2’-9”</td>
<td>4’-11” 4’-3” 3’-5” 2’-7”</td>
</tr>
<tr>
<td>2-1000S162-68</td>
<td>6’-10” 6’-0” 5’-3” 4’-6” 3’-10” 6’-9” 5’-11” 5’-2” 4’-5” 3’-9”</td>
<td></td>
</tr>
<tr>
<td>2-1200S162-54</td>
<td>4’-2” 3’-7” 3’-3” 2’-11”</td>
<td>4’-1” 3’-7” 3’-2” 2’-10”</td>
</tr>
<tr>
<td>2-1200S162-68</td>
<td>7’-7” 6’-7” 5’-9” 5’-0” 4’-2” 7”-6” 6’-6” 5’-8” 4’-10” 4’-1”</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

a. Deflection criteria: L/360 for live loads, L/240 for total loads.

b. Design load assumptions:
   - Second-floor dead load is 10 psf.
   - Roof/ceiling dead load is 12 psf.
   - Second-floor live load is 40 psf.
   - Third-floor live load is 30 psf.
   - Attic live load is 10 psf.

c. Building width is in the direction of horizontal framing members supported by the header.

d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.
### TABLE R603.6(6)
#### BOX-BEAM AND BACK-TO-BACK HEADER SPANS
Headers Supporting Two Floors, Roof and Ceiling

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>GROUND SNOW LOAD (50 psf)</th>
<th>GROUND SNOW LOAD (70 psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building-width C (feet)</td>
<td>Building-width C (feet)</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>2-350S162-33</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2-350S162-43</td>
<td>2'-2&quot;</td>
<td>-</td>
</tr>
<tr>
<td>2-350S162-54</td>
<td>3'-3&quot;</td>
<td>-</td>
</tr>
<tr>
<td>2-350S162-68</td>
<td>4'-9&quot;</td>
<td>3'-6&quot;</td>
</tr>
<tr>
<td>2-550S162-33</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2-550S162-43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2-550S162-54</td>
<td>3'-7&quot;</td>
<td>2'-11&quot;</td>
</tr>
<tr>
<td>2-550S162-68</td>
<td>4'-9&quot;</td>
<td>3'-6&quot;</td>
</tr>
<tr>
<td>2-800S162-43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2-800S162-54</td>
<td>4'-3&quot;</td>
<td>3'-5&quot;</td>
</tr>
<tr>
<td>2-800S162-68</td>
<td>5'-8&quot;</td>
<td>4'-2&quot;</td>
</tr>
<tr>
<td>2-1000S162-43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2-1000S162-54</td>
<td>4'-8&quot;</td>
<td>3'-7&quot;</td>
</tr>
<tr>
<td>2-1000S162-68</td>
<td>6'-5&quot;</td>
<td>5'-7&quot;</td>
</tr>
<tr>
<td>2-1200S162-43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2-1200S162-54</td>
<td>3'-11&quot;</td>
<td>3'-5&quot;</td>
</tr>
<tr>
<td>2-1200S162-68</td>
<td>7'-1&quot;</td>
<td>6'-2&quot;</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

a. Deflection criteria: L/360 for live loads, L/240 for total loads.
b. Design load assumptions:
   - Second-floor dead load is 10 psf.
   - Roof/ceiling dead load is 12 psf.
   - Second-floor live load is 40 psf.
   - Third-floor live load is 30 psf.
   - Attic live load is 10 psf.
c. Building width is in the direction of horizontal framing members supported by the header.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

R603.6.1 Headers in gable endwalls.
Box beam and back-to-back headers in gable endwalls shall be permitted to be constructed...
in accordance with Section R603.6 or with the header directly above the opening in accordance with Figures R603.6.1(1) and R603.6.1(2) and the following provisions:

1. Two 362S162-33 for openings less than or equal to 4 feet (1219 mm).
2. Two 600S162-43 for openings greater than 4 feet (1219 mm) but less than or equal to 6 feet (1830 mm).
3. Two 800S162-54 for openings greater than 6 feet (1829 mm) but less than or equal to 9 feet (2743 mm).

FIGURE R603.6.1(1)
BOX BEAM HEADER IN GABLE ENDWALL

FIGURE R603.6.1(2)
BACK-TO-BACK HEADER IN GABLE ENDWALL

For SI: 1 inch = 25.4 mm.

R603.7 Jack and king studs.
The number of jack and king studs installed on each side of a header shall comply with Table R603.7(1). King, jack and cripple studs shall be of the same dimension and thickness as the adjacent wall studs. Headers shall be connected to king studs in accordance with Table R603.7(2) and the following provisions:
1. For box beam headers, one-half of the total number of required screws shall be applied to the header and one-half to the king stud by use of C-shaped or track member in accordance with Figure R603.6(1). The track or C-shaped sections shall extend the depth of the header minus \(\frac{1}{2}\) inch (12.7 mm) and shall have a minimum thickness not less than that of the wall studs.

2. For back-to-back headers, one-half the total number of screws shall be applied to the header and one-half to the king stud by use of a minimum 2-inch by 2-inch (51 mm by 51 mm) clip angle in accordance with Figure R603.6(2). The clip angle shall extend the depth of the header minus \(\frac{1}{2}\) inch (12.7 mm) and shall have a minimum thickness not less than that of the wall studs. Jack and king studs shall be interconnected with structural sheathing in accordance with Figures R603.6(1) and R603.6(2).

### TABLE R603.7(1)
#### TOTAL NUMBER OF JACK AND KING STUDS REQUIRED AT EACH END OF AN OPENING

<table>
<thead>
<tr>
<th>SIZE OF OPENING (feet-inches)</th>
<th>24-INCH O.C. STUD SPACING</th>
<th>16-INCH O.C. STUD SPACING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of jack studs</td>
<td>No. of king studs</td>
</tr>
<tr>
<td>Up to 3'-6&quot;</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 3'-6&quot; to 5'-0&quot;</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 5'-0&quot; to 8'-0&quot;</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 8'-0&quot; to 10'-6&quot;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 10'-6&quot; to 12'-0&quot;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 12'-0&quot; to 13'-0&quot;</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 13'-0&quot; to 14'-0&quot;</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 14'-0&quot; to 16'-0&quot;</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 16'-0&quot; to 18'-0&quot;</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

### TABLE R603.7(2)
#### HEADER TO KING STUD CONNECTION REQUIREMENTS

<table>
<thead>
<tr>
<th>HEADER SPAN (feet)</th>
<th>ULTIMATE WIND SPEED (mph), EXPOSURE CATEGORY</th>
<th>110, Exposure Category C or Less than 139, Exposure Category B</th>
<th>Less than 139, Exposure Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 4'</td>
<td>4-No. 8 screws</td>
<td>6-No. 8 screws</td>
<td></td>
</tr>
<tr>
<td>&gt; 4&quot; to 8&quot;</td>
<td>4-No. 8 screws</td>
<td>8-No. 8 screws</td>
<td></td>
</tr>
<tr>
<td>&gt; 8&quot; to 12&quot;</td>
<td>6-No. 8 screws</td>
<td>10-No. 8 screws</td>
<td></td>
</tr>
<tr>
<td>&gt; 12&quot; to 16&quot;</td>
<td>8-No. 8 screws</td>
<td>12-No. 8 screws</td>
<td></td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound = 4.448 N.
a. All screw sizes shown are minimum.
b. For headers located on the first floor of a two-story building or the first or second floor of a three-story building, the total number of screws is permitted to be reduced by 2 screws, but the total number of screws shall not be less than four.
c. For roof slopes of 6:12 or greater, the required number of screws shall be permitted to be reduced by half, but the total number of screws shall not be less than four.
d. Screws can be replaced by an uplift connector that has a capacity of the number of screws multiplied by 164 pounds.

R603.8 Head and sill track.

Head track spans above door and window openings and sill track spans beneath window openings shall comply with Table R603.8. For openings less than 4 feet (1219 mm) in height that have both a head track and a sill track, multiplying the spans by 1.75 shall be permitted in Table R603.8. For openings less than or equal to 6 feet (1829 mm) in height that have both a head track and a sill track, the spans are permitted to be multiplied by a factor of 1.5.

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED AND EXPOSURE CATEGORY (mph)</th>
<th>ALLOWABLE HEAD AND SILL TRACK SPAN (feet-inches)</th>
<th>TRACK DESIGNATION d</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>350T125-33</td>
<td>350T125-43</td>
</tr>
<tr>
<td>115</td>
<td>5'-10&quot;</td>
<td>6'-8&quot;</td>
</tr>
<tr>
<td>126</td>
<td>5'-1&quot;</td>
<td>6'-11&quot;</td>
</tr>
<tr>
<td>&lt;139</td>
<td>5'-2&quot;</td>
<td>6'-4&quot;</td>
</tr>
<tr>
<td>—</td>
<td>4'-11&quot;</td>
<td>4'-10&quot;</td>
</tr>
<tr>
<td>—</td>
<td>3'-8&quot;</td>
<td>4'-9&quot;</td>
</tr>
<tr>
<td>—</td>
<td>2'-2&quot;</td>
<td>5'-4&quot;</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.
b. Head and sill track spans are based on components and cladding wind pressures and 48-inch tributary span.
c. For openings less than 4 feet in height that have both a head track and a sill track, the spans are permitted to be multiplied by 1.75. For openings less than or equal to 6 feet in height that have both a head track and a sill track, the spans are permitted to be multiplied by a factor of 1.5.
d. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

R603.9 Structural sheathing.

Structural sheathing shall be installed in accordance with Figure R603.9 and this section on all sheathable exterior wall surfaces, including areas above and below openings.
R603.9.1 Sheathing materials.
Structural sheathing panels shall consist of minimum $\frac{7}{16}$-inch-thick (11 mm) oriented strand board or $\frac{15}{32}$-inch-thick (12 mm) plywood.

R603.9.2 Determination of minimum length of full-height sheathing.
The minimum length of full-height sheathing on each braced wall line shall be determined by multiplying the length of the braced wall line by the percentage obtained from Table R603.9.2(1) and by the plan aspect ratio adjustment factors obtained from Table R603.9.2(2). The minimum length of full-height sheathing shall be not less than 20 percent of the braced wall line length.

To be considered full-height sheathing, structural sheathing shall extend from the bottom to the top of the wall without interruption by openings. Only sheathed, full-height wall sections, uninterrupted by openings, which are not less than 48 inches (1219 mm) wide, shall be counted toward meeting the minimum percentages in Table R603.9.2(1). In addition, structural sheathing shall comply with all of the following requirements:

1. Be installed with the long dimension parallel to the stud framing and shall cover the full vertical height of wall from the bottom of the bottom track to the top of the top track of each story. Installing the long dimension perpendicular to the stud framing or using shorter segments shall be permitted provided that the horizontal joint is blocked as described in Item 2.
2. Be blocked where the long dimension is installed perpendicular to the stud framing. Blocking shall be not less than 33 mil (0.84 mm) thickness. Each horizontal structural sheathing panel shall be fastened with No. 8 screws spaced at 6 inches (152 mm) on center to the blocking at the joint.

3. Be applied to each end (corners) of each of the exterior walls with a minimum 48-inch-wide (1219 mm) panel.

**Exception:** Where stone or masonry veneer is installed, the required length of full-height sheathing and overturning anchorage required shall be determined in accordance with Section R603.9.5.

### TABLE R603.9.2(1)
**MINIMUM PERCENTAGE OF FULL-HEIGHT STRUCTURAL SHEATHING ON EXTERIOR WALLS**

<table>
<thead>
<tr>
<th>WALL SUPPORTING</th>
<th>ROOF SLOPE</th>
<th>ULTIMATE WIND SPEED AND EXPOSURE (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115 B</td>
</tr>
<tr>
<td>Roof and ceiling only (one story or top floor of two- or three-story building).</td>
<td>3:12</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>6:12</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>9:12</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>12:12</td>
<td>33</td>
</tr>
<tr>
<td>One story, roof and ceiling (first floor of a two-story building or second floor of a three-story building).</td>
<td>3:12</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>6:12</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>9:12</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>12:12</td>
<td>45</td>
</tr>
<tr>
<td>Two stories, roof and ceiling (first floor of a three-story building).</td>
<td>3:12</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>6:12</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>9:12</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>12:12</td>
<td>57</td>
</tr>
</tbody>
</table>

For SI: 1 mph = 0.447 m/s.

**a.** Linear interpolation is permitted.

**b.** For hip-roofed homes the minimum percentage of full-height sheathing, based upon wind, is permitted to be multiplied by a factor of 0.95 for roof slopes not exceeding 7:12 and a factor of 0.9 for roof slopes greater than 7:12.

### TABLE R603.9.2(2)
**FULL-HEIGHT SHEATHING LENGTH ADJUSTMENT FACTORS**

<table>
<thead>
<tr>
<th>PLAN ASPECT RATIO</th>
<th>LENGTH ADJUSTMENT FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short wall</td>
</tr>
<tr>
<td>1:1</td>
<td>1.0</td>
</tr>
<tr>
<td>1.5:1</td>
<td>1.5</td>
</tr>
<tr>
<td>2:1</td>
<td>2.0</td>
</tr>
<tr>
<td>3:1</td>
<td>3.0</td>
</tr>
<tr>
<td>4:1</td>
<td>4.0</td>
</tr>
</tbody>
</table>
**R603.9.2.1 Full height sheathing.**
The minimum percentage of full-height structural sheathing shall be multiplied by 1.10 for 9-foot-high (2743 mm) walls and multiplied by 1.20 for 10-foot-high (3048 mm) walls.

**R603.9.2.2 Full-height sheathing in lowest story.**
In the lowest story of a dwelling, multiplying the percentage of full-height sheathing required in Table R603.9.2(1) by 0.6 shall be permitted provided hold-down anchors are provided in accordance with Section R603.9.4.2.

**R603.9.3 Structural sheathing fastening.**
Edges and interior areas of structural sheathing panels shall be fastened to framing members and tracks in accordance with Figure R603.9 and Table R603.3.2(1). Screws for attachment of structural sheathing panels shall be bugle-head, flat-head, or similar head style with a minimum head diameter of 0.29 inch (8 mm).

For continuously sheathed braced wall lines using wood structural panels installed with No. 8 screws spaced 4 inches (102 mm) on center at all panel edges and 12 inches (304.8 mm) on center on intermediate framing members, the following shall apply:

1. Multiplying the percentages of full-height sheathing in Table R603.9.2(1) by 0.72 shall be permitted.

2. For bottom track attached to foundations or framing below, the bottom track anchor or screw connection spacing in Tables R505.3.1(1) and R603.3.1 shall be multiplied by two-thirds.

**R603.9.4 Uplift connection requirements.**
Uplift connections shall be provided in accordance with this section.

**R603.9.4.1 Ultimate design wind speeds greater than 126 mph.**
Where ultimate design wind speeds exceed 126 miles per hour (56 m/s), Exposure Category C walls shall be provided with direct uplift connections in accordance with AISI S230, Section E13.3, and AISI S230, Section F7.2, as required for 39 miles per hour (62 m/s), Exposure Category C.

**R603.9.4.2 Hold-down anchor.**
Where the percentage of full-height sheathing is adjusted in accordance with Section R603.9.2.2, a hold-down anchor, with a strength of 4,300 pounds (19 kN), shall be provided at each end of each full-height sheathed wall section used to meet the minimum percent sheathing requirements of Section R603.9.2. Hold-down anchors shall be attached to back-to-back studs; structural sheathing panels shall have edge fastening to the studs, in accordance with Section R603.9.3 and AISI S230, Table E11-1.

A single hold-down anchor, installed in accordance with Figure R603.9.4.2, shall be permitted at the corners of buildings.
R603.9.5 Structural sheathing for stone and masonry veneer. Where stone and masonry veneer are installed in accordance with Section R703.8, the length of full-height sheathing for exterior and interior wall lines backing or perpendicular to and laterally supporting walls with veneer shall comply with this section.

**TABLE R603.9.5(1)**

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>STORY</th>
<th>BRACED WALL LINE LENGTH (feet)</th>
<th>SINGLE-STORY HOLD-DOWN FORCE (pounds)</th>
<th>CUMULATIVE HOLD-DOWN FORCE (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>D_0</td>
<td></td>
<td>3.3</td>
<td>4.7</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.3</td>
<td>8.7</td>
<td>12.1</td>
</tr>
</tbody>
</table>
TABLE R603.9.5(2)
REQUIRED LENGTH OF FULL-HEIGHT SHEATHING AND ASSOCIATED OVERTURNING ANCHORAGE FOR WALLS SUPPORTING WALLS WITH STONE OR MASONRY VENEER AND USING 43-MIL COLD-FORMED STEEL FRAMING AND 6-INCH SCREW SPACING ON THE PERIMETER OF EACH PANEL OF STRUCTURAL SHEATHING

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>STORY</th>
<th>BRACED-WALL LINE LENGTH (feet)</th>
<th>SINGLE-STORY HOLD-DOWN FORCE (pounds)</th>
<th>CUMULATIVE HOLD-DOWN FORCE (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimum total length of braced wall panels required along each braced wall line (feet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D0</td>
<td>2.8</td>
<td>4.0</td>
<td>5.1</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>7.4</td>
<td>10.2</td>
<td>13.1</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Seismic Design Category</th>
<th>Story</th>
<th>Braced Wall Line Length (feet)</th>
<th>Single-Story Hold-Down Force (pounds)</th>
<th>Cumulative Hold-Down Force (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum total length of braced wall panels required along each braced wall line (feet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table R603.9.5(3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>3.6</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0</td>
<td>6.6</td>
<td>9.2</td>
</tr>
</tbody>
</table>
### TABLE R603.9.5(4)

**REQUIRED LENGTH OF FULL-HEIGHT SHEATHING AND ASSOCIATED OVERTURNING ANCHORAGE FOR WALLS SUPPORTING WALLS WITH STONE OR MASONRY VENEER AND USING 43-MIL COLD-FORMED STEEL FRAMING AND 4-INCH SCREW SPACING ON THE PERIMETER OF EACH PANEL OF STRUCTURAL SHEATHING**

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>STORY</th>
<th>BRACED WALL LINE LENGTH <em>(feet)</em></th>
<th>SINGLE-STORY HOLD-DOWN FORCE <em>(pounds)</em></th>
<th>CUMULATIVE HOLD-DOWN FORCE <em>(pounds)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

**Minimum total length of braced wall panels required along each braced wall line *(feet)***

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>STORY</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D₀</strong></td>
<td></td>
<td>1.9</td>
<td>2.7</td>
<td>3.4</td>
<td>4.2</td>
<td>5.0</td>
<td>5.8</td>
<td>5,928</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0</td>
<td>4.9</td>
<td>6.8</td>
<td>8.8</td>
<td>10.7</td>
<td>12.6</td>
<td>5,928</td>
<td>11,856</td>
</tr>
</tbody>
</table>
R603.9.5.1 Seismic Design Category C.
In Seismic Design Category C, the length of structural sheathing for walls supporting one story, roof and ceiling shall be the greater of the amounts required by Section R603.9.2, except Section R603.9.2.2 shall be permitted.

R603.9.5.2 Seismic Design Categories D0, D1 and D2.
In Seismic Design Categories D0, D1 and D2, the required length of structural sheathing and overturning anchorage shall be determined in accordance with Tables R603.9.5(1), R603.9.5(2), R603.9.5(3), and R603.9.5(4). Overturning anchorage shall be installed on the doubled studs at the end of each full-height wall segment.

SECTION R604
WOOD STRUCTURAL PANELS

R604.1 Identification and grade.
Wood structural panels shall conform to DOC PS 1, DOC PS 2 or ANSI/APA PRP 210, CSA O437 or CSA O325. Panels shall be identified by a grade mark or certificate of inspection issued by an approved agency.

R604.2 Allowable spans.
The maximum allowable spans for wood structural panel wall sheathing shall not exceed the values set forth in Table R602.3(3).

R604.3 Installation.
Wood structural panel wall sheathing shall be attached to framing in accordance with Table R602.3(1) or R602.3(3).

SECTION R605
PARTICLEBOARD

R605.1 Identification and grade.
Particleboard shall conform to ANSI A208.1 and shall be so identified by a grade mark or certificate of inspection issued by an approved agency. Particleboard shall comply with the grades specified in Table R602.3(4).
SECTION R606
GENERAL MASONRY CONSTRUCTION

R606.1 General.
Masonry construction shall be designed and constructed in accordance with the provisions of this section, TMS 403 or in accordance with the provisions of TMS 402/ACI 530/ASCE 5.

R606.1.1 Professional registration not required.
When the empirical design provisions of Appendix A of TMS 402/ACI 530/ASCE 5, the provisions of TMS 403, or the provisions of this section are used to design masonry, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer registered design professional responsible for design, unless otherwise required by the state law of the jurisdiction having authority.

R606.2 Masonry construction materials.

R606.2.1 Concrete masonry units.
Concrete masonry units shall conform to the following standards: ASTM C 55 for concrete brick; ASTM C 73 for calcium silicate face brick; ASTM C 90 for load-bearing concrete masonry units; ASTM C 744 for prefaced concrete and calcium silicate masonry units; or ASTM C 1634 for concrete facing brick.

R606.2.2 Clay or shale masonry units.
Clay or shale masonry units shall conform to the following standards: ASTM C 34 for structural clay load-bearing wall tile; ASTM C 56 for structural clay nonload-bearing wall tile; ASTM C 62 for building brick (solid masonry units made from clay or shale); ASTM C 1088 for solid units of thin veneer brick; ASTM C 126 for ceramic-glazed structural clay facing tile, facing brick and solid masonry units; ASTM C 212 for structural clay facing tile; ASTM C 216 for facing brick (solid masonry units made from clay or shale); ASTM C652 for hollow brick (hollow masonry units made from clay or shale); or ASTM C1405 for glazed brick (single-fired solid brick units).

Exception: Structural clay tile for nonstructural use in fireproofing of structural members and in wall furring shall not be required to meet the compressive strength specifications. The fire-resistance rating shall be determined in accordance with ASTM E 119 or UL 263 and shall comply with the requirements of Section R302.

R606.2.3 AAC masonry.
AAC masonry units shall conform to ASTM C 1386 for the strength class specified.

R606.2.4 Stone masonry units.
Stone masonry units shall conform to the following standards: ASTM C 503 for marble building stone (exterior); ASTM C 568 for limestone building stone; ASTM C 615 for granite building stone; ASTM C 616 for sandstone building stone; or ASTM C 629 for slate building stone.

R606.2.5 Architectural cast stone.
Architectural cast stone shall conform to ASTM C 1364.
R606.2.6 Second hand units.
Second hand masonry units shall not be reused unless they conform to the requirements of new units. The units shall be of whole, sound materials and free from cracks and other defects that will interfere with proper laying or use. Old mortar shall be cleaned from the unit before reuse.

Exception: Second hand units are permitted to be used for interior nonbearing conditions.

R606.2.7 Mortar.
Except for mortars listed in Sections R606.2.8, R606.2.9 and R606.2.10, mortar for use in masonry construction shall meet the proportion specifications of Table R606.2.7 or the property specifications of ASTM C 270. The type of mortar shall be in accordance with Sections R606.2.7.1, R606.2.7.2 and R606.2.7.3.

TABLE R606.2.7
MORTAR PROPORTIONS\textsuperscript{a, b}

<table>
<thead>
<tr>
<th>MORTAR TYPE</th>
<th>MORTAR cement or blended cement</th>
<th>Mortar cement</th>
<th>Masonry cement</th>
<th>Hydrated lime or lime putty</th>
<th>Aggregate ratio (measured in damp, loose conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement-lime</td>
<td>M</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>(1/4)</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>over (1/4) to (1/2)</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>over (1/4) to (1/2)</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>over (1/4) to (1/2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not less than (2) and not more than (3) times the sum of separate volumes of lime, if used, and cement</td>
</tr>
<tr>
<td>Mortar cement</td>
<td>M</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>(1/2)</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Masonry cement</td>
<td>M</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>(1/2)</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
For SI: 1 cubic foot = 0.0283 m$^3$, 1 pound = 0.454 kg.

a. For the purpose of these specifications, the weight of 1 cubic foot of the respective materials shall be considered to be as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland Cement</td>
<td>94 pounds</td>
</tr>
<tr>
<td>Mortar Cement</td>
<td>Weight printed on bag</td>
</tr>
<tr>
<td>Lime Putty (Quicklime)</td>
<td>80 pounds</td>
</tr>
<tr>
<td>Masonry Cement</td>
<td>Weight printed on bag</td>
</tr>
<tr>
<td>Hydrated Lime</td>
<td>40 pounds</td>
</tr>
<tr>
<td>Sand, damp and loose</td>
<td>80 pounds of dry sand</td>
</tr>
</tbody>
</table>

b. Two air-entraining materials shall not be combined in mortar.

c. Hydrated lime conforming to the requirements of ASTM C 207.

R606.2.7.1 Foundation walls.
Mortar for masonry foundation walls constructed as set forth in Tables R404.1.1(1) through R404.1.1(4) shall be Type M or S mortar.

R606.2.7.2 Masonry in Seismic Design Categories A, B and C.
Mortar for masonry serving as the lateral-force-resisting system in Seismic Design Categories A, B and C shall be Type M, S or N mortar.

R606.2.7.3 Masonry in Seismic Design Categories D0, D1 and D2. Deleted.
Mortar for masonry serving as the lateral-force-resisting system in Seismic Design Categories D0, D1 and D2 shall be Type M or S Portland cement-lime or mortar cement mortar.

R606.2.8 Surface-bonding mortar.
Surface-bonding mortar shall comply with ASTM C 887. Surface bonding of concrete masonry units shall comply with ASTM C 946.

R606.2.9 Mortar for AAC masonry.
Thin-bed mortar for AAC masonry shall comply with Article 2.1 C.1 of TMS 602/ACI 530.1/ASCE 6. Mortar used for the leveling courses of AAC masonry shall comply with Article 2.1 C.2 of TMS 602/ACI 530.1/ASCE 6.

R606.2.10 Mortar for adhered masonry veneer.
Mortar for use with adhered masonry veneer shall conform to ASTM C 270 Type S or Type N or shall comply with ANSI A118.4 for latex-modified portland cement mortar.

R606.2.11 Grout.
Grout shall consist of cementitious material and aggregate in accordance with ASTM C 476 or the proportion specifications of Table R606.2.11. Type M or Type S mortar to which sufficient water has been added to produce pouring consistency shall be permitted to be used as grout.

### TABLE R606.2.11
**GROUT PROPORTIONS BY VOLUME FOR MASONRY CONSTRUCTION**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>PORTLAND CEMENT OR BLENDED CEMENT</th>
<th>SLAG CEMENT</th>
<th>HYDRATED LIME OR LIME PUTTY</th>
<th>AGGREGATE MEASURED IN A DAMP, LOOSE CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
### R606.2.12 Metal reinforcement and accessories.
Metal reinforcement and accessories shall conform to Article 2.4 of TMS 602/ACI 530.1/ASCE 6.

### R606.3 Construction requirements.

#### R606.3.1 Bed and head joints.

Unless otherwise required or indicated on the project drawings, head and bed joints shall be \( \frac{3}{8} \) inch (9.5 mm) thick, except that the thickness of the bed joint of the starting course placed over foundations shall be not less than \( \frac{1}{4} \) inch (6.4 mm) and not more than \( \frac{3}{4} \) inch (19.1 mm). Mortar joint thickness for load-bearing masonry shall be within the following tolerances from the specified dimensions:

1. Bed joint: + \( \frac{1}{8} \) inch (3.2 mm).

2. Head joint: - \( \frac{1}{4} \) inch (6.4 mm), + \( \frac{3}{8} \) inch (9.5 mm).

3. Collar joints: - \( \frac{1}{4} \) inch (6.4 mm), + \( \frac{3}{8} \) inch (9.5 mm).

#### R606.3.2 Masonry unit placement.
The mortar shall be sufficiently plastic and units shall be placed with sufficient pressure to extrude mortar from the joint and produce a tight joint. Deep furrowing of bed joints that produces voids shall not be permitted. Any units disturbed to the extent that initial bond is broken after initial placement shall be removed and relaid in fresh mortar. Surfaces to be in contact with mortar shall be clean and free of deleterious materials.

##### R606.3.2.1 Solid masonry.
Solid masonry units shall be laid with full head and bed joints and all interior vertical joints that are designed to receive mortar shall be filled.

##### R606.3.2.2 Hollow masonry.
For hollow masonry units, head and bed joints shall be filled solidly with mortar for a distance in from the face of the unit not less than the thickness of the face shell.

#### R606.3.3 Installation of wall ties.
The installation of wall ties shall be as follows:
1. The ends of wall ties shall be embedded in mortar joints. Wall ties shall have not less than \( \frac{5}{8} \) -inch (15.9 mm) mortar coverage from the exposed face.

2. Wall ties shall not be bent after being embedded in grout or mortar.

3. For solid masonry units, solid grouted hollow units, or hollow units in anchored masonry veneer, wall ties shall be embedded in mortar bed not less than \( 1 \frac{1}{2} \) inches (38 mm).

4. For hollow masonry units in other than anchored masonry veneer, wall ties shall engage outer face shells by not less than \( \frac{1}{2} \) inch (13 mm).

**R606.3.4 Protection for reinforcement.**
Bars shall be completely embedded in mortar or grout. Joint reinforcement embedded in horizontal mortar joints shall not have less than \( \frac{5}{8} \) -inch (15.9 mm) mortar coverage from the exposed face. Other reinforcement shall have a minimum coverage of one bar diameter over all bars, but not less than \( \frac{3}{4} \) inch (19 mm), except where exposed to weather or soil, in which case the minimum coverage shall be 2 inches (51 mm).

**R606.3.4.1 Corrosion protection.**
Minimum corrosion protection of joint reinforcement, anchor ties and wire fabric for use in masonry wall construction shall conform to Table R606.3.4.1.

**TABLE R606.3.4.1 MINIMUM CORROSION PROTECTION**

<table>
<thead>
<tr>
<th>MASONRY METAL ACCESSORY</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint reinforcement, interior walls</td>
<td>ASTM A 641, Class 1</td>
</tr>
<tr>
<td>Wire ties or anchors in exterior walls completely embedded in mortar or grout</td>
<td>ASTM A 641, Class 3</td>
</tr>
<tr>
<td>Wire ties or anchors in exterior walls not completely embedded in mortar or grout</td>
<td>ASTM A 153, Class B-2</td>
</tr>
<tr>
<td>Joint reinforcement in exterior walls or interior walls exposed to moist environment</td>
<td>ASTM A 153, Class B-2</td>
</tr>
<tr>
<td>Sheet metal ties or anchors exposed to weather</td>
<td>ASTM A 153, Class B-2</td>
</tr>
<tr>
<td>Sheet metal ties or anchors completely embedded in mortar or grout</td>
<td>ASTM A 653, Coating Designation G60</td>
</tr>
<tr>
<td>Stainless steel hardware for any exposure</td>
<td>ASTM A 167, Type 304</td>
</tr>
</tbody>
</table>

**R606.3.5 Grouting requirements.**

**R606.3.5.1 Grout placement.**
Grout shall be a plastic mix suitable for pumping without segregation of the constituents.
and shall be mixed thoroughly. Grout shall be placed by pumping or by an approved alternate method and shall be placed before any initial set occurs and not more than 1\(\frac{1}{2}\) hours after water has been added. Grout shall be consolidated by puddling or mechanical vibrating during placing and reconsolidated after excess moisture has been absorbed but before plasticity is lost. Grout shall not be pumped through aluminum pipes.

Maximum pour heights and the minimum dimensions of spaces provided for grout placement shall conform to Table R606.3.5.1. Grout shall be poured in lifts of 8-foot (2438 mm) maximum height. Where a total grout pour exceeds 8 feet (2438 mm) in height, the grout shall be placed in lifts not exceeding 64 inches (1626 mm) and special inspection during grouting shall be required. If the work is stopped for 1 hour or longer, the horizontal construction joints shall be formed by stopping all tiers at the same elevation and with the grout 1 inch (25 mm) below the top.

### Table R606.3.5.1
GROUT SPACE DIMENSIONS AND POUR HEIGHTS

<table>
<thead>
<tr>
<th>GROUT TYPE</th>
<th>GROUT POUR MAXIMUM HEIGHT (feet)</th>
<th>MINIMUM WIDTH OF GROUT SPACES a, b (inches)</th>
<th>MINIMUM GROUT SPACE DIMENSIONS FOR GROUTING CELLS OF HOLLOW UNITS (inches x inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>1</td>
<td>0.75</td>
<td>1.5 x 2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2</td>
<td>2 x 3</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2.5</td>
<td>2.5 x 3</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>3</td>
<td>3 x 3</td>
</tr>
<tr>
<td>Coarse</td>
<td>1</td>
<td>1.5</td>
<td>1.5 x 3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2</td>
<td>2.5 x 3</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2.5</td>
<td>3 x 3</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>3</td>
<td>3 x 4</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. For grouting between masonry wythes.

b. Grout space dimension is the clear dimension between any masonry protrusion and shall be increased by the horizontal projection of the diameters of the horizontal bars within the cross section of the grout space.

c. Area of vertical reinforcement shall not exceed 6 percent of the area of the grout space.

**R606.3.5.2 Cleanouts.**

Provisions shall be made for cleaning the space to be grouted. Mortar that projects more than \(\frac{1}{2}\) inch (12.7 mm) into the grout space and any other foreign matter shall be removed from the grout space prior to inspection and grouting. Where required by the building official, cleanouts shall be provided in the bottom course of masonry for each grout pour where the grout pour height exceeds 64 inches (1626 mm). In solid grouted masonry, cleanouts shall be spaced horizontally not more than 32 inches (813 mm) on center. The cleanouts shall be sealed before grouting and after inspection.

**R606.3.5.3 Construction.**

Requirements for grouted masonry construction shall be as follows:
1. Masonry shall be built to preserve the unobstructed vertical continuity of the cells or spaces to be filled. In partially grouted construction, cross webs forming cells to be filled shall be full-bedded in mortar to prevent leakage of grout. Head and end joints shall be solidly filled with mortar for a distance in from the face of the wall or unit not less than the thickness of the longitudinal face shells.

2. Vertical reinforcement shall be held in position at top and bottom and at intervals not exceeding 200 diameters of the reinforcement.

3. Cells containing reinforcement shall be filled solidly with grout.

4. The thickness of grout or mortar between masonry units and reinforcement shall be not less than $\frac{1}{4}$ inch (6.4 mm), except that $\frac{1}{4}$ -inch (6.4 mm) bars shall be permitted to be laid in horizontal mortar joints not less than $\frac{1}{2}$ inch (12.7 mm) thick, and steel wire reinforcement shall be permitted to be laid in horizontal mortar joints not less than twice the thickness of the wire diameter.

**R606.3.6 Grouted multiple-wythe masonry.**

Grouted multiple-wythe masonry shall conform to all the requirements specified in Section R606.3.5 and the requirements of this section.

**R606.3.6.1 Bonding of backup wythe.**

Where all interior vertical spaces are filled with grout in multiple-wythe construction, masonry headers shall not be permitted. Metal wall ties shall be used in accordance with Section R606.13.2 to prevent spreading of the wythes and to maintain the vertical alignment of the wall. Wall ties shall be installed in accordance with Section R606.13.2 where the backup wythe in multiple-wythe construction is fully grouted.

**R606.3.6.2 Grout barriers.**

Vertical grout barriers or dams shall be built of solid masonry across the grout space the entire height of the wall to control the flow of the grout horizontally. Grout barriers shall be not more than 25 feet (7620 mm) apart. The grouting of any section of a wall between control barriers shall be completed in one day without interruptions greater than 1 hour.

**R606.3.7 Masonry bonding pattern.**

Masonry laid in running and stack bond shall conform to Sections R606.3.7.1 and R606.3.7.2.

**R606.3.7.1 Masonry laid in running bond.**

In each wythe of masonry laid in running bond, head joints in successive courses shall be offset by not less than one-fourth the unit length, or the masonry walls shall be reinforced longitudinally as required in Section R606.3.7.2.

**R606.3.7.2 Masonry laid in stack bond.**

Where unit masonry is laid with less head joint offset than in Section R606.3.7.1, the minimum area of horizontal reinforcement placed in mortar bed joints or in bond beams spaced not more than 48 inches (1219 mm) apart shall be 0.0007 times the vertical cross-sectional area of the
In unreinforced masonry where masonry units are laid in stack bond, longitudinal reinforcement consisting of not less than two continuous wires each with a minimum aggregate cross-sectional area of 0.017 square inch (11 mm²) shall be provided in horizontal bed joints spaced not more than 16 inches (406 mm) on center vertically.

**R606.4 Thickness of masonry.**
The nominal thickness of masonry walls shall conform to the requirements of Sections R606.4.1 through R606.4.4.

**R606.4.1 Minimum thickness.**
The minimum thickness of masonry bearing walls more than one story high shall be 8 inches (203 mm). *Solid masonry* walls of one-story dwellings and garages shall be not less than 6 inches (152 mm) in thickness where not greater than 9 feet (2743 mm) in height, provided that where gable construction is used, an additional 6 feet (1829 mm) is permitted to the peak of the gable. Masonry walls shall be laterally supported in either the horizontal or vertical direction at intervals as required by Section R606.6.4.

**R606.4.2 Rubble stone masonry wall.**
The minimum thickness of rough, random or coursed rubble stone masonry walls shall be 16 inches (406 mm).

**R606.4.3 Change in thickness.**
Where walls of masonry of hollow units or masonry-bonded hollow walls are decreased in thickness, a course of solid masonry or masonry units filled with mortar or grout shall be constructed between the wall below and the thinner wall above, or special units or construction shall be used to transmit the loads from face shells or wythes above to those below.

**R606.4.4 Parapet walls.**
Unreinforced solid masonry parapet walls shall be not less than 8 inches (203 mm) thick and their height shall not exceed four times their thickness. Unreinforced hollow unit masonry parapet walls shall be not less than 8 inches (203 mm) thick, and their height shall not exceed three times their thickness. Masonry parapet walls in areas subject to wind loads of 30 pounds per square foot (1.44 kPa) located in Seismic Design Category D₀, D₁ or D₂, or on townhouses in Seismic Design Category C shall be reinforced in accordance with Section R606.12.

**R606.5 Corbeled masonry.**
Corbeled masonry shall be in accordance with Sections R606.5.1 through R606.5.3.

**R606.5.1 Units.**
*Solid masonry* units or masonry units filled with mortar or grout shall be used for corbeling.

**R606.5.2 Corbel projection.**
The maximum projection of one unit shall not exceed one-half the height of the unit or one-third the thickness at right angles to the wall. The maximum corbeled projection beyond the face of the wall shall not exceed:

1. One-half of the wall thickness for multiwythe walls bonded by mortar or grout and wall ties or masonry headers.
2. One-half the wythe thickness for single wythe walls, masonry-bonded hollow walls, multiwythe walls with open collar joints and veneer walls.

**R606.5.3 Corbeled masonry supporting floor or roof-framing members.**
Where corbeled masonry is used to support floor or roof-framing members, the top course of the corbel shall be a header course or the top course bed joint shall have ties to the vertical wall.

**R606.6 Support conditions.**
Bearing and support conditions shall be in accordance with Sections R606.6.1 through R606.6.4.

**R606.6.1 Bearing on support.**
Each masonry wythe shall be supported by at least two-thirds of the wythe thickness.

**R606.6.2 Support at foundation.**
Cavity wall or masonry veneer construction shall be permitted to be supported on an 8-inch (203 mm) foundation wall, provided the 8-inch (203 mm) wall is corbeled to the width of the wall system above with masonry constructed of solid masonry units or masonry units filled with mortar or grout. The total horizontal projection of the corbel shall not exceed 2 inches (51 mm) with individual corbels projecting not more than one-third the thickness of the unit or one-half the height of the unit. The hollow space behind the corbeled masonry shall be filled with mortar or grout.

**R606.6.3 Beam supports.**
Beams, girders or other concentrated loads supported by a wall or column shall have a bearing of not less than 3 inches (76 mm) in length measured parallel to the beam upon solid masonry not less than 4 inches (102 mm) in thickness, or upon a metal bearing plate of adequate design and dimensions to distribute the load safely, or upon a continuous reinforced masonry member projecting not less than 4 inches (102 mm) from the face of the wall.

**R606.6.3.1 Joist bearing.**
Joists shall have a bearing of not less than \( \frac{3}{2} \) inches (38 mm), except as provided in Section R606.6.3, and shall be supported in accordance with Figure R606.11(1).

**R606.6.4 Lateral support.**
Masonry walls shall be laterally supported in either the horizontal or the vertical direction. The maximum spacing between lateral supports shall not exceed the distances in Table R606.6.4. Lateral support shall be provided by cross walls, pilasters, buttresses or structural frame members where the limiting distance is taken horizontally, or by floors or roofs where the limiting distance is taken vertically.

<table>
<thead>
<tr>
<th>TABLE R606.6.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPACING OF LATERAL SUPPORT FOR MASONRY WALLS</td>
</tr>
<tr>
<td>CONSTRUCTION</td>
</tr>
<tr>
<td>---</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
Bearing walls:
- Solid or solid grouted: 20
- All other: 18

Nonbearing walls:
- Exterior: 18
- Interior: 36

For SI: 1 foot = 304.8 mm.
a. Except for cavity walls and cantilevered walls, the thickness of a wall shall be its nominal thickness measured perpendicular to the face of the wall. For cavity walls, the thickness shall be determined as the sum of the nominal thicknesses of the individual wythes. For cantilever walls, except for parapets, the ratio of height to nominal thickness shall not exceed 6 for solid masonry, or 4 for hollow masonry. For parapets, see Section R606.4.4.
b. An additional unsupported height of 6 feet is permitted for gable end walls.

**R606.6.4.1 Horizontal lateral support.**
Lateral support in the horizontal direction provided by intersecting masonry walls shall be provided by one of the methods in Section R606.6.4.1.1 or R606.6.4.1.2.

**R606.6.4.1.1 Bonding pattern.**
Fifty percent of the units at the intersection shall be laid in an overlapping masonry bonding pattern, with alternate units having a bearing of not less than 3 inches (76 mm) on the unit below.

**R606.6.4.1.2 Metal reinforcement.**
Interior nonload-bearing walls shall be anchored at their intersections, at vertical intervals of not more than 16 inches (406 mm) with joint reinforcement of not less than 9 gage [0.148 inch (4mm)], or \(\frac{1}{4}\)-inch (6 mm) galvanized mesh hardware cloth.

Intersecting masonry walls, other than interior nonloadbearing walls, shall be anchored at vertical intervals of not more than 8 inches (203 mm) with joint reinforcement of not less than 9 gage and shall extend not less than 30 inches (762 mm) in each direction at the intersection. Other metal ties, joint reinforcement or anchors, if used, shall be spaced to provide equivalent area of anchorage to that required by this section.

**R606.6.4.2 Vertical lateral support.**
Vertical lateral support of masonry walls in Seismic Design Category A, B or C shall be provided in accordance with one of the methods in Section R606.6.4.2.1 or R606.6.4.2.2.

**R606.6.4.2.1 Roof structures.**
Masonry walls shall be anchored to roof structures with metal strap anchors spaced in accordance with the manufacturer’s instructions, \(\frac{1}{2}\)-inch (13 mm) bolts spaced not more than 6 feet (1829 mm) on center, or other approved anchors. Anchors shall be embedded not less than 16 inches (406 mm) into the masonry, or be hooked or welded to bond beam reinforcement placed not less than 6 inches (152 mm) from the top of the wall.

**R606.6.4.2.2 Floor diaphragms.**
Masonry walls shall be anchored to floor diaphragm framing by metal strap anchors.
R606.7 Piers.
The unsupported height of masonry piers shall not exceed 10 times their least dimension. Where structural clay tile or hollow concrete masonry units are used for isolated piers to support beams and girders, the cellular spaces shall be filled solidly with grout or Type M or S mortar, except that unfilled hollow piers shall be permitted to be used if their unsupported height is not more than four times their least dimension. Where hollow masonry units are solidly filled with grout or Type M, S or N mortar, the allowable compressive stress shall be permitted to be increased as provided in Table R606.9.

R606.7.1 Pier cap.
Hollow piers shall be capped with 4 inches (102 mm) of solid masonry or concrete, a masonry cap block, or shall have cavities of the top course filled with concrete or grout. for one story and 8 inches (203 mm) of solid masonry or concrete for two story and two and one-half story or shall have cavities of the top course filled with concrete or grout or other approved methods.

R606.8 Chases.
Chases and recesses in masonry walls shall not be deeper than one-third the wall thickness, and the maximum length of a horizontal chase or horizontal projection shall not exceed 4 feet (1219 mm), and shall have not less than 8 inches (203 mm) of masonry in back of the chases and recesses and between adjacent chases or recesses and the jambs of openings. Chases and recesses in masonry walls shall be designed and constructed so as not to reduce the required strength or required fire resistance of the wall and in no case shall a chase or recess be permitted within the required area of a pier. Masonry directly above chases or recesses wider than 12 inches (305 mm) shall be supported on noncombustible lintels.

R606.9 Allowable stresses.
Allowable compressive stresses in masonry shall not exceed the values prescribed in Table R606.9. In determining the stresses in masonry, the effects of all loads and conditions of loading and the influence of all forces affecting the design and strength of the several parts shall be taken into account.

<table>
<thead>
<tr>
<th>TABLE R606.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALLOWABLE COMPR. STRESSES FOR EMPRICAL DESIGN OF MASONRY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONSTRUCTION; COMPRESSIVE STRENGTH OF UNIT, GROSS AREA</th>
<th>ALLOWABLE COMPR. STRESSES (a) GROSS CROSS-SECTIONAL AREA (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type M or S mortar</td>
<td>Type N mortar</td>
</tr>
</tbody>
</table>
### Solid masonry of brick and other solid units of clay or shale; sand-lime or concrete brick:

<table>
<thead>
<tr>
<th>Strength (psi)</th>
<th>8,000+</th>
<th>4,500</th>
<th>2,500</th>
<th>1,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>300</td>
<td>225</td>
<td>160</td>
<td>115</td>
</tr>
<tr>
<td>225</td>
<td>200</td>
<td>160</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>140</td>
<td>115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Grouted masonry, of clay or shale; sand-lime or concrete:

<table>
<thead>
<tr>
<th>Strength (psi)</th>
<th>4,500+</th>
<th>2,500</th>
<th>1,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>225</td>
<td>200</td>
<td>160</td>
<td>115</td>
</tr>
<tr>
<td>160</td>
<td>140</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Solid masonry of solid concrete masonry units:

<table>
<thead>
<tr>
<th>Strength (psi)</th>
<th>3,000+</th>
<th>2,000</th>
<th>1,200</th>
</tr>
</thead>
<tbody>
<tr>
<td>225</td>
<td>200</td>
<td>160</td>
<td>115</td>
</tr>
<tr>
<td>160</td>
<td>140</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Masonry of hollow load-bearing units:

<table>
<thead>
<tr>
<th>Strength (psi)</th>
<th>2,000+</th>
<th>1,500</th>
<th>1,000</th>
<th>700</th>
</tr>
</thead>
<tbody>
<tr>
<td>140</td>
<td>120</td>
<td>115</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>115</td>
<td>100</td>
<td>75</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>75</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Hollow walls (cavity or masonry bonded solid units):

<table>
<thead>
<tr>
<th>Strength (psi)</th>
<th>2,500+</th>
<th>1,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>140</td>
<td>115</td>
</tr>
<tr>
<td>115</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### Stone ashlar masonry:

- Granite: 720
- Limestone or marble: 450
- Sandstone or cast stone: 360

### Rubble stone masonry:

- Coarse, rough or random: 120

For SI: 1 pound per square inch = 6.895 kPa.

a. Linear interpolation shall be used for determining allowable stresses for masonry units having compressive strengths that are intermediate between those given in the table.

b. Gross cross-sectional area shall be calculated on the actual rather than nominal dimensions.

c. See Section R606.13.

d. Where floor and roof loads are carried upon one wythe, the gross cross-sectional area is that of the wythe under load; if both wythes are loaded, the gross cross-sectional area is that of the wall minus the area of the cavity between the wythes. Walls bonded with metal ties shall be considered as cavity walls unless the collar joints are filled with mortar or grout.

**R606.9.1 Combined units.**

In walls or other structural members composed of different kinds or grades of units, materials or mortars, the maximum stress shall not exceed the allowable stress for the weakest of the combination of units, materials and mortars of which the member is composed. The net thickness of any facing unit that is used to resist stress shall be not less than $1\frac{1}{2}$ inches (38 mm).
R606.10 Lintels.
Masonry over openings shall be supported by steel lintels, reinforced concrete or masonry lintels or masonry arches, designed to support load imposed.

R606.11 Anchorage.
Masonry walls shall be anchored to floor and roof systems in accordance with the details shown in Figure R606.11(1), or R606.11(2) or R606.11(3). Footings shall be permitted to be considered as points of lateral support.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
Note: Where bolts are located in hollow masonry, the cells in the courses receiving the bolt shall be grouted solid.

**FIGURE R606.11(1)**
ANCHORAGE REQUIREMENTS FOR MASONRY WALLS LOCATED IN SEISMIC DESIGN CATEGORY A, B OR C AND WHERE WIND LOADS ARE LESS THAN 30 PSF
FIGURE R606.11(2)
REQUIREMENTS FOR REINFORCED GROUTED MASONRY CONSTRUCTION IN SEISMIC DESIGN CATEGORY C
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

Note: A full bed joint must be provided. Cells containing vertical bars are to be filled to the top of wall and provide inspection opening as shown on detail "A." Horizontal bars are to be laid as shown on detail "B." Lintel bars are to be laid as shown on Section C.

**FIGURE R606.11(3)**

**REQUIREMENTS FOR REINFORCED MASONRY CONSTRUCTION IN SEISMIC DESIGN CATEGORY D<sub>0</sub>, D<sub>1</sub> OR D<sub>2</sub>**

**R606.12 Seismic requirements.**

The seismic requirements of this section shall apply to the design of masonry and the construction of masonry building elements located in Seismic Design Category D<sub>0</sub>, D<sub>1</sub> or D<sub>2</sub>.

Townhouses in Seismic Design Category C shall comply with the requirements of Section R606.12.2. These requirements shall not apply to glass unit masonry conforming to Section R610-R607, anchored masonry veneer conforming to Section R703.8 or adhered masonry veneer conforming to Section R703.12.
**R606.12.1 General.**

Masonry structures and masonry elements shall comply with the requirements of Sections R606.12 through R606.12.4 based on the seismic design category established in Table R301.2(1). Masonry structures and masonry elements shall comply with the requirements of Section R606.12 and Figures R606.11(1), R606.11(2), and R606.11(3) or shall be designed in accordance with TMS 402/ACI 530/ASCE 5 or TMS 403.

**R606.12.1.1 Floor and roof diaphragm construction.**

Floor and roof *diaphragms* shall be constructed of wood structural panels attached to wood framing in accordance with Table R602.3(1) or to cold-formed steel floor framing in accordance with Table R505.3.1(2) or to cold-formed steel roof framing in accordance with Table R804.3. Additionally, sheathing panel edges perpendicular to framing members shall be backed by blocking, and sheathing shall be connected to the blocking with fasteners at the edge spacing. For Seismic Design Categories C, D₀, D₁, and D₂, where the width-to-thickness dimension of the *diaphragm* exceeds 2-to-1, edge spacing of fasteners shall be 4 inches (102 mm) on center.

**R606.12.2 Seismic Design Category C.**

Townhouses located in Seismic Design Category C shall comply with the requirements of this section.

**R606.12.2.1 Minimum length of wall without openings.**

Table R606.12.2.1 shall be used to determine the minimum required solid wall length without openings at each masonry exterior wall. The provided percentage of solid wall length shall include only those wall segments that are 3 feet (914 mm) or longer. The maximum clear distance between wall segments included in determining the solid wall length shall not exceed 18 feet (5486 mm). Shear wall segments required to meet the minimum wall length shall be in accordance with Section R606.12.2.2.3.

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>MINIMUM SOLID WALL LENGTH ALONG EXTERIOR WALL LINES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One story or top story of two story</td>
</tr>
<tr>
<td>Townhouses in C</td>
<td>20</td>
</tr>
<tr>
<td>D₀ or D₁</td>
<td>25</td>
</tr>
<tr>
<td>D₂</td>
<td>30</td>
</tr>
</tbody>
</table>

NP = Not permitted, except with design in accordance with the *International Building Code*.

a. For all walls, the minimum required length of solid walls shall be based on the table percent multiplied by the dimension, parallel to the wall direction under consideration, of a rectangle inscribing the overall building plan.

**R606.12.2.2 Design of elements not part of the lateral force-resisting system.**
R606.12.2.2.1 Load-bearing frames or columns.
Elements not part of the lateral force-resisting system shall be analyzed to determine their effect on the response of the system. The frames or columns shall be adequate for vertical load carrying capacity and induced moment caused by the design story drift.

R606.12.2.2 Masonry partition walls.
Masonry partition walls, masonry screen walls and other masonry elements that are not designed to resist vertical or lateral loads, other than those induced by their own weight, shall be isolated from the structure so that vertical and lateral forces are not imparted to these elements. Isolation joints and connectors between these elements and the structure shall be designed to accommodate the design story drift.

R606.12.2.2.3 Reinforcement requirements for masonry elements.
Masonry elements listed in Section R606.12.2.2 shall be reinforced in either the horizontal or vertical direction as shown in Figure R606.11(2) and in accordance with the following:

1. Horizontal reinforcement. Horizontal joint reinforcement shall consist of not less than two longitudinal W1.7 wires spaced not more than 16 inches (406 mm) for walls greater than 4 inches (102 mm) in width and not less than one longitudinal W1.7 wire spaced not more than 16 inches (406 mm) for walls not exceeding 4 inches (102 mm) in width; or not less than one No. 4 bar spaced not more than 48 inches (1219 mm). Where two longitudinal wires of joint reinforcement are used, the space between these wires shall be the widest that the mortar joint will accommodate. Horizontal reinforcement shall be provided within 16 inches (406 mm) of the top and bottom of these masonry elements.

2. Vertical reinforcement. Vertical reinforcement shall consist of not less than one No. 4 bar spaced not more than 48 inches (1219 mm). Vertical reinforcement shall be located within 16 inches (406 mm) of the ends of masonry walls.

R606.12.2.3 Design of elements part of the lateral force-resisting system.

R606.12.2.3.1 Connections to masonry shear walls.
Connectors shall be provided to transfer forces between masonry walls and horizontal elements in accordance with the requirements of Section 4.1.4 of TMS 402/ACI 530/ASCE 5. Connectors shall be designed to transfer horizontal design forces acting either perpendicular or parallel to the wall, but not less than 200 pounds per linear foot (2919 N/m) of wall. The maximum spacing between connectors shall be 4 feet (1219 mm). Such anchorage mechanisms shall not induce tension stresses perpendicular to grain in ledgers or nailers.

R606.12.2.3.2 Connections to masonry columns.
Connectors shall be provided to transfer forces between masonry columns and horizontal elements in accordance with the requirements of Section 4.1.4 of TMS 402/ACI 530/ASCE 5. Where anchor bolts are used to connect horizontal elements to the tops of columns, the bolts shall be placed within lateral ties. Lateral ties shall
enclose both the vertical bars in the column and the anchor bolts. There shall be not less than two No. 4 lateral ties provided in the top 5 inches (127 mm) of the column.

R606.12.2.3.3 Minimum reinforcement requirements for masonry shear walls.
Vertical reinforcement of not less than one No. 4 bar shall be provided at corners, within 16 inches (406 mm) of each side of openings, within 8 inches (203 mm) of each side of movement joints, within 8 inches (203 mm) of the ends of walls, and at a maximum spacing of 10 feet (3048 mm).

Horizontal joint reinforcement shall consist of not less than two wires of W1.7 spaced not more than 16 inches (406 mm); or bond beam reinforcement of not less than one No. 4 bar spaced not more than 10 feet (3048 mm) shall be provided.

Horizontal reinforcement shall be provided at the bottom and top of wall openings and shall extend not less than 24 inches (610 mm) nor less than 40 bar diameters past the opening; continuously at structurally connected roof and floor levels; and within 16 inches (406 mm) of the top of walls.

R606.12.3 Seismic Design Category D0 or D1. Deleted.
Structures in Seismic Design Category D or D shall comply with the requirements of Seismic Design Category C and the additional requirements of this section. AAC masonry shall not be used for the design of masonry elements that are part of the lateral force-resisting system.

R606.12.3.1 Design requirements.
Masonry elements other than those covered by Section R606.12.2.2.2 shall be designed in accordance with the requirements of Chapters 1 through 7 and Sections 8.1 and 8.3 of TMS 402, ACI 530/ASCE 5 and shall meet the minimum reinforcement requirements contained in Sections R606.12.3.2 and R606.12.3.2.1. Otherwise, masonry shall be designed in accordance with TMS 403.

Exception: Masonry walls limited to one story in height and 9 feet (2743 mm) between lateral supports need not be designed provided they comply with the minimum reinforcement requirements of Sections R606.12.3.2 and R606.12.3.2.1.

R606.12.3.2 Minimum reinforcement requirements for masonry walls.
Masonry walls other than those covered by Section R606.12.2.2.3 shall be reinforced in both the vertical and horizontal direction. The sum of the cross-sectional area of horizontal and vertical reinforcement shall be not less than 0.002 times the gross cross-sectional area of the wall, and the minimum cross-sectional area in each direction shall be not less than 0.0007 times the gross cross-sectional area of the wall. Reinforcement shall be uniformly distributed. Table R606.12.3.2 shows the minimum reinforcing bar sizes required for varying thicknesses of masonry walls. The maximum spacing of reinforcement shall be 48 inches (1219 mm) provided that the walls are solid grouted and constructed of hollow open-end units, hollow units laid with full head joints or two wythes of solid units. The maximum spacing of reinforcement shall be 24 inches (610 mm) for all other masonry.

**TABLE R606.12.3.2**
**MINIMUM DISTRIBUTED WALL REINFORCEMENT FOR BUILDINGS ASSIGNED TO**
SEISMIC DESIGN CATEGORY D -or- D

<table>
<thead>
<tr>
<th>NOMINAL WALL THICKNESS (inches)</th>
<th>MINIMUM SUM OF THE VERTICAL AND HORIZONTAL REINFORCEMENT AREAS^a (square inches per foot)</th>
<th>MINIMUM REINFORCEMENT AS DISTRIBUTED IN BOTH HORIZONTAL AND VERTICAL DIRECTIONS^b (square inches per foot)</th>
<th>MINIMUM BAR SIZE FOR REINFORCEMENT SPACED AT 48 INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0.135</td>
<td>0.047</td>
<td>#4</td>
</tr>
<tr>
<td>8</td>
<td>0.183</td>
<td>0.064</td>
<td>#5</td>
</tr>
<tr>
<td>10</td>
<td>0.231</td>
<td>0.081</td>
<td>#6</td>
</tr>
<tr>
<td>12</td>
<td>0.279</td>
<td>0.098</td>
<td>#6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square inch per foot = 2064 mm^2/m.

^a Based on the minimum reinforcing ratio of 0.002 times the gross cross-sectional area of the wall.

^b Based on the minimum reinforcing ratio each direction of 0.0007 times the gross cross-sectional area of the wall.

R606.12.3.2.1 Shear wall reinforcement requirements.
The maximum spacing of vertical and horizontal reinforcement shall be the smaller of one-third the length of the shear wall, one-third the height of the shear wall, or 48 inches (1219 mm). The minimum cross-sectional area of vertical reinforcement shall be one-third of the required shear reinforcement. Shear reinforcement shall be anchored around vertical reinforcing bars with a standard hook.

R606.12.3.3 Minimum reinforcement for masonry columns.
Lateral ties in masonry columns shall be spaced not more than 8 inches (203 mm) on center and shall be not less than \( \frac{3}{8} \) -inch (9.5 mm) diameter. Lateral ties shall be embedded in grout.

R606.12.3.4 Material restrictions.
Type N mortar or masonry cement shall not be used as part of the lateral force-resisting system.

R606.12.3.5 Lateral tie anchorage.
Standard hooks for lateral tie anchorage shall be either a 135-degree (2.4 rad) standard hook or a 180-degree (3.2 rad) standard hook.

R606.12.4 Seismic Design Category D2. Deleted.
Structures in Seismic Design Category D -shall comply with the requirements of Seismic Design Category D -and to the additional requirements of this section.

R606.12.4.1 Design of elements not part of the lateral force-resisting system.
Stack bond masonry that is not part of the lateral force-resisting system shall have a horizontal cross-sectional area of reinforcement of not less than 0.0015 times the gross
cross-sectional area of masonry. Table R606.12.4.1 shows minimum reinforcing bar sizes for masonry walls. The maximum spacing of horizontal reinforcement shall be 24 inches (610 mm). These elements shall be solidly grouted and shall be constructed of hollow open-end units or two wythes of solid units.

### TABLE R606.12.4.1
MINIMUM REINFORCING FOR STACKED BONDED MASONRY WALLS IN SEISMIC DESIGN CATEGORY D

<table>
<thead>
<tr>
<th>NOMINAL WALL THICKNESS (inches)</th>
<th>MINIMUM BAR SIZE SPACED AT 24 INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>#4</td>
</tr>
<tr>
<td>8</td>
<td>#5</td>
</tr>
<tr>
<td>10</td>
<td>#5</td>
</tr>
<tr>
<td>12</td>
<td>#6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

### R606.12.4.2 Design of elements part of the lateral force-resisting system.
Stack bond masonry that is part of the lateral force-resisting system shall have a horizontal cross-sectional area of reinforcement of not less than 0.0025 times the gross cross-sectional area of masonry. Table R606.12.4.2 shows minimum reinforcing bar sizes for masonry walls. The maximum spacing of horizontal reinforcement shall be 16 inches (406 mm). These elements shall be solidly grouted and shall be constructed of hollow open-end units or two wythes of solid units.

### TABLE R606.12.4.2
MINIMUM REINFORCING FOR STACKED BONDED MASONRY WALLS IN SEISMIC DESIGN CATEGORY D

<table>
<thead>
<tr>
<th>NOMINAL WALL THICKNESS (inches)</th>
<th>MINIMUM BAR SIZE SPACED AT 16 INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>#4</td>
</tr>
<tr>
<td>8</td>
<td>#5</td>
</tr>
<tr>
<td>10</td>
<td>#5</td>
</tr>
<tr>
<td>12</td>
<td>#6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

### R606.13 Multiple-wythe masonry.
The facing and backing of multiple-wythe masonry walls shall be bonded in accordance with Section R606.13.1, R606.13.2 or R606.13.3. In cavity walls, neither the facing nor the backing shall be less than 3 inches (76 mm) nominal in thickness and the cavity shall be not more than 4 inches (102 mm) nominal in width. The backing shall be not less than as thick as the facing.

**Exception:** Cavities shall be permitted to exceed the 4-inch (102 mm) nominal dimension provided tie size and tie spacing have been established by calculation.
R606.13.1 Bonding with masonry headers.
Bonding with solid or hollow masonry headers shall comply with Sections R606.13.1.1 and R606.13.1.2.

R606.13.1.1 Solid units.
Where the facing and backing (adjacent wythes) of solid masonry construction are bonded by means of masonry headers, not less than 4 percent of the wall surface of each face shall be composed of headers extending not less than 3 inches (76 mm) into the backing. The distance between adjacent full-length headers shall not exceed 24 inches (610 mm) either vertically or horizontally. In walls in which a single header does not extend through the wall, headers from the opposite sides shall overlap not less than 3 inches (76 mm), or headers from opposite sides shall be covered with another header course overlapping the header below not less than 3 inches (76 mm).

R606.13.1.2 Hollow units.
Where two or more hollow units are used to make up the thickness of a wall, the stretcher courses shall be bonded at vertical intervals not exceeding 34 inches (864 mm) by lapping not less than 3 inches (76 mm) over the unit below, or by lapping at vertical intervals not exceeding 17 inches (432 mm) with units that are not less than 50 percent thicker than the units below.

R606.13.2 Bonding with wall ties or joint reinforcement.
Bonding with wall ties or joint reinforcement shall comply with Section R606.13.2.3.

R606.13.2.1 Bonding with wall ties.
Bonding with wall ties, except as required by Section R607, where the facing and backing (adjacent wythes) of masonry walls are bonded with $\frac{3}{16}$-inch-diameter (5 mm) wall ties embedded in the horizontal mortar joints, there shall be not less than one metal tie for each $4\frac{1}{2}$ square feet ($0.418 \text{ m}^2$) of wall area. Ties in alternate courses shall be staggered. The maximum vertical distance between ties shall not exceed 24 inches (610 mm), and the maximum horizontal distance shall not exceed 36 inches (914 mm). Rods or ties bent to rectangular shape shall be used with hollow masonry units laid with the cells vertical. In other walls, the ends of ties shall be bent to 90-degree (0.79 rad) angles to provide hooks not less than 2 inches (51 mm) long. Additional bonding ties shall be provided at all openings, spaced not more than 3 feet (914 mm) apart around the perimeter and within 12 inches (305 mm) of the opening.

R606.13.2.2 Bonding with adjustable wall ties.
Where the facing and backing (adjacent wythes) of masonry are bonded with adjustable wall ties, there shall be not less than one tie for each 2.67 square feet ($0.248 \text{ m}^2$) of wall area. Neither the vertical nor the horizontal spacing of the adjustable wall ties shall exceed 24 inches (610 mm). The maximum vertical offset of bed joints from one wythe to the other shall be 1.25 inches (32 mm). The maximum clearance between connecting parts of the ties shall be 1/16 inch (2 mm). Where pintle legs are used, ties shall have not less than two $\frac{3}{16}$-inch-diameter (5 mm) legs.
R606.13.2.3 Bonding with prefabricated joint reinforcement.
Where the facing and backing (adjacent wythes) of masonry are bonded with prefabricated joint reinforcement, there shall be not less than one cross wire serving as a tie for each 2.67 square feet (0.248 m$^2$) of wall area. The vertical spacing of the joint reinforcement shall not exceed 16 inches (406 mm). Cross wires on prefabricated joint reinforcement shall not be smaller than No. 9 gage. The longitudinal wires shall be embedded in the mortar.

R606.13.3 Bonding with natural or cast stone.
Bonding with natural and cast stone shall conform to Sections R606.13.3.1 and R606.13.3.2.

R606.13.3.1 Ashlar masonry.
In ashlar masonry, bonder units, uniformly distributed, shall be provided to the extent of not less than 10 percent of the wall area. Such bonder units shall extend not less than 4 inches (102 mm) into the backing wall.

R606.13.3.2 Rubble stone masonry.
Rubble stone masonry 24 inches (610 mm) or less in thickness shall have bonder units with a maximum spacing of 3 feet (914 mm) vertically and 3 feet (914 mm) horizontally, and if the masonry is of greater thickness than 24 inches (610 mm), shall have one bonder unit for each 6 square feet (0.557 m$^2$) of wall surface on both sides.

R606.14 Anchored and adhered masonry veneer.

R606.14.1 Anchored veneer.
Anchored masonry veneer installed over a backing of wood or cold-formed steel shall meet the requirements of Section R703.8.

R606.14.2 Adhered veneer.
Adhered masonry veneer shall be installed in accordance with the requirements of Section R703.12.

SECTION R607
GLASS UNIT MASONRY

R607.1 General.
Panels of glass unit masonry located in load-bearing and nonload-bearing exterior and interior walls shall be constructed in accordance with this section.

R607.2 Materials.
Hollow glass units shall be partially evacuated and have a minimum average glass face thickness of 3/16 inch (5 mm). The surface of units in contact with mortar shall be treated with a polyvinyl butyral coating or latex-based paint. The use of reclaimed units is prohibited.

R607.3 Units.
Hollow or solid glass block units shall be standard or thin units.
R607.3.1 Standard units.
The specified thickness of standard units shall be not less than $3 \frac{7}{8}$ inches (98 mm).

R607.3.2 Thin units.
The specified thickness of thin units shall be not less than $3 \frac{1}{8}$ inches (79 mm) for hollow units and not less than 3 inches (76 mm) for solid units.

R607.4 Isolated panels.
Isolated panels of glass unit masonry shall conform to the requirements of this section.

R607.4.1 Exterior standard-unit panels.
The maximum area of each individual standard-unit panel shall be 144 square feet (13.4 m$^2$) where the design wind pressure is 20 pounds per square foot (958 Pa). The maximum area of such panels subjected to design wind pressures other than 20 pounds per square foot (958 Pa) shall be in accordance with Figure R607.4.1. The maximum panel dimension between structural supports shall be 25 feet (7620 mm) in width or 20 feet (6096 mm) in height.

For SI: 1 square foot = 0.0929 m$^2$, 1 pound per square foot = 0.0479 kPa

**FIGURE R607.4.1
GLASS UNIT MASONRY DESIGN WIND LOAD RESISTANCE**

R607.4.2 Exterior thin-unit panels.
The maximum area of each individual thin-unit panel shall be 85 square feet (7.9 m$^2$). The
maximum dimension between structural supports shall be 15 feet (4572 mm) in width or 10 feet (3048 mm) in height. Thin units shall not be used in applications where the design wind pressure as stated in Table R301.2(1) exceeds 20 pounds per square foot (958 Pa).

R607.4.3 Interior panels.
The maximum area of each individual standard-unit panel shall be 250 square feet (23.2 m²). The maximum area of each thin-unit panel shall be 150 square feet (13.9 m²). The maximum dimension between structural supports shall be 25 feet (7620 mm) in width or 20 feet (6096 mm) in height.

R607.4.4 Curved panels.
The width of curved panels shall conform to the requirements of Sections R607.4.1, R607.4.2 and R607.4.3, except additional structural supports shall be provided at locations where a curved section joins a straight section, and at inflection points in multicurved walls.

R607.5 Panel support.
Glass unit masonry panels shall conform to the support requirements of this section.

R607.5.1 Deflection.
The maximum total deflection of structural members that support glass unit masonry shall not exceed $\frac{l}{600}$.

R607.5.2 Lateral support.
Glass unit masonry panels shall be laterally supported along the top and sides of the panel. Lateral supports for glass unit masonry panels shall be designed to resist not less than 200 pounds per lineal feet (2918 N/m) of panel, or the actual applied loads, whichever is greater. Except for single unit panels, lateral support shall be provided by panel anchors along the top and sides spaced not greater than 16 inches (406 mm) on center or by channel-type restraints. Single unit panels shall be supported by channel-type restraints.

Exceptions:

1. Lateral support is not required at the top of panels that are one unit wide.

2. Lateral support is not required at the sides of panels that are one unit high.

R607.5.2.1 Panel anchor restraints.
Panel anchors shall be spaced not greater than 16 inches (406 mm) on center in both jamb and across the head. Panel anchors shall be embedded not less than 12 inches (305 mm) and shall be provided with two fasteners so as to resist the loads specified in Section R607.5.2.

R607.5.2.2 Channel-type restraints.
Glass unit masonry panels shall be recessed not less than 1 inch (25 mm) within channels and chases. Channel-type restraints shall be oversized to accommodate expansion material in the opening, packing and sealant between the framing restraints, and the glass unit masonry perimeter units.
R607.6 Sills.
Before bedding of glass units, the sill area shall be covered with a water base asphaltic emulsion coating. The coating shall be not less than $\frac{1}{8}$ inch (3 mm) thick.

R607.7 Expansion joints.
Glass unit masonry panels shall be provided with expansion joints along the top and sides at all structural supports. Expansion joints shall be not less than $\frac{3}{8}$ inch (10 mm) in thickness and shall have sufficient thickness to accommodate displacements of the supporting structure. Expansion joints shall be entirely free of mortar and other debris and shall be filled with resilient material.

R607.8 Mortar.
Glass unit masonry shall be laid with Type S or N mortar. Mortar shall not be retempered after initial set. Mortar unused within $1\frac{1}{2}$ hours after initial mixing shall be discarded.

R607.9 Reinforcement.
Glass unit masonry panels shall have horizontal joint reinforcement spaced not greater than 16 inches (406 mm) on center located in the mortar bed joint. Horizontal joint reinforcement shall extend the entire length of the panel but shall not extend across expansion joints. Longitudinal wires shall be lapped not less than 6 inches (152 mm) at splices. Joint reinforcement shall be placed in the bed joint immediately below and above openings in the panel. The reinforcement shall have not less than two parallel longitudinal wires of size W1.7 or greater, and have welded cross wires of size W1.7 or greater.

R607.10 Placement.
Glass units shall be placed so head and bed joints are filled solidly. Mortar shall not be furrowed. Head and bed joints of glass unit masonry shall be $\frac{1}{4}$ inch (6.4 mm) thick, except that vertical joint thickness of radial panels shall be not less than $\frac{1}{8}$ inch (3 mm) or greater than $\frac{5}{8}$ inch (16 mm). The bed joint thickness tolerance shall be minus $1/16$ inch (1.6 mm) and plus $\frac{1}{8}$ inch (3 mm). The head joint thickness tolerance shall be plus or minus $\frac{1}{8}$ inch (3 mm).

SECTION R608
EXTERIOR CONCRETE WALL CONSTRUCTION

R608.1 General.
Exterior concrete walls shall be designed and constructed in accordance with the provisions of this section or in accordance with the provisions of PCA 100 or ACI 318. Where PCA 100, ACI 318 or the provisions of this section are used to design concrete walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, registered design professional, unless otherwise required by the state law of the jurisdiction having authority.

R608.1.1 Interior construction.
These provisions are based on the assumption that interior walls and partitions, both load-
bearing and nonload-bearing, floors and roof/ceiling assemblies are constructed of light-framed construction complying with the limitations of this code and the additional limitations of Section R608.2. Design and construction of light-framed assemblies shall be in accordance with the applicable provisions of this code. Where second-story exterior walls are of light-framed construction, they shall be designed and constructed as required by this code.

Aspects of concrete construction not specifically addressed by this code, including interior concrete walls, shall comply with ACI 318.

R608.1.2 Other concrete walls.
Exterior concrete walls constructed in accordance with this code shall comply with the shapes and minimum concrete cross-sectional dimensions of Table R608.3. Other types of forming systems resulting in concrete walls not in compliance with this section shall be designed in accordance with ACI 318.

R608.2 Applicability limits.
The provisions of this section shall apply to the construction of exterior concrete walls for buildings not greater than 60 feet (18 288 mm) in plan dimensions, floors with clear spans not greater than 32 feet (9754 mm) and roofs with clear spans not greater than 40 feet (12 192 mm). Buildings shall not exceed 35 feet (10 668 mm) in mean roof height or two stories in height above grade. Floor/ceiling dead loads shall not exceed 10 pounds per square foot (479 Pa), roof/ceiling dead loads shall not exceed 15 pounds per square foot (718 Pa) and attic live loads shall not exceed 20 pounds per square foot (958 Pa). Roof overhangs shall not exceed 2 feet (610 mm) of horizontal projection beyond the exterior wall and the dead load of the overhangs shall not exceed 8 pounds per square foot (383 Pa).

Walls constructed in accordance with the provisions of this section shall be limited to buildings subjected to a maximum design wind speed of 160 mph (72 m/s) Exposure B, 136 mph (61 m/s) Exposure C and 125 mph (56 m/s) Exposure D. Walls constructed in accordance with the provisions of this section shall be limited to detached one- and two-family dwellings and townhouses assigned to Seismic Design Category A or B, and detached one- and two-family dwellings assigned to Seismic Design Category C.

Buildings that are not within the scope of this section shall be designed in accordance with PCA 100 or ACI 318.

R608.3 Concrete wall systems.
Concrete walls constructed in accordance with these provisions shall comply with the shapes and minimum concrete cross-sectional dimensions of Table R608.3.

<table>
<thead>
<tr>
<th>WALL TYPE AND NOMINAL THICKNESS</th>
<th>MAXIMUM WALL WEIGHT (psf)</th>
<th>MINIMUM WIDTH, W, OF VERTICAL CORES (inches)</th>
<th>MINIMUM THICKNESS, T, OF VERTICAL CORES (inches)</th>
<th>MAXIMUM SPACING OF VERTICAL CORES (inches)</th>
<th>MAXIMUM SPACING OF HORIZONTAL CORES (inches)</th>
<th>MINIMUM WEB THICKNESS (inches)</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Flat Type</th>
<th>Width (d)</th>
<th>N/A</th>
<th>N/A</th>
<th>N/A</th>
<th>N/A</th>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>6” Flat</td>
<td>75</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>8” Flat</td>
<td>100</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>10” Flat</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>6” Waffle-grid</td>
<td>56</td>
<td>8</td>
<td>5.5</td>
<td>12</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>8” Waffle-grid</td>
<td>76</td>
<td>8</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>6” Screen-grid</td>
<td>53</td>
<td>6.25</td>
<td>6.25</td>
<td>12</td>
<td>12</td>
<td>N/A</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 pound per square foot = 0.0479 kPa, 1 pound per cubic foot = 2402.77 kg/m$^3$.

1 square inch = 645.16 mm$^2$, 1 inch$^4$ = 42 cm$^4$.

a. Width “W,” thickness “T,” spacing and web thickness, refer to Figures R608.3(2) and R608.3(3).
b. N/A indicates not applicable.
c. Wall weight is based on a unit weight of concrete of 150 pcf. For flat walls the weight is based on the nominal thickness. The tabulated values do not include any allowance for interior and exterior finishes.
d. Nominal wall thickness. The actual as-built thickness of a flat wall shall not be more than $\frac{1}{2}$ inch less or more than $\frac{1}{4}$ inch more than the nominal dimension indicated.
e. Vertical core is assumed to be elliptical-shaped. Another shape core is permitted provided the minimum thickness is 5 inches, the moment of inertia, $I$, about the centerline of the wall (ignoring the web) is not less than 65 inch$^4$, and the area, $A$, is not less than 31.25 square inches. The width used to calculate $A$ and $I$ shall not exceed 8 inches.
f. Vertical core is assumed to be circular. Another shape core is permitted provided the minimum thickness is 7 inches, the moment of inertia, $I$, about the centerline of the wall (ignoring the web) is not less than 200 inch$^4$, and the area, $A$, is not less than 49 square inches. The width used to calculate $A$ and $I$ shall not exceed 8 inches.
g. Vertical core is assumed to be circular. Another shape core is permitted provided the minimum thickness is 5.5 inches, the moment of inertia, $I$, about the centerline of the wall is not less than 76 inch$^4$, and the area, $A$, is not less than 30.25 square inches. The width used to calculate $A$ and $I$ shall not exceed 6.25 inches.
FIGURE R608.3(1)
FLAT WALL SYSTEM
FIGURE R608.3(2)
WAFFLE-GRID WALL SYSTEM
FIGURE R608.3(3)
SCREEN-GRID WALL SYSTEM

R608.3.1 Flat wall systems.
Flat concrete wall systems shall comply with Table R608.3 and Figure R608.3(1) and have a minimum nominal thickness of 4 inches (102 mm).

R608.3.2 Waffle-grid wall systems.
Waffle-grid wall systems shall comply with Table R608.3 and Figure R608.3(2) and shall have a minimum nominal thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The core and web dimensions shall comply with Table R608.3. The maximum weight of waffle-grid walls shall comply with Table R608.3.

R608.3.3 Screen-grid wall systems.
Screen-grid wall systems shall comply with Table R608.3 and Figure R608.3(3) and shall have a minimum nominal thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The core dimensions shall comply with Table R608.3. The maximum weight of screen-grid walls shall comply with Table R608.3.

R608.4 Stay-in-place forms.
Stay-in-place concrete forms shall comply with this section.
R608.4.1 Surface burning characteristics.
The flame spread index and smoke-developed index of forming material, other than foam plastic, left exposed on the interior shall comply with Section R302.9. The surface burning characteristics of foam plastic used in insulating concrete forms shall comply with Section R316.3.

R608.4.2 Interior covering.
Stay-in-place forms constructed of rigid foam plastic shall be protected on the interior of the building as required by Sections R316.4 and R702.3.4. Where gypsum board is used to protect the foam plastic, it shall be installed with a mechanical fastening system. Use of adhesives is permitted in addition to mechanical fasteners.

R608.4.3 Exterior wall covering.
Stay-in-place forms constructed of rigid foam plastics shall be protected from sunlight and physical damage by the application of an approved exterior wall covering complying with this code. Exterior surfaces of other stay-in-place forming systems shall be protected in accordance with this code.

Requirements for installation of masonry veneer, stucco and other finishes on the exterior of concrete walls and other construction details not covered in this section shall comply with the requirements of this code.

R608.4.4 Flat ICF wall systems.
Flat ICF wall system forms shall conform to ASTM E 2634.

R608.5 Materials.
Materials used in the construction of concrete walls shall comply with this section.

R608.5.1 Concrete and materials for concrete.
Materials used in concrete, and the concrete itself, shall conform to requirements of this section, PCA 100 or ACI 318.

R608.5.1.1 Cements.
The following standards as referenced in Chapter 44 shall be permitted to be used.

1. ASTM C 150
2. ASTM C 595
3. ASTM C 1157

R608.5.1.2 Concrete mixing and delivery.
Mixing and delivery of concrete shall comply with ASTM C 94 or ASTM C 685.

R608.5.1.3 Maximum aggregate size.
The nominal maximum size of coarse aggregate shall not exceed one-fifth the narrowest distance between sides of forms, or three-fourths the clear spacing between reinforcing bars or between a bar and the side of the form.
**Exception:** When approved, these limitations shall not apply where removable forms are used and workability and methods of consolidation permit concrete to be placed without honeycombs or voids.

**R608.5.1.4 Proportioning and slump of concrete.**
Proportions of materials for concrete shall be established to provide workability and consistency to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding. Slump of concrete placed in removable forms shall not exceed 6 inches (152 mm).

**Exception:** When approved, the slump is permitted to exceed 6 inches (152 mm) for concrete mixtures that are resistant to segregation, and are in accordance with the form manufacturer's recommendations.

Slump of concrete placed in stay-in-place forms shall exceed 6 inches (152 mm).

**R608.5.1.5 Compressive strength.**
The minimum specified compressive strength of concrete, $f'c$, shall comply with Section R402.2 and shall be not less than 2,500 pounds per square inch (17.2 MPa) at 28 days.

**R608.5.1.6 Consolidation of concrete.**
Concrete shall be consolidated by suitable means during placement and shall be worked around embedded items and reinforcement and into corners of forms. Where stay-in-place forms are used, concrete shall be consolidated by internal vibration.

**Exception:** When approved, self-consolidating concrete mixtures with slumps equal to or greater than 8 inches (203 mm) that are specifically designed for placement without internal vibration need not be internally vibrated.

**R608.5.2 Steel reinforcement and anchor bolts.**

**R608.5.2.1 Steel reinforcement.**
Steel reinforcement shall comply with ASTM A 615, ASTM A 706, or ASTM A 996. ASTM A 996 bars produced from rail steel shall be Type R.

**R608.5.2.2 Anchor bolts.**
Anchor bolts for use with connection details in accordance with Figures R608.9(1) through R608.9(12) shall be bolts with heads complying with ASTM A 307 or ASTM F 1554. ASTM A 307 bolts shall be Grade A with heads. ASTM F 1554 bolts shall be Grade 36 minimum. Instead of bolts with heads, it is permissible to use rods with threads on both ends fabricated from steel complying with ASTM A 36. The threaded end of the rod to be embedded in the concrete shall be provided with a hex or square nut.

**R608.5.2.3 Sheet steel angles and tension tie straps.**
Angles and tension tie straps for use with connection details in accordance with Figures R608.9(1) through R608.9(6) **R608.9(12)** shall be fabricated from sheet steel complying with ASTM A 653 SS, ASTM A 792 SS, or ASTM A 875 SS. The steel shall be minimum Grade 33 unless a higher grade is required by the applicable figure.
R608.5.3 Form materials and form ties.
Forms shall be made of wood, steel, aluminum, plastic, a composite of cement and foam insulation, a composite of cement and wood chips, or other approved material suitable for supporting and containing concrete. Forms shall provide sufficient strength to contain concrete during the concrete placement operation.

Form ties shall be steel, solid plastic, foam plastic, a composite of cement and wood chips, a composite of cement and foam plastic, or other suitable material capable of resisting the forces created by fluid pressure of fresh concrete.

R608.5.4 Reinforcement installation details.

<table>
<thead>
<tr>
<th>TABLE R608.5.4(1) LAP SPLICE AND TENSION DEVELOPMENT LENGTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAR SIZE NO.</strong></td>
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<tr>
<td>Lap splice length-tension</td>
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<tr>
<td>4</td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
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<tr>
<td>Tension development length for straight bar</td>
</tr>
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<td>4</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>6</td>
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<tr>
<td>Tension development length for:</td>
</tr>
<tr>
<td>a. 90-degree and 180-degree standard hooks with not less than 1 inch of side cover perpendicular to plane of hook, and</td>
</tr>
<tr>
<td>b. 90-degree standard hooks with not less than 2 inches of cover on the bar extension beyond the hook.</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>Tension development length for bar with 90-degree or 180-degree standard hook having less cover than required above.</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
For SI: 1 inch = 25.4 mm.

FIGURE R608.5.4(1)
LAP SPLICES

For SI: 1 degree = 0.0175 rad.

FIGURE R608.5.4(2)
DEVELOPMENT LENGTH AND COVER FOR HOOKS AND BAR EXTENSION
For SI: 1 inch = 25.4 mm, 1 degree = 0.0175 rad.

**FIGURE R608.5.4(3)**

**STANDARD HOOKS**

**TABLE R608.5.4(2)**

<table>
<thead>
<tr>
<th>BAR SPACING FROM APPLICABLE TABLE IN SECTION R608.6 (inches)</th>
<th>BAR SIZE FROM APPLICABLE TABLE IN SECTION R608.6</th>
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<th>#5</th>
<th>#6</th>
</tr>
</thead>
<tbody>
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<td>Maximum spacing for alternate bar size and/or alternate grade of steel (inches)</td>
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<td>#5</td>
<td>#6</td>
</tr>
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<td>Grade 40</td>
<td>Grade 60</td>
<td>Grade 40</td>
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<td>28</td>
</tr>
</tbody>
</table>
vertical wall reinforcement for foundation walls and above-grade walls. Reinforcement specified in tables in Section R608.6 is based on Grade 60 (420 MPa) steel reinforcement.

R608.5.4.3 Lap splices.
Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system such that displacement will not occur during the concrete placement operation. Steel reinforcement in concrete cast against the earth shall have a minimum cover of 3 inches (76 mm). Minimum cover for reinforcement in concrete cast in removable forms that will be exposed to the earth or weather shall be \(1\frac{1}{2}\) inches (38 mm) for No. 5 bars and smaller, and 2 inches (50 mm) for No. 6 bars and larger. For concrete cast in removable forms that will not be exposed to the earth or weather, and for concrete cast in stay-in-place forms, minimum cover shall be \(3/4\) inch (19 mm). The minus tolerance for cover shall not exceed the smaller of one-third the required cover and \(3/8\) inch (10 mm). See Section R608.5.4.4 for cover requirements for hooks of bars developed in tension.

R608.5.4.2 Location of reinforcement in walls.
For location of reinforcement in foundation walls and above-grade walls, see Sections R404.1.2.3.7.2 and R608.6.5, respectively.

R608.5.4.3 Lap splices.
Vertical and horizontal wall reinforcement required by Sections R608.6 and R608.7 shall be the longest lengths practical. Where splices are necessary in reinforcement, the
length of lap splices shall be in accordance with Table R608.5.4(1) and Figure R608.5.4(1). The maximum gap between noncontact parallel bars at a lap splice shall not exceed the smaller of one-fifth the required lap length and 6 inches (152 mm). See Figure R608.5.4(1).

R608.5.4.4 Development of bars in tension.
Where bars are required to be developed in tension by other provisions of this code, development lengths and cover for hooks and bar extensions shall comply with Table R608.5.4(1) and Figure R608.5.4(2). The development lengths shown in Table R608.5.4(1) shall apply to bundled bars in lintels installed in accordance with Section R608.8.2.2.

R608.5.4.5 Standard hooks.
Where reinforcement is required by this code to terminate with a standard hook, the hook shall comply with Figure R608.5.4(3).

R608.5.4.6 Webs of waffle-grid walls.
Reinforcement, including stirrups, shall not be placed in webs of waffle-grid walls, including lintels. Webs are permitted to have form ties.

R608.5.4.7 Alternate grade of reinforcement and spacing.
Where tables in Sections R404.1.3 and R608.6 specify vertical wall reinforcement based on minimum bar size and maximum spacing, which are based on Grade 60 (420 MPa) steel reinforcement, different size bars or bars made from a different grade of steel are permitted provided an equivalent area of steel per linear foot of wall is provided. Use of Table R608.5.4(2) is permitted to determine the maximum bar spacing for different bar sizes than specified in the tables and/or bars made from a different grade of steel. Bars shall not be spaced less than one-half the wall thickness, or more than 48 inches (1219 mm) on center.

R608.5.5 Construction joints in walls.
Construction joints shall be made and located to not impair the strength of the wall. Construction joints in plain concrete walls, including walls required to have not less than No. 4 bars at 48 inches (1219 mm) on center by Section R608.6, shall be located at points of lateral support, and not less than one No. 4 bar shall extend across the construction joint at a spacing not to exceed 24 inches (610 mm) on center. Construction joint reinforcement shall have not less than 12 inches (305 mm) embedment on both sides of the joint. Construction joints in reinforced concrete walls shall be located in the middle third of the span between lateral supports, or located and constructed as required for joints in plain concrete walls.

Exception: Vertical wall reinforcement required by this code is permitted to be used in lieu of construction joint reinforcement, provided the spacing does not exceed 24 inches (610 mm), or the combination of wall reinforcement and No. 4 bars described in Section R608.5.5 does not exceed 24 inches (610 mm).

R608.6 Above-grade wall requirements.
For SI: 1 foot = 304.8 mm.

FIGURE R608.6(1) ABOVE-GRADE CONCRETE WALL CONSTRUCTION ONE STORY
FIGURE R608.6(2)
ABOVE-GRADIE CONCRETE WALL CONSTRUCTION CONCRETE
FIRST STORY AND LIGHT-FRAMED SECOND STORY
FIGURE R608.6(3)
ABOVE-GRADE CONCRETE WALL CONSTRUCTION TWO-STORY

For SI: 1 foot = 304.8 mm.
FIGURE R608.6(4)
ABOVE-GRADE CONCRETE WALL SUPPORTED ON MONOLITHIC SLAB-ON-GROUND FOOTING

TABLE R608.6(1)
### Minimum Vertical Reinforcement for Flat Above-Grade Walls

For SI: 61 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 1.895 kPa, 1 square foot = 0.0929 m².

**a.** Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, $K_{zt}$ equal to 1.0, and Risk Category II.

**b.** Table is based on concrete with a minimum specified compressive strength of 2,500 psi.

**c.** See Section R608.6.5 for location of reinforcement in wall.

**d.** Deflection criterion is $L/240$, where $L$ is the unsupported height of the wall in inches.

**e.** Interpolation is not permitted.

**f.** Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.

**g.** Other than for No. 4 bars spaced at 48 inches on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi. Vertical reinforcement with a yield strength of less than 60,000 psi or bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4(2).

**h.** See Table R608.3 for tolerances on nominal thicknesses.

**i.** “Top” means gravity load from roof or floor construction bears on top of wall. “Side” means gravity load from floor construction is transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall. For nonload-bearing walls where floor framing members span parallel to the wall, use of the “Top” bearing condition is permitted.

<table>
<thead>
<tr>
<th>Maximum Wind Speed (mph)</th>
<th>Maximum Unsupported Wall Height Per Story (feet)</th>
<th>Minimum Vertical Reinforcement-Bar Size and Spacing (inches)</th>
<th>Nominal wall thickness (inches)</th>
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2018 North Carolina Residential Code
TABLE R608.6(2)
MINIMUM VERTICAL REINFORCEMENT FOR WAFFLE-GRID ABOVE-GRADE WALLS\textsuperscript{a, b, c, d, e}

<table>
<thead>
<tr>
<th>MAXIMUM WIND SPEED (mph)</th>
<th>MAXIMUM UNSUPPORTED WALL HEIGHT PER STORY (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)\textsuperscript{f, g}</th>
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</thead>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 6.895 kPa, 1 square foot = 0.0929 m\textsuperscript{2}.

\textsuperscript{a} Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, Kz, equal to 1.0, and Risk Category II.

\textsuperscript{b} Table is based on concrete with a minimum specified compressive strength of 2,500 psi.

\textsuperscript{c} See Section R608.6.5 for location of reinforcement in wall.

\textsuperscript{d} Deflection criterion is L/240, where L is the unsupported height of the wall in inches.

\textsuperscript{e} Interpolation is not permitted.

\textsuperscript{f} Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.

\textsuperscript{g} Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches such as, 12, 24, 36 and 48, that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi or bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4.2.

\textsuperscript{h} See Table R608.3 for minimum core dimensions and maximum spacing of horizontal and vertical cores.

\textsuperscript{i} “Top” means gravity load from roof or floor construction bears on top of wall. “Side” means gravity load from floor construction is transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall.
For nonload-bearing walls and where floor framing members span parallel to the wall, the “top” bearing condition is permitted to be used.

### TABLE R608.6(3)
**MINIMUM VERTICAL REINFORCEMENT FOR 6-INCH SCREEN-GRID ABOVE-GRADE WALLS**

<table>
<thead>
<tr>
<th>MAXIMUM WIND SPEED (mph)</th>
<th>MAXIMUM UNSUPPORTED WALL HEIGHT PER STORY (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Nominal wall thickness (inches)</td>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 6.895 kPa, 1 square foot = 0.0929 m².

- a. Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II.
- b. Table is based on concrete with a minimum specified compressive strength of 2,500 psi.
- c. See Section R608.6.5 for location of reinforcement in wall.
- d. Deflection criterion is $L/240$, where $L$ is the unsupported height of the wall in inches.
- e. Interpolation is not permitted.
- f. Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.
- g. Other than for No. 4 bars spaced at 48 inches on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi. Maximum spacings shown are the values calculated for the specified bar size. Where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches such as, 12, 24, 36 and 48, that is less than or equal to the...
tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi or bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4(2).

h. See Table R608.3 for minimum core dimensions and maximum spacing of horizontal and vertical cores.

i. “Top” means gravity load from roof or floor construction bears on top of wall. “Side” means gravity load from floor construction is transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall. For nonload-bearing wall and where floor framing members span parallel to the wall, use of the “Top” bearing condition is permitted.

### TABLE R608.6(4)

**MINIMUM VERTICAL REINFORCEMENT FOR FLAT, WAFFLE- AND SCREEN-GRID ABOVE-GRADE WALLS DESIGNED CONTINUOUS WITH FOUNDATION STEM WALLS**

<table>
<thead>
<tr>
<th>Maximum Wind Speed (mph)</th>
<th>Exposure Category</th>
<th>Height of Stem Wall (feet)</th>
<th>Maximum Design Lateral Soil Load (psf/ft)</th>
<th>Maximum Unsupported Height of Above-Grade Wall (feet)</th>
<th>Minimum Vertical Reinforcement Bar Size and Spacing (inches)*</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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<td>5@31</td>
<td>6@45</td>
<td>4@48</td>
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<td>5@21</td>
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<td>6@27</td>
<td>DR</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square inch = 6.895 kPa, 1 square foot = 0.0929 m$^2$.

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a. Table is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 feet, interior wall area 4, an effective wind area of 10 square feet, topographic factor, $K_{zt}$ equal to 1.0, and Risk Category II.
b. Table is based on concrete with a minimum specified compressive strength of 2,500 psi.
c. See Section R608.6.5 for location of reinforcement in wall.
d. Deflection criterion is $L/240$, where $L$ is the height of the wall in inches from the exterior finish ground level to the top of the above-grade wall.
e. Interpolation is not permitted. For intermediate values of basic wind speed, heights of stem wall and above-grade wall, and design lateral soil load, use next higher value.
f. Where No. 4 reinforcing bars at a spacing of 48 inches are specified in the table as indicated by shaded cells, use of bars with a minimum yield strength of 40,000 psi or 60,000 psi is permitted.
g. Other than for No. 4 bars spaced at 48 inches on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi. Maximum spacings shown are the values calculated for the specified bar size. In waffle and screen-grid walls where the bar used is Grade 60 and the size specified in the table, the actual spacing in the wall shall not exceed a whole-number multiple of 12 inches such as, 12, 24, 36 and 48, that is less than or equal to the tabulated spacing. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section R608.5.4.7 and Table R608.5.4(2).
h. Height of stem wall is the distance from the exterior finish ground level to the top of the slab-on-ground.
i. Where the distance from the exterior finish ground level to the top of the slab-on-ground is equal to or greater than 4 feet, the stem wall shall be laterally supported at the top and bottom before backfilling. Where the wall is designed and constructed to be continuous with the above-grade wall, temporary supports bracing the top of the stem wall shall remain in place until the above-grade wall is laterally supported at the top by floor or roof construction.
j. See Table R608.3 for tolerances on nominal thicknesses, and minimum core dimensions and maximum spacing of horizontal and vertical cores for waffle- and screen-grid walls.
k. Tabulated values are applicable to construction where gravity loads bear on top of wall, and conditions where gravity loads from floor construction are transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall. See Tables R608.6(1), R608.6(2) and R608.6(3).
l. DR = Design Required.

R608.6.1 General.
The minimum thickness of load-bearing and nonload-bearing above-grade walls and reinforcement shall be as set forth in the appropriate table in this section based on the type of wall form to be used. The wall shall be designed in accordance with ACI 318 where the wall or building is not within the limitations of Section R608.2, where design is required by the tables in this section or where the wall is not within the scope of the tables in this section.

Above-grade concrete walls shall be constructed in accordance with this section and Figure R608.6(1), R608.6(2), R608.6(3) or R608.6(4). Above-grade concrete walls that are continuous with stem walls and not laterally supported by the slab-on-ground shall be designed and constructed in accordance with this section. Concrete walls shall be supported on continuous foundation walls or slabs-on-ground that are monolithic with the footing in accordance with Section R403. The minimum length of solid wall without openings shall be in accordance with Section R608.7. Reinforcement around openings, including lintels, shall be in accordance with Section R608.8. Lateral support for above-grade walls in the out-of-plane direction shall be provided by connections to the floor framing system, if applicable, and to ceiling and roof framing systems in accordance with Section R608.9. The wall thickness shall be equal to or greater than the thickness of the wall in the story above.

R608.6.2 Wall reinforcement for wind.
Vertical wall reinforcement for resistance to out-of-plane wind forces shall be determined from Table R608.6(1), R608.6(2), R608.6(3) or R608.6(4). For the design of nonload-bearing walls, in Tables R608.6(1), R608.6(2) and R608.6(3) use the appropriate column labeled “Top.” (see Sections R608.7.2.2.2 and R608.7.2.2.3). There shall be a vertical bar at
corners of exterior walls. Unless more horizontal reinforcement is required by Section R608.7.2.2.1, the minimum horizontal reinforcement shall be four No. 4 bars [Grade 40 (280 MPa)] placed as follows: top bar within 12 inches (305 mm) of the top of the wall, bottom bar within 12 inches (305 mm) of the finish floor and one bar each at approximately one-third and two-thirds of the wall height.

R608.6.3 Continuity of wall reinforcement between stories.
Vertical reinforcement required by this section shall be continuous between elements providing lateral support for the wall. Reinforcement in the wall of the story above shall be continuous with the reinforcement in the wall of the story below, or the foundation wall, if applicable. Lap splices, where required, shall comply with Section R608.5.4.3 and Figure R608.5.4(1). Where the above-grade wall is supported by a monolithic slab-on-ground and footing, dowel bars with a size and spacing to match the vertical above-grade concrete wall reinforcement shall be embedded in the monolithic slab-on-ground and footing the distance required to develop the dowel bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2) and lap-spliced with the above-grade wall reinforcement in accordance with Section R608.5.4.3 and Figure R608.5.4(1).

Exception: Where reinforcement in the wall above cannot be made continuous with the reinforcement in the wall below, the bottom of the reinforcement in the wall above shall be terminated in accordance with one of the following:

1. Extend below the top of the floor the distance required to develop the bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2).

2. Lap-spliced in accordance with Section R608.5.4.3 and Figure R608.5.4(1) with a dowel bar that extends into the wall below the distance required to develop the bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2).

Where a construction joint in the wall is located below the level of the floor and less than the distance required to develop the bar in tension, the distance required to develop the bar in tension shall be measured from the top of the concrete below the joint. See Section R608.5.5.

R608.6.4 Termination of reinforcement.
Where indicated in Items 1 through 3, vertical wall reinforcement in the top-most story with concrete walls shall be terminated with a 90-degree (1.57 rad) standard hook complying with Section R608.5.4.5 and Figure R608.5.4(3).

1. Vertical bars adjacent to door and window openings required by Section R608.8.1.2.

2. Vertical bars at the ends of required solid wall segments (see Section R608.7.2.2.2).

3. Vertical bars (other than end bars, see Item 2) used as shear reinforcement in required solid wall segments where the reduction factor for design strength, $R_3$, used is based on the wall having horizontal and vertical shear reinforcement (see Section R608.7.2.2.3).
The bar extension of the hook shall be oriented parallel to the horizontal wall reinforcement and be within 4 inches (102 mm) of the top of the wall.

Horizontal reinforcement shall be continuous around the building corners by bending one of the bars and lap-splicing it with the bar in the other wall in accordance with Section R608.5.4.3 and Figure R608.5.4(1).

**Exception:** In lieu of bending horizontal reinforcement at corners, separate bent reinforcing bars shall be permitted provided that the bent bar is lap-spliced with the horizontal reinforcement in both walls in accordance with Section R608.5.4.3 and Figure R608.5.4(1).

In required solid wall segments where the reduction factor for design strength, \( R_3 \), is based on the wall having horizontal and vertical shear reinforcement in accordance with Section R608.7.2.2.1, horizontal wall reinforcement shall be terminated with a standard hook complying with Section R608.5.4.5 and Figure R608.5.4(3) or in a lap-splice, except at corners where the reinforcement shall be continuous as required.

**R608.6.5 Location of reinforcement in wall.**
Except for vertical reinforcement at the ends of required solid wall segments, which shall be located as required by Section R608.7.2.2.2, the location of the vertical reinforcement shall not vary from the center of the wall by more than the greater of 10 percent of the wall thickness and \( \frac{3}{8} \)-inch (10 mm). Horizontal and vertical reinforcement shall be located to provide not less than the minimum cover required by Section R608.5.4.1.

**R608.7 Solid walls for resistance to lateral forces.**

**TABLE R608.7(1A)\(^a, c, d, e, f, g\)**
**UNREDUCED LENGTH, **\( UR \), **OF SOLID WALL REQUIRED IN EACH EXTERIOR ENDWALL FOR WIND PERPENDICULAR TO RIDGE ONE STORY OR TOP STORY OF TWO STORY**

<table>
<thead>
<tr>
<th>SIDEWALL LENGTH (feet)</th>
<th>ENDWALL LENGTH (feet)</th>
<th>ROOF SLOPE</th>
<th>UNREDUCED LENGTH, ( UR ), OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Basic Wind Speed (mph) Exposure</td>
<td>115B</td>
</tr>
<tr>
<td>15</td>
<td>&lt; 1:12</td>
<td>1.03</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>5:12</td>
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<td>&lt; 1:12</td>
<td>1.03</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>5:12</td>
<td>1.43</td>
<td>1.56</td>
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<tr>
<td></td>
<td>7:12</td>
<td>2.78</td>
<td>3.03</td>
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<td></td>
<td>12:12</td>
<td>5.17</td>
<td>5.63</td>
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<td>5:12</td>
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</tr>
<tr>
<td></td>
<td>7:12</td>
<td>3.57</td>
<td>3.88</td>
</tr>
</tbody>
</table>

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### TABLE R608.7(1A)—continued

**UNREDUCED LENGTH, $UR$, OF SOLID WALL REQUIRED IN EACH EXTERIOR ENDWALL FOR WIND PERPENDICULAR TO RIDGE ONE STORY OR TOP STORY OF TWO STORY**

<table>
<thead>
<tr>
<th>SIDEWALL LENGTH (feet)</th>
<th>ENDWALL LENGTH (feet)</th>
<th>ROOF SLOPE</th>
<th>UNREDUCED LENGTH, $UR$, OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Basic Wind Speed (mph) Exposure</strong></td>
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<td></td>
<td></td>
<td></td>
<td><strong>115B</strong></td>
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<td>2.35</td>
</tr>
<tr>
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<td>3.27</td>
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<td>19.86</td>
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</tbody>
</table>

(continued)
a. Tabulated lengths were derived by calculating design wind pressures in accordance with Figure 28.4-1 of ASCE 7 for a building with a mean roof height of 35 feet, topographic factor, $K_z$, equal to 1.0, and Risk Category II. For wind perpendicular to the ridge, the effects of a 2-foot overhang on each endwall are included. The design pressures were used to calculate forces to be resisted by solid wall segments in each. The forces to be resisted by each wall line were then divided by the default design strength of 840 pounds per linear foot of length to determine the unreduced length, $UR$, of solid wall length required in each endwall. The actual mean roof height of the building shall not exceed the least horizontal dimension of the building.

b. Tabulated lengths in the “minimum” column are based on the requirement of Section 28.4.4 of ASCE 7 that the main windforce-resisting system be designed for a minimum pressure of 16 psf multiplied by the wall area of the building and 8 psf multiplied by the roof area of the building projected onto a vertical plane normal to the assumed wind direction. Tabulated lengths in shaded cells are less than the “minimum” value. Where the minimum controls, it is permitted to be reduced in accordance with Notes c, d and e. See Section R608.7.1.1.

c. For buildings with a mean roof height of less than 35 feet, tabulated lengths are permitted to be reduced by multiplying by the appropriate factor, $R_1$, from Table R608.7(2). The reduced length shall be not less than the “minimum” value shown in the table.

d. Tabulated lengths for “one story or top story of two story” are based on a floor-to-ceiling height of 10 feet. Tabulated lengths for “first story of two story” are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor-to-ceiling heights less than assumed, use the lengths in this table or Table R608.7 (1B) or (1C), or multiply the value in the table by the reduction factor, $R_2$, from Table R608.7(3).

e. Tabulated lengths are based on the default design shear strength of 840 pounds per linear foot of solid wall segment. The tabulated lengths are permitted to be reduced by multiplying by the applicable reduction factor for design strength, $R_3$, from Table R608.7(4).

f. The reduction factors, $R_1$, $R_2$, and $R_3$, in Tables R608.7(2), R608.7(3), and R608.7(4), respectively, are permitted to be compounded, subject to the limitations of Note b. However, the minimum number and minimum length of solid wall segments in each wall line shall comply with Sections R608.7.1 and R608.7.2.1, respectively.

g. For intermediate values of sidewall length, endwall length, roof slope and basic wind speed, use the next higher value, or determine by interpolation.

<table>
<thead>
<tr>
<th>SIDEWALL LENGTH (feet)</th>
<th>ENDWALL LENGTH (feet)</th>
<th>ROOF SLOPE</th>
<th>UNREduced LENGTH, $UR$, OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Basic Wind Speed (mph) Exposure</td>
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<td></td>
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<th>SIDEWALL LENGTH (feet)</th>
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<th>ROOF SLOPE</th>
<th>UNREDUCED LENGTH, UR, OF SOLID WALL REQUIRED IN ENDWALLS FOR WIND PERPENDICULAR TO RIDGE (feet)</th>
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<td>Basic Wind Speed (mph) Exposure</td>
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</tbody>
</table>

(continued)

TABLE R608.7(1B)—continued

UNREDUCED LENGTH, UR, OF SOLID WALL REQUIRED IN EACH EXTERIOR ENDWALL FOR WIND PERPENDICULAR TO RIDGE FIRST STORY OF TWO STORY

a, c, d, e, f, g
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound force per linear foot = 0.146 kN/m, 1 pound per square foot = 47.88 Pa.

a. Tabulated lengths were derived by calculating design wind pressures in accordance with Figure 28.4-1 of ASCE 7 for a building with a mean roof height of 35 feet, topographic factor, $K_{zt}$, equal to 1.0, and Risk Category II. For wind perpendicular to the ridge, the effects of a 2-foot overhang on each endwall are included. The design pressures were used to calculate forces to be resisted by solid wall segments in each endwall. The forces to be resisted by each wall line were then divided by the default design strength of 840 pounds per linear foot of length to determine the unReduced length, $UR$, of solid wall length required in each endwall. The actual mean roof height of the building shall not exceed the least horizontal dimension of the building.

b. Tabulated lengths in the “minimum” column are based on the requirement of Section 28.4.4 of ASCE 7 that the main wind-force-resisting system be designed for a minimum pressure of 1016 psf multiplied by the area of the building and 8 psf multiplied by the roof area of the building projected onto a vertical plane normal to the assumed wind direction. Tabulated lengths in shaded cells are less than the “minimum” value. Where the minimum controls, it is permitted to be reduced in accordance with Notes c, d and e. See Section R608.7.1.1.

c. For buildings with a mean roof height of less than 35 feet, tabulated lengths are permitted to be reduced by multiplying by the appropriate factor, $R_1$, from Table R608.7(2). The reduced length shall be not less than the “minimum” value shown in the table.

d. Tabulated lengths for “one story or top story of two story” are based on a floor-to-ceiling height of 10 feet. Tabulated lengths for “first story of two story” are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor-to-ceiling heights less than assumed, use the lengths in this table or Table R608.7(1A) or (1C), or multiply the value in the table by the reduction factor, $R_2$, from Table R608.7(3).

e. Tabulated lengths are based on the default design shear strength of 840 pounds per linear foot of solid wall segment. The tabulated lengths are permitted to be reduced by multiplying by the applicable reduction factor for design strength, $R_3$, from Table R608.7(4).

f. The reduction factors, $R_1$, $R_2$ and $R_3$, in Tables R608.7(2), R608.7(3), and R608.7(4), respectively, are permitted to be compounded, subject to the limitations of Note b. However, the minimum number and minimum length of solid wall segments in each wall line shall comply with Sections R608.7.1 and R608.7.2.1, respectively.

g. For intermediate values of sidewall length, endwall length, roof slope and basic wind speed, use the next higher value, or determine by interpolation.

### TABLE R608.7(1C)

**UNREDUCED LENGTH, $UR$, OF SOLID WALL REQUIRED IN EACH EXTERIOR SIDEWALL FOR WIND PARALLEL TO RIDGE**

<table>
<thead>
<tr>
<th>SIDEWALL LENGTH (feet)</th>
<th>ENDWALL LENGTH (feet)</th>
<th>ROOF SLOPE</th>
<th>UNREDUCED LENGTH, $UR$, OF SOLID WALL REQUIRED IN SIDEWALLS FOR WIND PARALLEL TO RIDGE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Basic Wind Speed (mph) Exposure</td>
<td>115B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110C</td>
<td>119C</td>
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<tr>
<td>&lt; 30</td>
<td>15</td>
<td>&lt; 1:12</td>
<td>1.08</td>
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<td>5:12</td>
<td>1.29</td>
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<td>7:12</td>
<td>1.38</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
### TABLE R608.7(1C)—continued

**UNREDUCED LENGTH, UR, OF SOLID WALL REQUIRED IN EACH EXTERIOR SIDEWALL FOR WIND PARALLEL TO RIDGE**

<table>
<thead>
<tr>
<th>SIDEWALL LENGTH (feet)</th>
<th>ENDWALL LENGTH (feet)</th>
<th>ROOF SLOPE</th>
<th>UNREDUCED LENGTH, UR, OF SOLID WALL REQUIRED IN SIDEWALLS FOR WIND PARALLEL TO RIDGE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td><strong>Basic Wind Speed Exposure (mph)</strong></td>
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</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound force per linear foot = 0.146 kN/m, 1 pound per square foot = 47.88 Pa.

a. Tabulated lengths were derived by calculating design wind pressures in accordance with Figure 28.4-1 of ASCE 7 for a building with a mean roof height of 35 feet, topographic factor, $K_z$, equal to 1.0, and Risk Category II. The design pressures were used to calculate forces to be resisted by solid wall segments in each sidewall. The forces to be resisted by each wall line were then divided by the default design strength of 840 pounds per linear foot of length to determine the unreduced length, $UR$, of solid wall length required in each sidewall. The actual mean roof height of the building shall not exceed the least horizontal dimension of the building.

b. Tabulated lengths in the "minimum" column are based on the requirement of Section 28.4.4 of ASCE 7 that the main windforce-resisting system be designed for a minimum pressure of 16 psf multiplied by the wall area of the building and 8 psf multiplied by the roof area of the building projected onto a vertical plane normal to the assumed wind direction. Tabulated lengths in shaded cells are less than the "minimum" value. Where the minimum controls, it is permitted to be reduced in accordance with Notes c, d and e. See Section R608.7.1.1.

c. For buildings with a mean roof height of less than 35 feet, tabulated lengths are permitted to be reduced by multiplying by the appropriate factor, $R_1$, from Table R608.7(2). The reduced length shall be not less than the "minimum" value shown in the table.

d. Tabulated lengths for "one story or top story of two story" are based on a floor-to-ceiling height of 10 feet. Tabulated lengths for "first story of two story" are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor-to-ceiling heights less than assumed, use the lengths in this table or Table R608.7(1A) or (1B), or multiply the value in the table by the reduction factor, $R_2$, from Table R608.7(3).

e. Tabulated lengths are based on the default design shear strength of 840 pounds per linear foot of solid wall segment. The tabulated lengths are permitted to be reduced by multiplying by the applicable reduction factor for design strength, $R_3$, from Table R608.7(4).

f. The reduction factors, $R_1$, $R_2$ and $R_3$, in Tables R608.7(2), R608.7(3), and R608.7(4), respectively, are permitted to be compounded, subject to the limitations of Note b. However, the minimum number and minimum length of solid walls segments in each wall line shall comply with Sections R608.7.1 and R608.7.2.1, respectively.

g. For intermediate values of sidewall length, endwall length, roof slope and basic wind speed, use the next higher value, or determine by interpolation.

<table>
<thead>
<tr>
<th>MEAN ROOF HEIGHT \ Exposure category</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.25 \ 15 \ 20 \ 25 \ 30</td>
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<td></td>
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<tr>
<td>12.25 \ 14.53 \ 22.01 \ 28.13 \ 36.74</td>
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<tr>
<td>13.54 \ 18.48</td>
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<td>16.85 \ 22.91 \ 24.13 \ 32.29 \ 47.88</td>
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<tr>
<td>19.35 \ 26.29 \ 27.45</td>
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<tr>
<td>22.01 \ 29.92 \ 32.29</td>
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<td>27.45</td>
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</tbody>
</table>

TABLE R608.7(2)
REDUCTION FACTOR, $R_1$, FOR BUILDINGS WITH MEAN ROOF HEIGHT LESS THAN 35 FEET

2018 North Carolina Residential Code
For SI: 1 foot = 304.8 mm, 1 degree = 0.0175 rad.
a. See Section R608.7.1.1 and Note c to Table R608.7(1A) for application of reduction factors in this table. This reduction is not permitted for “minimum” values.
b. For intermediate values of mean roof height, use the factor for the next greater height, or determine by interpolation.
c. Mean roof height is the average of the roof eave height and height of the highest point on the roof surface, except that for roof slopes of less than or equal to $\frac{1}{8}:12$ (10 degrees), the mean roof height is permitted to be taken as the roof eave height.

### Table R608.7(3)
**Reduction Factor, $R_2$, for Floor-to-Ceiling Wall Heights Less Than 10 Feet**

<table>
<thead>
<tr>
<th>STORY UNDER CONSIDERATION</th>
<th>FLOOR-TO-CEILING HEIGHT&lt;sup&gt;c&lt;/sup&gt; (feet)</th>
<th>ENDWALL LENGTH (feet)</th>
<th>ROOF SLOPE</th>
<th>REDUCTION FACTOR, $R_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endwalls—For wind perpendicular to ridge</strong></td>
<td></td>
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<tr>
<td>One story or top story of two story</td>
<td>8</td>
<td>15</td>
<td>$&lt; 5:12$</td>
<td>0.83</td>
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<tr>
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<td>7:12</td>
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<td>12:12</td>
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<td></td>
<td></td>
<td>60</td>
<td>$&lt; 5:12$</td>
<td>0.83</td>
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<td>12:12</td>
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<tr>
<td>First story of two story</td>
<td>16 combined first and second story</td>
<td>15</td>
<td>$&lt; 5:12$</td>
<td>0.83</td>
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<td><strong>Sidewalls—For wind parallel to ridge</strong></td>
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<tr>
<td>One story or top story of two story</td>
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<td>$&lt; 1:12$</td>
<td>0.84</td>
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<td>First story of two story</td>
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For SI: 1 foot = 304.8 mm.

a. See Section R608.7.1.1 and Note d to Table R608.7(1A) for application of reduction factors in this table.
b. For intermediate values of endwall length, and/or roof slope, use the next higher value, or determine by interpolation.
c. Tabulated values in Table R608.7(1A) and (1C) for “one story or top story of two story” are based on a floor-to-ceiling height of 10 feet. Tabulated values in Table R608.7(1B) and (1C) for “first story of two story” are based on floor-to-ceiling heights of 10 feet each for the first and second story. For floor to ceiling heights between those shown in this table and those assumed in Table R608.7(1A), (1B) or (1C), use the solid wall lengths in Table R608.7(1A), (1B) or (1C), or determine the reduction factor by interpolating between 1.0 and the factor shown in this table.

<table>
<thead>
<tr>
<th>TABLE R608.7(4) REDUCTION FACTOR FOR DESIGN STRENGTH, $R_3^a$, FOR FLAT, WAFFLE- AND SCREEN-GGRID WALLS$^a, c$</th>
<th></th>
<th></th>
</tr>
</thead>
</table>

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<table>
<thead>
<tr>
<th>Nominal Thickness of Wall (inches)</th>
<th>Vertical Bars at Each End of Solid Wall Segment</th>
<th>Vertical Reinforcement Layout Detail [See Figure R608.7(2)]</th>
<th>Reduction Factor, $R_f$, for Length of Solid Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of bars</td>
<td>Bar Size</td>
<td>40,000$^a$</td>
</tr>
<tr>
<td>Flat Walls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
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<td>1</td>
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<td>3</td>
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<td>4</td>
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<td>8</td>
<td>2</td>
<td>4</td>
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<td>4</td>
<td>6</td>
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<td>5</td>
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<tr>
<td>10</td>
<td>2</td>
<td>4</td>
<td>3</td>
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<td></td>
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<td>5</td>
<td>3</td>
</tr>
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<td>4</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>12</td>
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<td>5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Waffle-grid Walls*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
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<td></td>
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<tr>
<td>8</td>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
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<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Screen-grid Walls*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1,000 pounds per square inch = 6.895 MPa.

a. See Note e to Table R608.7(1A) for application of adjustment factors in this table.
b. Yield strength in pounds per square inch of vertical wall reinforcement at ends of solid wall segments.
c. Values are based on concrete with a specified compressive strength, $f'_c$, of 2,500 psi. Where concrete with $f'_c$ of not less than 3,000 psi is used, values in shaded cells are permitted to be decreased by multiplying by 0.91.
d. Horizontal and vertical shear reinforcement shall be provided in accordance with Section R608.7.2.2.
e. Each end of each solid wall segment shall have rectangular flanges. In the through-the-wall dimension, the flange shall be not less than \(5\frac{1}{2}\) inches for 6-inch-nominal waffle- and screen-grid walls, and not less than \(7\frac{1}{2}\) inches for 8-inch-nominal waffle-grid walls. In the in-plane dimension, flanges shall be long enough to accommodate the vertical reinforcement required by the layout detail selected from Figure R608.7(2) and provide the cover required by Section R608.5.4.1. If necessary to achieve the required dimensions, form material shall be removed or use of flat wall forms is permitted.
FIGURE R608.7(1)
MINIMUM SOLID WALL LENGTH

<table>
<thead>
<tr>
<th>DETAIL NO.</th>
<th>NOM. WALL THICKNESS, IN.</th>
<th>REINFORCEMENT LAYOUT AT ENDS OF SOLID WALL SEGMENTS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>[Diagram showing 3 inch Max. Typical, 2 inch Typical]</td>
<td>For SI: 1 inch = 25.4 mm.</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>[Diagram showing bar layout]</td>
<td>1. See Table R608.7(4) for use of details.</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>[Diagram showing bar layout]</td>
<td>2. Minimum length of solid wall segment and size and grade of reinforcement in each end of each solid wall segment shall be determined from Table R608.7(4).</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td>3. For minimum cover requirements, see Section R608.5.4.1.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
<td>4. For details 3 - 8 where two or more bars are in the same row parallel to the end of the segment, place bars so that corner bars are as close to the sides of the wall segments as minimum cover requirements of Section R608.5.4.1 will permit.</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>[Diagram showing 1 inch Min. clear spacing Typical]</td>
<td>5. For waffle- and screen-grid walls, each end of each solid wall segment shall have rectangular flanges. In the through-the-wall dimension, the flange shall be not less than 5½ inches for 6-inch nominal waffle and screen-grid forms, and not less than 7½ inches for 8-inch nominal waffle-grid forms. In the in-plane dimension, flanges shall be long enough to accommodate the vertical reinforcement required by the layout detail selected and provide the cover required by Section R608.5.4.1. If necessary to achieve the required dimensions, form material shall be removed or flat wall forms are permitted. See Table R608.7(4), Note e.</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>[Diagram showing bar layout]</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>[Diagram showing bar layout]</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>[Diagram showing bar layout]</td>
<td></td>
</tr>
</tbody>
</table>

* For minimum cover see Section R608.5.4.1
R608.7.1 Length of solid wall.
Each exterior wall line in each story shall have a total length of solid wall required by Section R608.7.1.1. A solid wall is a section of flat, waffle-grid or screen-grid wall, extending the full story height without openings or penetrations, except those permitted by Section R608.7.2. Solid wall segments that contribute to the total length of solid wall shall comply with Section R608.7.2.

R608.7.1.1 Length of solid wall for wind.
Buildings shall have solid walls in each exterior endwall line (the side of a building that is parallel to the span of the roof or floor framing) and sidewall line (the side of a building that is perpendicular to the span of the roof or floor framing) to resist lateral in-plane wind forces. The site-appropriate basic wind speed and exposure category shall be used in Tables R608.7(1A) through (1C) to determine the unreduced total length, $UR$, of solid wall required in each exterior endwall line and sidewall line. For buildings with a mean roof height of less than 35 feet (10 668 mm), the unreduced values determined from Tables R608.7(1A) through (1C) are permitted to be reduced by multiplying by the applicable factor, $R_1$, from Table R608.7(2); however, reduced values shall be not less than the minimum values in Tables R608.7(1A) through (1C). Where the floor-to-ceiling height of a story is less than 10 feet (3048 mm), the unreduced values determined from Tables R608.7(1A) through (C), including minimum values, are permitted to be reduced by multiplying by the applicable factor, $R_2$, from Table R608.7(3). To account for different design strengths than assumed in determining the values in Tables R608.7(1A) through (1C), the unreduced lengths determined from Tables R608.7(1A) through (1C), including...
minimum values, are permitted to be reduced by multiplying by the applicable factor, $R_3$, from Table R608.7(4). The reductions permitted by Tables R608.7(2), R608.7(3) and R608.7(4) are cumulative.

The total length of solid wall segments, $TL$, in a wall line that comply with the minimum length requirements of Section R608.7.2.1 [see Figure R608.7(1)] shall be equal to or greater than the product of the unreduced length of solid wall from Tables R608.7(1A) through (1C), $UR$ and the applicable reduction factors, if any, from Tables R608.7(2), R608.7(3) and R608.7(4) as indicated by Equation R6-1.

$$TL \geq R_1 \cdot R_2 \cdot R_3 \cdot UR$$  
(Equation R6-1)

where:

$TL$ = Total length of solid wall segments in a wall line that comply with Section R608.7.2.1 [see Figure R608.7(1)].
$R_1$ = 1.0 or reduction factor for mean roof height from Table R608.7(2).
$R_2$ = 1.0 or reduction factor for floor-to-ceiling wall height from Table R608.7(3).
$R_3$ = 1.0 or reduction factor for design strength from Table R608.7(4).
$UR$ = Unreduced length of solid wall from Tables R608.7(1A) through (1C).

The total length of solid wall in a wall line, $TL$, shall be not less than that provided by two solid wall segments complying with the minimum length requirements of Section R608.7.2.1.

To facilitate determining the required wall thickness, wall type, number and grade of vertical bars at each end of each solid wall segment, and whether shear reinforcement is required, use of Equation R6-2 is permitted.

$$R \leq \frac{TL}{R_1 \cdot R_2 \cdot UR}$$  
(Equation R6-2)

After determining the maximum permitted value of the reduction factor for design strength, $R_3$, in accordance with Equation R6-2, select a wall type from Table R608.7(4) with $R_3$ less than or equal to the value calculated.

**R608.7.2 Solid wall segments.**
Solid wall segments that contribute to the required length of solid wall shall comply with this section. Reinforcement shall be provided in accordance with Section R608.7.2.2 and Table R608.7(4). Solid wall segments shall extend the full story-height without openings, other than openings for the utilities and other building services passing through the wall. In flat
walls and waffle-grid walls, such openings shall have an area of less than 30 square inches (19355 mm$^2$) without any dimension exceeding $6\frac{1}{4}$ inches (159 mm), and shall not be located within 6 inches (152 mm) of the side edges of the solid wall segment. In screen-grid walls, such openings shall be located in the portion of the solid wall segment between horizontal and vertical cores of concrete and opening size and location are not restricted provided there is not any concrete removed.

**R608.7.2.1 Minimum length of solid wall segment and maximum spacing.**

Only solid wall segments equal to or greater than 24 inches (610 mm) in length shall be included in the total length of solid wall required by Section R608.7.1. In addition, not more than two solid wall segments equal to or greater than 24 inches (610 mm) in length and less than 48 inches (1219 mm) in length shall be included in the required total length of solid wall. The maximum clear opening width shall be 18 feet (5486 mm). See Figure R608.7(1).

**R608.7.2.2 Reinforcement in solid wall segments.**

**R608.7.2.2.1 Horizontal shear reinforcement.**

Where reduction factors for design strength, $R_9$, from Table R608.7(4) based on horizontal and vertical shear reinforcement being provided are used, solid wall segments shall have horizontal reinforcement consisting of minimum No. 4 bars. Horizontal shear reinforcement shall be the same grade of steel required for the vertical reinforcement at the ends of solid wall segments by Section R608.7.2.2.2.

The spacing of horizontal reinforcement shall not exceed the smaller of one-half the length of the solid wall segment, minus 2 inches (51 mm), and 18 inches (457 mm). Horizontal shear reinforcement shall terminate in accordance with Section R608.6.4.

**R608.7.2.2.2 Vertical reinforcement.**

Vertical reinforcement applicable to the reduction factor(s) for design strength, $R_9$, from Table R608.7(4) that is used, shall be located at each end of each solid wall segment in accordance with the applicable detail in Figure R608.7(2). The No. 4 vertical bar required on each side of an opening by Section R608.8.1.2 is permitted to be used as reinforcement at the ends of solid wall segments where installed in accordance with the applicable detail in Figure R608.7(2). There shall be not less than two No. 4 bars at each end of solid wall segments located as required by the applicable detail in Figure R608.7(2). One of the bars at each end of solid wall segments shall be deemed to meet the requirements for vertical wall reinforcement required by Section R608.6.

The vertical wall reinforcement at each end of each solid wall segment shall be developed below the bottom of the adjacent wall opening [see Figure R608.7(3)] by one of the following methods:

1. Where the wall height below the bottom of the adjacent opening is equal to or greater than 22 inches (559 mm) for No. 4 or 28 inches (711 mm) for No. 5 vertical wall reinforcement, reinforcement around openings in accordance with Section R608.8.1 shall be sufficient.
2. Where the wall height below the bottom of the adjacent opening is less than required by Item 1 above, the vertical wall reinforcement adjacent to the opening shall extend into the footing far enough to develop the bar in tension in accordance with Section R608.5.4.4 and Figure R608.5.4(2), or shall be lap-spliced with a dowel that is embedded in the footing far enough to develop the dowel-bar in tension.

**R608.7.2.2.3 Vertical shear reinforcement.**
Where reduction factors for design strength, \( R_3 \), from Table R608.7(4) based on horizontal and vertical shear reinforcement being provided are used, solid wall segments shall have vertical reinforcement consisting of minimum No. 4 bars. Vertical shear reinforcement shall be the same grade of steel required by Section R608.7.2.2.2 for the vertical reinforcement at the ends of solid wall segments. The spacing of vertical reinforcement throughout the length of the segment shall not exceed the smaller of one third the length of the segment, and 18 inches (457 mm). Vertical shear reinforcement shall be continuous between stories in accordance with Section R608.6.3, and shall terminate in accordance with Section R608.6.4. Vertical shear reinforcement required by this section is permitted to be used for vertical reinforcement required by Table R608.6(1), R608.6(2), R608.6(3) or R608.6(4), whichever is applicable.

**R608.7.2.3 Solid wall segments at corners.**
At all interior and exterior corners of exterior walls, a solid wall segment shall extend the full height of each wall story. The segment shall have the length required to develop the horizontal reinforcement above and below the adjacent opening in tension in accordance with Section R608.5.4.4. For an exterior corner, the limiting dimension is measured on the outside of the wall, and for an interior corner the limiting dimension is measured on the inside of the wall. See Section R608.8.1. The length of a segment contributing to the required length of solid wall shall comply with Section R608.7.2.1.

The end of a solid wall segment complying with the minimum length requirements of Section R608.7.2.1 shall be located not more than 6 feet (1829 mm) from each corner.

**R608.8 Requirements for lintels and reinforcement around openings.**
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE R608.8(1)**

**REINFORCEMENT OF OPENINGS**

For SI: 1 inch = 25.4 mm.

**FIGURE R608.8(2)**

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LINTEL FOR FLAT WALLS

(a) SINGLE FORM HEIGHT SECTION CUT THROUGH VERTICAL CORE OF A WAFFLE-GRID LINTEL

(b) DOUBLE FORM HEIGHT SECTION CUT THROUGH VERTICAL CORE OF A WAFFLE-GRID LINTEL

*FOR BUNDLED BARS, SEE SECTION R608.2.2.

NOTE: CROSS-HATCHING REPRESENTS THE AREA IN WHICH FORM MATERIAL SHALL BE REMOVED, IF NECESSARY TO CREATE FLANGES CONTINUOUS THE LENGTH OF THE LINTEL. FLANGES SHALL HAVE A MINIMUM THICKNESS OF 3 IN., AND A MINIMUM WIDTH OF 5 IN. AND 7 IN. IN 6 IN. NOMINAL AND 8 IN. NOMINAL WAFFLE-GRID WALLS, RESPECTIVELY. SEE NOTE 1 TO TABLES R608.8(6) AND R608.8(10).

For SI: 1 inch = 25.4 mm.

FIGURE R608.8(3)
**Lintels for Waffle-Grid Walls**

(a) Single form height section cut through vertical core of a screen-grid lintel

(h) Double form height section cut through vertical core of a screen-grid lintel

*For bundled bars, see Section R608.8.2.2

NOTE: CROSS-HATCHING REPRESENTS THE AREA IN WHICH FORM MATERIAL SHALL BE REMOVED, IF NECESSARY, TO CREATE FLANGES CONTINUOUS THE LENGTH OF THE LINTEL. FLANGES SHALL HAVE A MINIMUM THICKNESS OF 2.5 IN. AND A MINIMUM WIDTH OF 5 IN. SEE NOTE a TO TABLES R608.8(8) AND R608.8(10).
**FIGURE R608.8(4)**
LINTELS FOR SCREEN-GRID WALLS

**TABLE R608.8(1)**
LINTEL DESIGN LOADING CONDITIONS\(^{a,b,d}\)

<table>
<thead>
<tr>
<th>DESCRIPTION OF LOADS AND OPENINGS ABOVE INFLUENCING DESIGN OF LINTEL</th>
<th>DESIGN LOAD CONDITION(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening in wall of top story of two-story building, or first story of one-story building</td>
<td></td>
</tr>
</tbody>
</table>
| Wall supporting loads from roof, including attic floor, if applicable, and Wall not supporting loads from roof or attic floor | Top of lintel equal to or less than \(W/2\) below top of wall  
Top of lintel greater than \(W/2\) below top of wall | 2  
NLB |
| Opening in wall of first story of two-story building where wall immediately above is of concrete construction, or opening in basement wall of one-story building where wall immediately above is of concrete construction | |
| LB ledger board mounted to side of wall with bottom of ledger less than or equal to \(W/2\) above top of lintel, and | Top of lintel greater than \(W/2\) below bottom of opening in story above  
Top of lintel less than or equal to \(W/2\) below bottom of opening in story above, and Opening is entirely within the footprint of the opening in the story above | 1  
1 |
| Opening is partially within the footprint of the opening in the story above | 4 |
| NLB ledger board mounted to side of wall with bottom of ledger more than \(W/2\) above top of lintel, or no ledger board, and | Top of lintel greater than \(W/2\) below bottom of opening in story above  
Top of lintel less than or equal to \(W/2\) below bottom of opening in story above, and Opening is entirely within the footprint of the opening in the story above | NLB  
NLB |
| Opening is partially within the footprint of the opening in the story above | 1 |
| Opening in basement wall of two-story building where walls of two stories above are of concrete construction | |
| LB ledger board mounted to side of wall with bottom of ledger less than or equal to \(W/2\) above top of lintel, and | Top of lintel greater than \(W/2\) below bottom of opening in story above  
Top of lintel less than or equal to \(W/2\) below bottom of opening in story above, and Opening is entirely within the footprint of the opening in the story above | 1  
1 |

For SI: 1 inch = 25.4 mm.
| LB ledger board mounted to side of wall with bottom of ledger more than W/2 above top of lintel | Opening is partially within the footprint of the opening in the story above | 5 |
| NLB ledger board mounted to side of wall with bottom of ledger less than or equal to W/2 above top of lintel, or no ledger board, and Top of lintel greater than W/2 below bottom of opening in story above | NLB | |
| | Top of lintel less than or equal to W/2 below bottom of opening in story above, and Opening is entirely within the footprint of the opening in the story above | NLB | |
| | Opening is partially within the footprint of the opening in the story above | 1 |

Opening in wall of first story of two-story building where wall immediately above is of light-framed construction, or opening in basement wall of one-story building where wall immediately above is of light-framed construction

| Wall supporting loads from roof, second floor and top-story wall of light-framed construction, and Top of lintel equal to or less than W/2 below top of wall | 3 |
| Wall supporting loads from roof, second floor and top-story wall of light-framed construction, and Top of lintel greater than W/2 below top of wall | NLB |
| Wall not supporting loads from roof or second floor | NLB |

a. LB means load bearing, NLB means nonload bearing, and W means width of opening.
b. Footprint is the area of the wall below an opening in the story above, bounded by the bottom of the opening and vertical lines extending downward from the edges of the opening.
c. For design loading condition “NLB” see Tables R608.8(9) and R608.8(10). For all other design loading conditions, see Tables R608.8(2) through R608.8(8).
d. A NLB ledger board is a ledger attached to a wall that is parallel to the span of the floor, roof or ceiling framing that supports the edge of the floor, ceiling or roof.

TABLE R608.8(2)
MAXIMUM ALLOWABLE CLEAR SPANS FOR 4-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS
ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET

<table>
<thead>
<tr>
<th>LINTEL DEPTH, D^g (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF Lintel</th>
<th>STEEL YIELD STRENGTH h, f_y (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Span without stirrups</td>
<td>1-i</td>
<td>3-2 3-4 2-4 2-6 2-2 2-1 2-0 2-0 2-0</td>
</tr>
<tr>
<td></td>
<td>1-#4</td>
<td>40,000</td>
<td>5-2 5-5 4-1 4-3 3-10 3-7 3-4 2-9 2-9</td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>6-2 6-5 4-11 5-1 4-6 4-2 3-8 2-11 2-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#5</td>
<td>40,000</td>
<td>6-3 6-7 5-0 5-2 4-6 4-2 3-8 2-11 2-10</td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>DR  DR  DR  DR  DR  DR  DR  DR  DR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Center distance A</td>
<td>1-k</td>
<td>1-1 1-2 0-8 0-9 0-7 0-6 0-5 0-4 0-4</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Number of Bars and Bar Size in Top and Bottom of Lintel</th>
<th>Steel Yield Strength, ( f_y ) (psi)</th>
<th>Design Loading Condition Determined from Table R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Maximum ground snow load (psf)</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Maximum clear span of lintel (feet - inches)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
TABLE R608.8(3)
MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS

<table>
<thead>
<tr>
<th>Clear Span, feet</th>
<th>6-11</th>
<th>7-9</th>
<th>6-1</th>
<th>6-3</th>
<th>5-9</th>
<th>5-7</th>
<th>5-3</th>
<th>4-9</th>
<th>4-8</th>
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<tr>
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<td>9-0</td>
<td>6-11</td>
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<td>11-6</td>
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<td>12-8</td>
<td>11-9</td>
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<tr>
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<td>21-6</td>
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<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
</tr>
</tbody>
</table>

Center distance, \( A \), in inches

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

- a. See Table R608.3 for tolerances permitted from nominal thickness.
- b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note j.
- c. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.
- d. Deflection criterion is \( L/240 \), where \( L \) is the clear span of the lintel in inches, or \( \frac{1}{2} - \text{-inch}, \) whichever is less.
- e. Linear interpolation is permitted between ground snow loads and between lintel depths.
- f. DR indicates design required.
- g. Lintel depth, \( D \), is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.
- h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.
- i. Allowable clear span without stirrups applicable to all lintels of the same depth, \( D \). Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than \( d/2 \).
- j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.
- k. Center distance, \( A \), is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.
- l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, \( A \), shall be permitted to be multiplied by 1.10.
- m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.
### ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET

<table>
<thead>
<tr>
<th>LINTEL DEPTH, $D^g$ (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH $f_y$ (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
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<tr>
<td></td>
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<td>1 2 3 4 5</td>
<td>Maximum ground snow load (psf)</td>
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<td></td>
<td></td>
<td>— 30 70 30 70 30 70 30 70</td>
<td>Maximum clear span of lintel (feet - inches)</td>
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</tr>
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<tr>
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<td>60,000</td>
<td>DR DR DR DR DR DR DR DR DR DR</td>
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<tr>
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<td>Center distance $A^{k, l}$</td>
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<tr>
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<td>60,000</td>
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<tr>
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<td>60,000</td>
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</tr>
<tr>
<td></td>
<td>2-#4</td>
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<td></td>
</tr>
<tr>
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<td>1-#6</td>
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</tr>
<tr>
<td></td>
<td>2-#5</td>
<td>40,000 12-8 14-3 10-11 11-4 10-2 9-2 8-7 6-9 6-6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>15-2 17-1 13-1 13-7 12-3 11-0 10-3 7-11 7-7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-#6</td>
<td>40,000 14-11 16-9 12-8 13-4 11-4 9-8 8-8 6-9 6-6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>DR DR DR DR DR DR DR DR DR DR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Center distance $A^{k, l}$</td>
<td>i 3-3 4-1 2-5 2-7 2-1 1-9 1-6 1-0 1-0</td>
<td></td>
</tr>
</tbody>
</table>

(continued)

**TABLE R608.8(3)—continued**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS**

2018 North Carolina Residential Code
## Table R608.8(1)

### For lintels without stirrups

<table>
<thead>
<tr>
<th>Linetl Depth, (d) (inches)</th>
<th>Number of Bars and Bar Size in Top and Bottom of Lintel</th>
<th>Steel Yield Strength (f_y) (psi)</th>
<th>Design Loading Condition Determined from Table R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1-#5, i, j</td>
<td>6-11</td>
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</tr>
<tr>
<td></td>
<td>2-#4</td>
<td>6-1</td>
<td>10-1</td>
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<tr>
<td></td>
<td>2-#5</td>
<td>15-10</td>
<td>10-3</td>
</tr>
<tr>
<td></td>
<td>2-#6</td>
<td>12-2</td>
<td>12-8</td>
</tr>
<tr>
<td></td>
<td>Center distance (A) (k, l)</td>
<td>3-11</td>
<td>5-2</td>
</tr>
</tbody>
</table>

### Maximum Ground Snow Load (psf)

Maximun clear span of lintel (feet - inches)

- 20: 6-11, 8-2, 6-1, 6-3, 5-8, 5-2, 4-11, 4-4, 4-3
- 24: 8-2, 9-10, 7-4, 7-8, 6-11, 6-4, 5-11, 5-3, 5-2

---

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pounds per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

- **a.** See Table R608.3 for tolerances permitted from nominal thickness.
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- **d.** Deflection criterion is \(L/240\), where \(L\) is the clear span of the lintel in inches, or \(1/\sqrt{d}\) -inch, whichever is less.
- **e.** Linear interpolation is permitted between ground snow loads and between lintel depths.
- **f.** DR indicates design required.
- **g.** Lintel depth, \(D\), is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.
- **h.** Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.
- **i.** Allowable clear span without stirrups applicable to all lintels of the same depth, \(D\). Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than \(d/2\).
j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

k. Center distance, $A$, is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, $A$, shall be permitted to be multiplied by 1.10.

m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.

### TABLE R608.8(4)
MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS
ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET

<table>
<thead>
<tr>
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<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH, $f_y$ (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
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<tr>
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<td>1 2 3 4 5</td>
<td>Maximum ground snow load (psf)</td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 70 30 30 70 30 70 30 70</td>
<td></td>
</tr>
<tr>
<td>Span without stirrups</td>
<td>4-4 4-9 3-7 3-9 3-4 2-10 2-7 2-1 2-0</td>
<td>2-1 2-6 1-5 1-6 1-3 0-11 0-10 0-6 0-6</td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>40,000</td>
<td>4-4 4-9 3-7 3-9 3-4 2-10 2-7 2-1 2-0</td>
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<td>1-5</td>
<td>60,000</td>
<td>6-1 6-7 5-0 5-3 4-8 4-0 3-9 3-1 3-0</td>
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<tr>
<td>Span without stirrups</td>
<td>4-4 4-9 3-7 3-9 3-4 2-10 2-7 2-1 2-0</td>
<td>2-1 2-6 1-5 1-6 1-3 0-11 0-10 0-6 0-6</td>
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<td>Span without stirrups</td>
<td>4-4 4-9 3-7 3-9 3-4 2-10 2-7 2-1 2-0</td>
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<td>6-1 6-7 5-0 5-3 4-8 4-0 3-9 3-1 3-0</td>
<td></td>
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</table>

Center distance $A$, shall be

<table>
<thead>
<tr>
<th>LINTEL DEPTH, $D_d$ (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH, $f_y$ (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>1 2 3 4 5</td>
<td>Maximum ground snow load (psf)</td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 70 30 30 70 30 70 30 70</td>
<td></td>
</tr>
<tr>
<td>Span without stirrups</td>
<td>4-4 4-9 3-7 3-9 3-4 2-10 2-7 2-1 2-0</td>
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<td>Span without stirrups</td>
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<td>Span without stirrups</td>
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<td>2-1 2-6 1-5 1-6 1-3 0-11 0-10 0-6 0-6</td>
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<td>Span without stirrups</td>
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</tbody>
</table>

Center distance $A$, shall be
### TABLE R608.8(4)—continued

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS**

**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

<table>
<thead>
<tr>
<th>LINTEL DEPTH, (b^g) (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH, (f_y) (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum ground snow load (psf)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
<tr>
<td>20</td>
<td>span without stirrups(^{1, j})</td>
<td>7-10</td>
<td>9-10</td>
</tr>
<tr>
<td>1-#5</td>
<td>40,000</td>
<td>8-4</td>
<td>9-11</td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>10-2</td>
<td>12-1</td>
</tr>
<tr>
<td>2-#4</td>
<td>40,000</td>
<td>9-5</td>
<td>11-3</td>
</tr>
<tr>
<td>1-#6</td>
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<td>13-8</td>
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<tr>
<td>2-#5</td>
<td>40,000</td>
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<td>13-11</td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>16-4</td>
<td>19-5</td>
</tr>
<tr>
<td>2-#6</td>
<td>40,000</td>
<td>16-0</td>
<td>19-0</td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>19-3</td>
<td>22-11</td>
</tr>
<tr>
<td></td>
<td>Center distance (A^{k, l})</td>
<td>4-10</td>
<td>6-10</td>
</tr>
<tr>
<td></td>
<td>span without stirrups(^{1, j})</td>
<td>9-2</td>
<td>11-9</td>
</tr>
<tr>
<td>24</td>
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<td>8-11</td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>10-11</td>
<td>13-3</td>
</tr>
<tr>
<td>2-#4</td>
<td>40,000</td>
<td>10-1</td>
<td>12-3</td>
</tr>
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<td>1-#6</td>
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<td>12-3</td>
<td>15-0</td>
</tr>
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<td>2-#5</td>
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<td>12-6</td>
<td>15-3</td>
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<td>60,000</td>
<td>17-6</td>
<td>21-3</td>
</tr>
<tr>
<td>2-#6</td>
<td>40,000</td>
<td>17-2</td>
<td>20-11</td>
</tr>
</tbody>
</table>

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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa; Grade 60 = 420 MPa.

**Note:** Top and bottom reinforcement for lintels without stirrups shown in shaded cells shall be equal to or greater than that required for lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups.

a. See Table R608.3 for tolerances permitted from nominal thickness.

b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note j.

c. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $\frac{h}{d}$-inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads and between lintel depths.

f. DR indicates design required.

g. Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Allowable clear span without stirrups applicable to all lintels of the same depth, $D$. Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than $d/2$.

j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

k. Center distance, $A$, is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, $A$, shall be permitted to be multiplied by 1.10.

m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.

**TABLE R608.8(5)**

MAXIMUM ALLOWABLE CLEAR SPANS FOR 10-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS

ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET

<table>
<thead>
<tr>
<th>Lintel depth, $D$ (inches)</th>
<th>Number of bars and bar size in top and bottom of lintel</th>
<th>Steel yield strength, $f_y$ (psi)</th>
<th>Design loading condition determined from Table R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$h$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$y$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$f_y$ (psi)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum ground snow load (psf)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
<tr>
<td>Span without stirrups $i, j$</td>
<td>6-0</td>
<td>7-2</td>
<td>4-7</td>
</tr>
<tr>
<td>1-#4</td>
<td>40,000</td>
<td>4-3</td>
<td>4-9</td>
</tr>
<tr>
<td>1-#5</td>
<td>60,000</td>
<td>5-11</td>
<td>6-7</td>
</tr>
<tr>
<td>1-#6</td>
<td>60,000</td>
<td>7-4</td>
<td>8-1</td>
</tr>
<tr>
<td>2-#4</td>
<td>40,000</td>
<td>6-1</td>
<td>6-9</td>
</tr>
<tr>
<td>2-#5</td>
<td>60,000</td>
<td>8-2</td>
<td>9-1</td>
</tr>
</tbody>
</table>

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### TABLE R608.8(5)—continued

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 10-INCH-NOMINAL THICK FLAT LINTELS IN LOAD-BEARING WALLS**

**ROOF CLEAR SPAN 40 FEET AND FLOOR CLEAR SPAN 32 FEET**

<table>
<thead>
<tr>
<th>Lintel Depth, $D$ (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>Steel Yield Strength, $f_y$ (psi)</th>
<th>Design Loading Condition Determined from Table R608.8(1)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>8-7, 11-4, 8-1, 8-5, 7-5, 6-1, 5-9, 4-10, 4-9</td>
<td></td>
<td>Maximum ground snow load (psf)</td>
<td></td>
</tr>
<tr>
<td>Span without stirrups</td>
<td>40,000</td>
<td>6-5, 7-10, 6-2, 6-4, 5-9, 4-9, 3-8, 3-7</td>
<td>Maximum clear span of lintel (feet - inches)</td>
<td></td>
</tr>
<tr>
<td>1-#4</td>
<td>60,000</td>
<td>7-10, 9-7, 7-6, 7-9, 7-0, 5-10, 5-6, 4-5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
|     | 1-#5   | 2-#4   | 2-#6   | Center distance A
\(^{k, l}\) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1-#5</td>
<td>40,000</td>
<td>9-0</td>
<td>11-1</td>
<td>5-7</td>
</tr>
<tr>
<td></td>
<td>99</td>
<td>11-1</td>
<td>9-4</td>
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<tr>
<td>2-#5</td>
<td>40,000</td>
<td>11-0</td>
<td>13-6</td>
<td>6-1</td>
</tr>
<tr>
<td></td>
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<td>10-6</td>
<td>10-11</td>
<td>5-0</td>
</tr>
<tr>
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<td>9-4</td>
<td>8-2</td>
<td>5-0</td>
</tr>
<tr>
<td>2-#6</td>
<td>40,000</td>
<td>15-5</td>
<td>18-10</td>
<td>5-7</td>
</tr>
<tr>
<td></td>
<td>18-10</td>
<td>14-8</td>
<td>13-9</td>
<td>6-3</td>
</tr>
<tr>
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<td>6-3</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>7-5</td>
<td>1-9</td>
<td>1-9</td>
<td>6-3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

**Note:** Top and bottom reinforcement for lintels without stirrups shown in shaded cells shall be equal to or greater than that required for lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups.

a. See Table R608.3 for tolerances permitted from nominal thickness.

b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note j.

c. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is \(L/240\), where \(L\) is the clear span of the lintel in inches, or \(d/2\) -inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads and between lintel depths.

f. DR indicates design required.

g. Lintel depth, \(D\), is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Allowable clear span without stirrups applicable to all lintels of the same depth, \(D\). Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than \(d/2\).

j. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

k. Center distance, \(A\), is the center portion of the clear span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.
I. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, \( A \), shall be permitted to be multiplied by 1.10.

m. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel clear spans in the table greater than 18 feet are shown for interpolation and information only.

### TABLE R608.8(6)

**MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS**

**MAXIMUM ROOF CLEAR SPAN 40 FEET AND MAXIMUM FLOOR SPAN 32 FEET**

<table>
<thead>
<tr>
<th>LINTEL DEPTH, ( D ) (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH ( f_y ) (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Span without stirrups</td>
<td></td>
<td>Maximum ground snow load (psf)</td>
</tr>
<tr>
<td></td>
<td>( k, l )</td>
<td></td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
<tr>
<td></td>
<td>1-#4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-#4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#6</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Center distance ( A )</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Span without stirrups</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( k, l )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#4</td>
<td></td>
<td></td>
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<tr>
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<td>1-#5</td>
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</tr>
<tr>
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<td>2-#4</td>
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<td></td>
<td>1-#6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Center distance ( A )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Span without stirrups</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( k, l )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Linel Depth, ( D ) (inches)</th>
<th>Number of Bars and Bar Size in Top and Bottom of Lintel</th>
<th>Steel Yield Strength ( f_y ) (psi)</th>
<th>Design Loading Condition Determined From Table R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Span without stirrups</td>
<td></td>
<td>Maximum ground snow load (psf)</td>
</tr>
<tr>
<td></td>
<td>( k, l )</td>
<td></td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
<tr>
<td></td>
<td>1-#4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-#4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Center distance ( A )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Span without stirrups</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( k, l )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### TABLE R608.8(6)—continued
MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS
MAXIMUM ROOF CLEAR SPAN 40 FEET AND MAXIMUM FLOOR SPAN 32 FEET

<table>
<thead>
<tr>
<th>LINTEL DEPTH, $D^g$ (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH $f_y$ (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Span without stirrups $k, l$</td>
<td>$f_y$</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>24 j w</td>
<td></td>
<td>Maximum ground snow load (psf)</td>
</tr>
<tr>
<td></td>
<td>1-#4</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>10-3 11-5 8-9 9-1 8-2 7-8 7-1 6-0 5-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#5</td>
<td>14-3 15-11 11-9 12-5 10-8 9-9 8-9 7-1 6-10</td>
<td></td>
</tr>
<tr>
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<td>60,000</td>
<td>14-6 16-3 11-6 12-1 10-4 9-6 8-6 6-11 6-8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-#4</td>
<td>16-3 17-11 12-8 13-4 11-6 10-7 9-7 7-10 7-7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-#6</td>
<td>DR DR DR DR DR DR DR DR DR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-#5</td>
<td>DR DR DR DR DR DR DR DR DR</td>
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</tr>
<tr>
<td></td>
<td>60,000</td>
<td>DR DR DR DR DR DR DR DR DR</td>
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</tr>
<tr>
<td></td>
<td>Center distance $A^m, n$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-#4</td>
<td>2-4 3-0 1-9 1-11 1-6 1-4 1-2 STL STL</td>
<td></td>
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<td></td>
<td>1-#5</td>
<td>14-3 15-11 11-9 12-5 10-8 9-9 8-9 7-1 6-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60,000</td>
<td>14-6 16-3 11-6 12-1 10-4 9-6 8-6 6-11 6-8</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 foot = 304.8 mm, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. Where lintels are formed with waffle-grid forms, form material shall be removed, if necessary, to create top and bottom flanges of the lintel that are not less than 3 inches in depth (in the vertical direction), are not less than 5 inches in width for 6-inch-nominal waffle-grid forms and not less than 7 inches in width for 8-inch-nominal waffle-grid forms. See Figure R608.8(3). Flat form lintels shall be permitted in place of waffle-grid lintels. See Tables R608.8(2) through R608.8(5).

b. See Table R608.3 for tolerances permitted from nominal thicknesses and minimum dimensions and spacing of cores.

c. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Notes l and n. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $1/2$-inch, whichever is less.
e. Linear interpolation is permitted between ground snow loads.
f. DR indicates design required. STL - stirrups required throughout lintel.
g. Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.
h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.
i. Lintels less than 24 inches in depth with stirrups shall be formed from flat-walls forms [see Tables R608.8(2) through R608.8(5)], or, if necessary, form material shall be removed from waffle-grid forms so as to provide the required cover for stirrups. Allowable spans for lintels formed with flat-wall forms shall be determined from Tables R608.8(2) through R608.8(5).
j. Where stirrups are required for 24-inch deep lintels, the spacing shall not exceed 12 inches on center.
k. Allowable clear span without stirrups applicable to all lintels of the same depth, $D$. Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than $d/2$.
l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.
m. Center distance, $A$, is the center portion of the span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.
n. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, $A$, shall be permitted to be multiplied by 1.10.
o. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information only.

### TABLE R608.8(7)
**MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS, a, b, c, d, e, f, o**

<table>
<thead>
<tr>
<th>LINTEL DEPTH, $D$ (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH $f_y$ (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td>Maximum ground snow load (psf)</td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>8</td>
<td>Span with stirrups</td>
<td>k, l</td>
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<tr>
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<td>1-#4</td>
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<td>4-5</td>
</tr>
<tr>
<td></td>
<td>1-#5</td>
<td>60,000</td>
<td>5-6</td>
</tr>
<tr>
<td></td>
<td>Center distance $A$</td>
<td>m, n</td>
<td>0-9</td>
</tr>
<tr>
<td>12</td>
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<td>6-11</td>
</tr>
<tr>
<td></td>
<td>1-#6</td>
<td>40,000</td>
<td>8-8</td>
</tr>
<tr>
<td></td>
<td>Center distance $A$</td>
<td>m, n</td>
<td>1-2</td>
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</table>

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### Table R608.8(7)—continued
**MAXIMUM ALLOWABLE CLEAR SPANS FOR 8-INCH-THICK WAFFLE-GRID LINTELS IN LOAD-BEARING WALLS**

**MAXIMUM ROOF CLEAR SPAN 40 FEET AND MAXIMUM FLOOR CLEAR SPAN 32 FEET**

<table>
<thead>
<tr>
<th>LINTEL DEPTH, $D^g$ (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH $f_y$ (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Span without stirrups $^k, l$</td>
<td>$3-10$</td>
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<tr>
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<td>9-0</td>
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<tr>
<td></td>
<td>1-#6</td>
<td>60,000</td>
<td>11-5</td>
</tr>
<tr>
<td></td>
<td>Center distance $A^m, n$</td>
<td>1-6</td>
<td>1-11</td>
</tr>
<tr>
<td>20</td>
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<td>7-0</td>
</tr>
<tr>
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<td>1-#5</td>
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<td>8-7</td>
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<tr>
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<td>2-#4</td>
<td>40,000</td>
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<tr>
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<td>1-#6</td>
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</tr>
<tr>
<td></td>
<td>Center distance $A^m, n$</td>
<td>1-10</td>
<td>2-5</td>
</tr>
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</table>

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### TABLE R608.8(8)
MAXIMUM ALLOWABLE CLEAR SPANS FOR 6-INCH-THICK SCREEN-GRID LINTELS IN LOAD-BEARING WALLS

<table>
<thead>
<tr>
<th>LINTEL DEPTH, D (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE IN TOP AND BOTTOM OF LINTEL</th>
<th>STEEL YIELD STRENGTH fy (psi)</th>
<th>DESIGN LOADING CONDITION DETERMINED FROM TABLE R608.8(1)</th>
</tr>
</thead>
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<td></td>
<td></td>
<td></td>
<td>Maximum ground snow load (psf)</td>
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<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum clear span of lintel (feet - inches)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 foot = 304.8 mm, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. Where lintels are formed with waffle-grid forms, form material shall be removed, if necessary, to create top and bottom flanges of the lintel that are not less than 3 inches in depth (in the vertical direction), are not less than 5 inches in width for 6-inch-nominal waffle-grid forms and not less than 7 inches in width for 8-inch-nominal waffle-grid forms. See Figure R608.8(3). Flat form lintels shall be permitted in lieu of waffle-grid lintels. See Tables R608.8(2) through R608.8(5).

b. See Table R608.3 for tolerances permitted from nominal thicknesses and minimum dimensions and spacing of cores.

c. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Notes I and n. Table values are based on uniform loading. See Section R608.8.2 for lintels supporting concentrated loads.

d. Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $1/2$-inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads.

f. DR indicates design required. STL - stirrups required throughout lintel.

g. Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Lintels less than 24 inches in depth with stirrups shall be formed from flat-walls forms [see Tables R608.8(2) through R608.8(5)], or, if necessary, form material shall be removed from waffle-grid forms so as to provide the required cover for stirrups. Allowable spans for lintels formed with flat-wall forms shall be determined from Tables R608.8(2) through R608.8(5).

j. Where stirrups are required for 24-inch deep lintels, the spacing shall not exceed 12 inches on center.

k. Allowable clear span without stirrups applicable to all lintels of the same depth, $D$. Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than $d/2$.

l. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

m. Center distance, $A$, is the center portion of the span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

n. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, $A$, shall be permitted to be multiplied by 1.10.

o. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information only.
For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 foot = 304.8 mm, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. Where lintels are formed with screen-grid forms, form material shall be removed if necessary to create top and bottom flanges of the lintel that are not less than 5 inches in width and not less than 2.5 inches in depth (in the vertical direction). See Figure R608.8(4). Flat form lintels shall be permitted in lieu of screen-grid lintels. See Tables R608.8(2) through R608.8(5).

b. See Table R608.3 for tolerances permitted from nominal thickness and minimum dimensions and spacings of cores.

c. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Notes m and o. Table values are based on uniform loading. See Section R608.7.2.1 for lintels supporting concentrated loads.

d. Deflection criterion is \( L/240 \), where \( L \) is the clear span of the lintel in inches, or \( \frac{L}{2} \) -inch, whichever is less.

e. Linear interpolation is permitted between ground snow loads.

f. DR indicates design required. STL indicates stirrups required throughout lintel.

Table R608.8(2) through R608.8(5), form material shall be removed from screen-grid forms to provide a concrete core. See Figure R608.8(4). Flat form lintels shall be permitted in lieu of screen-grid lintels. See Figure R608.8(4).

g. Lintel depth, \( D \), is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

h. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.

i. Stirrups are not required for lintels less than 24 inches in depth fabricated from screen-grid forms. Top and bottom reinforcement shall consist of a No. 4 bar having a yield strength of 40,000 psi or 60,000 psi.

j. Lintels between 12 and 24 inches in depth with stirrups shall be formed from flat-wall forms [see Tables R608.8(2) through R608.8(5)], or form material shall be removed from screen-grid forms to provide a concrete section comparable to that required for a flat wall. Allowable spans for flat lintels with stirrups shall be determined from Tables R608.8(2) through R608.8(5).

k. Where stirrups are required for 24-inch deep lintels, the spacing shall not exceed 12 inches on center.

l. Allowable clear span without stirrups applicable to all lintels of the same depth, \( D \). Top and bottom reinforcement for lintels without stirrups shall be not less than the least amount of reinforcement required for a lintel of the same depth and loading condition with stirrups. All other spans require stirrups spaced at not more than 12 inches.

m. Where concrete with a minimum specified compressive strength of 3,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without stirrups that has been increased.

n. Center distance, \( A \), is the center portion of the span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.

---

<table>
<thead>
<tr>
<th></th>
<th>Span without stirrups</th>
<th>2-9</th>
<th>2-11</th>
<th>2-4</th>
<th>2-5</th>
<th>2-3</th>
<th>2-2</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|   | Span without stirrups | l, m | 5-8 | 6-3 | 5-2 | 5-3 | 5-0 | 4-10 | 4-8 | 4-4 | 4-4 |
|---|-----------------------|------|-----|-----|-----|-----|-----|------|-----|-----|
| 1-#4 |                      | 40,000 | 7-11 | 9-0 | 6-11 | 7-2 | 6-5 | 6-1 | 5-8 | 4-9 | 4-7 |
| 1-#5 |                      | 60,000 | 9-9 | 11-0 | 8-5 | 8-9 | 7-10 | 7-5 | 6-10 | 5-9 | 5-7 |
| 2-#4 |                      | 40,000 | 11-2 | 12-8 | 9-9 | 10-1 | 9-1 | 8-7 | 7-11 | 6-8 | 6-6 |
| 1-#6 |                      | 60,000 | 15-7 | 17-7 | 12-8 | 13-4 | 11-6 | 10-8 | 9-8 | 7-11 | 7-8 |
| 2-#5 |                      | 40,000 | 14-11 | 18-0 | 12-2 | 12-10 | 11-1 | 10-3 | 9-4 | 7-8 | 7-5 |
|     | 60,000 | DR | DR | DR | DR | DR | DR | DR | DR |

Center distance \( A \) | \( n, o \) | 2-0 | 2-6 | 1-6 | 1-7 | 1-4 | 1-2 | 1-0 |
|---|---------|-----|-----|-----|-----|-----|-----|-----|
|   | STL | STL |!
o. Where concrete with a minimum specified compressive strength of 3,000 psi is used, center distance, $A$, shall be permitted to be multiplied by 1.10.

p. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information only.

**TABLE R608.8(9)**

**MAXIMUM ALLOWABLE CLEAR SPANS FOR FLAT LINTELS WITHOUT STIRRUPS IN NONLOAD-BEARING WALLS**

<table>
<thead>
<tr>
<th>LINTEL DEPTH, $D$ (inches)</th>
<th>NUMBER OF BARS AND BAR SIZE</th>
<th>STEEL YIELD STRENGTH, $f_y$ (psi)</th>
<th>NOMINAL WALL THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Concrete Wall</td>
<td>Light-framed Gable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lintel Supporting</td>
<td>Maximum Clear Span of Lintel (feet - inches)</td>
</tr>
</tbody>
</table>

(continued)
### TABLE R608.8(9)—continued

**MAXIMUM ALLOWABLE CLEAR SPANS FOR FLAT LINTELS WITHOUT STIRRUPS IN NONLOAD-BEARING WALLS**

<table>
<thead>
<tr>
<th>Lintel Depth, (D) (inches)</th>
<th>Number of Bars and Bar Size</th>
<th>Steel Yield Strength, (f_y) (psi)</th>
<th>NOMINAL WALL THICKNESS (inches)</th>
<th>Light-framed Gable</th>
<th>Concrete Wall</th>
<th>Light-framed Gable</th>
<th>Concrete Wall</th>
<th>Light-framed Gable</th>
<th>Concrete Wall</th>
<th>Light-framed Gable</th>
<th>Concrete Wall</th>
<th>Light-framed Gable</th>
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<td></td>
<td></td>
<td>4</td>
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<tr>
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<td>17-1</td>
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<td>12-7</td>
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<tr>
<td></td>
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<td>18-5</td>
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<tr>
<td>2-#4</td>
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<td>60,000</td>
<td>16-11</td>
<td>18-5</td>
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<td>17-8</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

a. See Table R608.3 for tolerances permitted from nominal thickness.
b. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note e.
c. Deflection criterion is \(L/240\), where \(L\) is the clear span of the lintel in inches, or \(1/2\) inch, whichever is less.
d. Linear interpolation between lintels depths, \(D\), is permitted provided the two cells being used to interpolate are shaded.
e. Where concrete with a minimum specified compressive strength of 3,000 psi is used, spans in cells that are shaded shall be permitted to be multiplied by 1.05.
f. Lintel depth, \(D\), is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.
g. DR indicates design required.
h. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section R608.7.2.1. Lintel spans in the table greater than 18 feet are shown for interpolation and information purposes only.

### TABLE R608.8(10)

**MAXIMUM ALLOWABLE CLEAR SPANS FOR WAFFLE-GRID AND SCREEN-GRID LINTELS WITHOUT STIRRUPS IN NONLOAD-BEARING WALLS**

<table>
<thead>
<tr>
<th>FORM TYPE AND NOMINAL WALL THICKNESS (inches)</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
### Table: Lintel Depth and Clear Span

<table>
<thead>
<tr>
<th>Lintel Depth, $D$ (inches)</th>
<th>6-inch Waffle-grid$^a$</th>
<th>8-inch Waffle-grid$^a$</th>
<th>6-inch Screen-grid$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concrete Wall</td>
<td>Light-framed Gable</td>
<td>Concrete Wall</td>
</tr>
<tr>
<td>8</td>
<td>10-3</td>
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<tr>
<td>24</td>
<td>13-9</td>
<td>14-2</td>
<td>11-10</td>
</tr>
</tbody>
</table>

**For SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, Grade 40 = 280 MPa, Grade 60 = 420 MPa.

- **a.** Where lintels are formed with waffle-grid forms, form material shall be removed, if necessary, to create top and bottom flanges of the lintel that are not less than 3 inches in depth (in the vertical direction), are not less than 5 inches in width for 6-inch waffle-grid forms and not less than 7 inches in width for 8-inch waffle-grid forms. See Figure R608.8(3). Flat form lintels shall be permitted in lieu of waffle-grid lintels. See Tables R608.8(2) through R608.8(5).
- **b.** Where lintels are formed with screen-grid forms, form material shall be removed if necessary to create top and bottom flanges of the lintel that are not less than 5 inches in width and not less than 2.5 inches in depth (in the vertical direction). See Figure R608.8(4). Flat form lintels shall be permitted in lieu of screen-grid lintels. See Tables R608.8(2) through R608.8(5).
- **c.** See Table R608.3 for tolerances permitted from nominal thickness and minimum dimensions and spacing of cores.
- **d.** Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See Note g.
- **e.** Deflection criterion is $L/240$, where $L$ is the clear span of the lintel in inches, or $1/2$ inch, whichever is less.
- **f.** Top and bottom reinforcement shall consist of a No. 4 bar having a minimum yield strength of 40,000 psi.
- **g.** Where concrete with a minimum specified compressive strength of 3,000 psi is used, spans in shaded cells shall be permitted to be multiplied by 1.05.
- **h.** Lintel depth, $D$, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.

### R608.8 Reinforcement around openings.

Reinforcement shall be provided around openings in walls equal to or greater than 2 feet (610 mm) in width in accordance with this section and Figure R608.8(1), in addition to the minimum wall reinforcement required by Sections R404.1.3, R608.6 and R608.7. Vertical wall reinforcement required by this section is permitted to be used as reinforcement at the ends of solid wall segments required by Section R608.7.2.2.2 provided it is located in accordance with Section R608.8.1.2. Wall openings shall have a minimum depth of concrete over the width of the opening of 8 inches (203 mm) in flat walls and waffle-grid walls, and 12 inches (305 mm) in screen-grid walls. Wall openings in waffle-grid and screen-grid walls shall be located such that not less than one-half of a vertical core occurs along each side of the opening.

**R608.8.1.1 Horizontal reinforcement.**

Lintels complying with Section R608.8.2 shall be provided above wall openings equal to or greater than 2 feet (610 mm) in width.

**Exception:** Continuous horizontal wall reinforcement placed within 12 inches (305 mm) of the top of the wall story as required in Sections R404.1.2.2 and R608.6.2 is permitted in lieu of top or bottom lintel reinforcement required by Section R608.8.2 provided that the continuous horizontal wall reinforcement meets the location...
requirements specified in Figures R608.8(2), R608.8(3), and R608.8(4) and the size requirements specified in Tables R608.8(2) through R608.8(10).

Openings equal to or greater than 2 feet (610 mm) in width shall have not less than one No. 4 bar placed within 12 inches (305 mm) of the bottom of the opening. See Figure R608.8(1).

Horizontal reinforcement placed above and below an opening shall extend beyond the edges of the opening the dimension required to develop the bar in tension in accordance with Section R608.5.4.4.

R608.8.1.2 Vertical reinforcement.
Not less than one No. 4 bar [Grade 40 (280 MPa)] shall be provided on each side of openings equal to or greater than 2 feet (610 mm) in width. The vertical reinforcement required by this section shall extend the full height of the wall story and shall be located within 12 inches (305 mm) of each side of the opening. The vertical reinforcement required on each side of an opening by this section is permitted to serve as reinforcement at the ends of solid wall segments in accordance with Section R608.7.2.2.2, provided it is located as required by the applicable detail in Figure R608.7(2). Where the vertical reinforcement required by this section is used to satisfy the requirements of Section R608.7.2.2.2 in waffle- and screen-grid walls, a concrete flange shall be created at the ends of the solid wall segments in accordance with Table R608.7(4), Note e. In the top-most story, the reinforcement shall terminate in accordance with Section R608.6.4.

R608.8.2 Lintels.
Lintels shall be provided over all openings equal to or greater than 2 feet (610 mm) in width. Lintels with uniform loading shall conform to Sections R608.8.2.1 and R608.8.2.2, or Section R608.8.2.3. Lintels supporting concentrated loads, such as from roof or floor beams or girders, shall be designed in accordance with ACI 318.

R608.8.2.1 Lintels designed for gravity load-bearing conditions.
Where a lintel will be subjected to gravity load condition 1 through 5 of Table R608.8(1), the clear span of the lintel shall not exceed that permitted by Tables R608.8(2) through R608.8(8). The maximum clear span of lintels with and without stirrups in flat walls shall be determined in accordance with Tables R608.8(2) through R608.8(5), and constructed in accordance with Figure R608.8(2). The maximum clear span of lintels with and without stirrups in waffle-grid walls shall be determined in accordance with Tables R608.8(6) and R608.8(7), and constructed in accordance with Figure R608.8(3). The maximum clear span of lintels with and without stirrups in screen-grid walls shall be determined in accordance with Table R608.8(8), and constructed in accordance with Figure R608.8(4).

Where required by the applicable table, No. 3 stirrups shall be installed in lintels at a maximum spacing of \(d/2\) where \(d\) equals the depth of the lintel, \(D\), less the cover of the concrete as shown in Figures R608.8(2) through R608.8(4). The smaller value of \(d\) computed for the top and bottom bar shall be used to determine the maximum stirrup spacing. Where stirrups are required in a lintel with a single bar or two bundled bars in the top and bottom, they shall be fabricated like the letter “c” or “s” with 135-degree (2.36 rad) standard hooks at each end that comply with Section R608.5.4.5 and Figure
R608.5.4(3) and installed as shown in Figures R608.8(2) through R608.8(4). Where two bars are required in the top and bottom of the lintel and the bars are not bundled, the bars shall be separated by not less than 1 inch (25 mm). The free end of the stirrups shall be fabricated with 90- or 135-degree (1.57 or 2.36 rad) standard hooks that comply with Section R608.5.4.5 and Figure R608.5.4(3) and installed as shown in Figures R608.8(2) and R608.8(3). For flat, waffle-grid and screen-grid lintels, stirrups are not required in the center distance, A, portion of spans in accordance with Figure R608.8(1) and Tables R608.8(2) through R608.8(8). See Section R608.8.2.2, Item 5, for requirement for stirrups through out lintels with bundled bars.

**R608.8.2.2 Bundled bars in lintels.**

It is permitted to bundle two bars in contact with each other in lintels if all of the following are observed:

1. Bars equal to or less than No. 6 are bundled.

2. Where the wall thickness is not sufficient to provide not less than 3 inches (76 mm) of clear space beside bars (total on both sides) oriented horizontally in a bundle, the bundled bars shall be oriented in a vertical plane.

3. Where vertically oriented bundled bars terminate with standard hooks to develop the bars in tension beyond the support (see Section R608.5.4.4), the hook extensions shall be staggered to provide not less than 1 inch (25 mm) clear spacing between the extensions.

4. Bundled bars shall not be lap spliced within the lintel span and the length on each end of the lintel that is required to develop the bars in tension.

5. Bundled bars shall be enclosed within stirrups throughout the length of the lintel. Stirrups and the installation thereof shall comply with Section R608.8.2.1.

**R608.8.2.3 Lintels without stirrups designed for nonload-bearing conditions.**

The maximum clear span of lintels without stirrups designed for nonload-bearing conditions of Table R608.8(1).1 shall be determined in accordance with this section. The maximum clear span of lintels without stirrups in flat walls shall be determined in accordance with Table R608.8(9), and the maximum clear span of lintels without stirrups in walls of waffle-grid or screen-grid construction shall be determined in accordance with Table R608.8(10).

**R608.9 Requirements for connections—general.**

Concrete walls shall be connected to footings, floors, ceilings and roofs in accordance with this section.
FIGURE R608.9(1)
WOOD-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PERPENDICULAR

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.
TABLE R608.9(1)
WOOD-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PERPENDICULAR \(^{a, b}\)

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115B  120B  130B  140B  150B  160B</td>
</tr>
<tr>
<td></td>
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<td>110C  119C  127C  136C</td>
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<td>110D  117D  125D</td>
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<td>48</td>
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<td>32</td>
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<td>19.2</td>
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</tr>
<tr>
<td>19.2</td>
<td>38.4</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(1). Use of this detail is permitted where a cell is not shaded and prohibited where shaded.

b. Wall design per other provisions of Section R608 is required.
FIGURE R608.9(2)
WOOD-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PARALLEL

TABLE R608.9(2)
WOOD-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PARALLEL\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>12</td>
<td>115b 120B 130B 140B 150B 160B 110C 119C 127C 136C 110D 117D 125D</td>
</tr>
<tr>
<td>12</td>
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<td>19.2</td>
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<tr>
<td>24</td>
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</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

\textsuperscript{a} This table is for use with the detail in Figure R608.9(2). Use of this detail is permitted where a cell is not shaded and prohibited where shaded.

\textsuperscript{b} Wall design per other provisions of Section R608 is required.
FIGURE R608.9(3)
WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL FRAMING, PERPENDICULAR
### TABLE R608.9(3)
**WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR**

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115B</td>
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<tr>
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<tr>
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<tr>
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<td>38.4</td>
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<tr>
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<td>24</td>
<td>6A</td>
</tr>
<tr>
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<td>48</td>
<td>6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(3). Use of this detail is permitted where cell is not shaded.
b. Wall design per other provisions in Section R608 is required.
c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.
d. Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(3). For the remainder of the wall, see Note b.
e. Letter “A” indicates that a minimum nominal 3 x 6 sill plate is required. Letter “B” indicates that a 5/8-inch-diameter anchor bolt and a minimum nominal 3 x 6 sill plate are required.
FIGURE R608.9(4)
WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PARALLEL

TABLE R608.9(4)

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound-force = 4.448 N.
## WOOD-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PARALLEL

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY</th>
</tr>
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<tbody>
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<tr>
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<tr>
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<tr>
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<td>48</td>
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For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(4). Use of this detail is permitted where a cell is not shaded.

b. Wall design per other provisions of Section R608 is required.

c. For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.

d. Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(4). For the remainder of the wall, see Note b.

e. Letter “A” indicates that a minimum nominal 3 × 6 sill plate is required. Letter “B” indicates that a 5/8-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.
For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.

**FIGURE R608.9(5)**
**COLD-FORMED STEEL FLOOR TO SIDE OF CONCRETE WALL, FRAMING**

2018 North Carolina Residential Code
**TABLE R608.9(5)**

COLD-FORMED STEEL-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING PERPENDICULAR

<table>
<thead>
<tr>
<th>Anchor Bolt Spacing (inches)</th>
<th>Tension Tie Spacing (inches)</th>
<th>Basic Wind Speed (mph) and Wind Exposure Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115B  120B  130B  140B  150B  160B</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>-     -     -     -     -     -</td>
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<td>48</td>
<td>-     -     -     -     -     -</td>
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<td>-     -     -     -     -     -</td>
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<td>-     -     -     -     -     -</td>
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<td>-     -     -     -     -     -</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.4470 m/s.

- **a.** This table is for use with the detail in Figure R608.9(5). Use of this detail is permitted where a cell is not shaded.
- **b.** Wall design per other provisions of Section R608 is required.
- **c.** For wind design, minimum 4-inch nominal wall is permitted in unshaded cells that do not contain a number.
FIGURE R608.9(6)
COLD-FORMED STEEL FLOOR TO SIDE OF CONCRETE WALL, FRAMING PARALLEL

TABLE R608.9(6)
COLD-FORMED STEEL-FRAMED FLOOR TO SIDE OF CONCRETE WALL, FRAMING
<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>115B</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.
a. This table is for use with the detail in Figure R608.9(6). Use of this detail is permitted where a cell is not shaded.
b. Wall design per other provisions of Section R608 is required.
c. For wind design, minimum 4-inch nominal wall is permitted in unshaded cells that do not contain a number.
**TABLE R608.9(7)**
COLD-FORMED STEEL-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED AND WIND EXPOSURE CATEGORY (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>115B</td>
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<tr>
<td>12</td>
<td>12</td>
<td>-</td>
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<td>24</td>
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</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(7). Use of this detail is permitted where a cell is not shaded.
b. Wall design per other provisions of Section R608 is required.
c. For wind design, minimum 4-inch nominal wall is permitted in unshaded cells that do not contain a number.
d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(7). For the remainder of the wall, see Note b.
e. Letter "A" indicates that a minimum nominal 3 × 6 sill plate is required. Letter "B" indicates that a 5/8-inch diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.
FIGURE R608.9(8)
COLD-FORMED STEEL FLOOR TO TOP OF CONCRETE WALL, FRAMING PARALLEL

TABLE R608.9(8)
COLD-FORMED STEEL-FRAMED FLOOR TO TOP OF CONCRETE WALL, FRAMING PARALLEL

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED AND WIND EXPOSURE CATEGORY (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>19.2</td>
<td>19.2</td>
<td>6A</td>
</tr>
<tr>
<td>19.2</td>
<td>38.4</td>
<td>6</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>6A</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(8). Use of this detail is permitted where a cell is not shaded.
b. Wall design per other provisions of Section R608 is required.
c. For wind design, minimum 4-inch nominal wall is permitted in unshaded cells that do not contain a number.
d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(8). For the remainder of the wall, see Note b.
e. Letter “A” indicates that a minimum nominal 3 × 6 sill plate is required. Letter “B” indicates that a 5/8-inch-diameter anchor bolt and a minimum nominal 3 × 6 sill plate are required.
### FIGURE R608.9(95)
WOOD-FRAMED ROOF TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR

### TABLE R608.9(95)
WOOD-FRAMED ROOF TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115B 120B 130B 140B 150B 160B 110C 119C 127C 136C 110D 117D 125D</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td>6 6</td>
</tr>
<tr>
<td>12</td>
<td>48</td>
<td>6 6</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>6 6</td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td>6 6</td>
</tr>
<tr>
<td>16</td>
<td>48</td>
<td>6 6</td>
</tr>
<tr>
<td>19.2</td>
<td>19.2</td>
<td>6 6</td>
</tr>
<tr>
<td>19.2</td>
<td>38.4</td>
<td>6 6</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>24</td>
<td>48</td>
<td>6 8B</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

- **a.** This table is for use with the detail in Figure R608.9(95). Use of this detail is permitted where cell a is not shaded, prohibited where shaded.
- **b.** Wall design per other provisions of Section R608 is required.
- **c.** For wind design, minimum 4-inch-nominal wall is permitted in unshaded cells that do not contain a number.
- **d.** Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(95). For the remainder of the wall, see Note b.
- **e.** Letter “B” indicates that a 5/8-inch-diameter anchor bolt and a minimum nominal 3 x 6 sill plate are required.
2x FULL DEPTH BLOCKING, TWO BAYS MINIMUM AT EACH TENSION TIE. PROVIDE 43 MIL MINIMUM CLIP ANGLE EACH END WITH NOT LESS THAN 4-10d COMMON NAILS EACH LOG

SECTION

8 IN. MINIMUM WITH WEB MATERIAL REMOVED

7 IN. MIN.

CEILING DIAPHRAGM SHEATHING

43 MIL CONTINUOUS ANGLE WITH 10d COMMON NAILS AT BOUNDARY NAIL SPACING THROUGH SHEATHING TO JOIST AND HORIZONTAL TO SILL PLATE. SEE TABLE R602.3(1)

¾ IN. DIAMETER ANCHOR BOLTS TYPICAL. ¾ IN. WHERE REQUIRED. SEE TABLE R602.3(1) FOR SIZE AND SPACING.

TENSION TIE STRAP UNDER BLOCKING

BLOCKING

JOISTS

TENSION TIE STRAP UNDER BLOCKING

ANCHOR BOLT WITH ¼ X 3 STEEL PLATE WASHER. SEE TABLE R608.9(10) FOR SPACING

FIGURE R608.9(106)
WOOD-FRAMED ROOF TO TOP OF CONCRETE WALL, FRAMING PARALLEL

TABLE R608.9(106)

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.
## Wood-Framed Roof to Top of Concrete Wall, Framing Parallel

<table>
<thead>
<tr>
<th>Anchor Bolt Spacing (inches)</th>
<th>Tension Tie Spacing (inches)</th>
<th>Basic Wind Speed (mph) and Wind Exposure Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115B</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>48</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>19.2</td>
<td>19.2</td>
<td></td>
</tr>
<tr>
<td>19.2</td>
<td>38.4</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>48</td>
<td>6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(106). Use of this detail is permitted where a cell is not shaded, prohibited where shaded.

b. Wall design per other provisions of Section R608 is required.

c. For wind design, minimum 4-inch-nominal wall is permitted in cells that do not contain a number.

d. Numbers 6 and 8 indicate minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(106). For the remainder of the wall, see Note b.

e. Letter “B” indicates that a \( \frac{5}{8} \)-inch-diameter anchor bolt and a minimum nominal 3 \( \times \) 6 sill plate are required.
FIGURE R608.9(11)
COLD-FORMED STEEL ROOF TO TOP OF CONCRETE WALL, FRAMING PERPENDICULAR

TABLE R608.9(11)
COLD-FORMED STEEL ROOF TO TOP OF CONCRETE WALL, FRAMING
### PERPENDICULAR

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION-TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110C</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>19.2</td>
<td>19.2</td>
<td></td>
</tr>
<tr>
<td>19.2</td>
<td>38.4</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.
a. This table is for use with the detail in Figure R608.9(11). Use of this detail is permitted where a cell is not shaded.
b. Wall design per other provisions of Section R608 is required.
c. For wind design, minimum 4-inch nominal wall is permitted in unshaded cells that do not contain a number.
d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(11). For the remainder of the wall, see Note b.
e. Letter “A” indicates that a minimum nominal 3 x 6 sill plate is required. Letter “B” indicates that a 5/8-inch-diameter anchor bolt and a minimum nominal 3 x 6 sill plate are required.
FIGURE R608.9(12)
COLD-FORMED STEEL ROOF TO TOP OF CONCRETE WALL, FRAMING PARALLEL

TABLE R608.9(12)
COLD-FORMED STEEL ROOF TO TOP OF CONCRETE WALL, FRAMING PARALLEL

---

For SI: 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 pound-force = 4.448 N.
### Anchor Bolt Spacing and Tension Tie Spacing

<table>
<thead>
<tr>
<th>ANCHOR BOLT SPACING (inches)</th>
<th>TENSION TIE SPACING (inches)</th>
<th>BASIC WIND SPEED (mph) AND WIND EXPOSURE CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>115B</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>16</td>
<td>24</td>
<td>-</td>
</tr>
<tr>
<td>19.2</td>
<td>19.2</td>
<td>-</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>-</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. This table is for use with the detail in Figure R608.9(12). Use of this detail is permitted where a cell is not shaded.
b. Wall design per other provisions of Section R608 is required.
c. For wind design, minimum 4-inch nominal wall is permitted in cells that do not contain a number.
d. Number 6 indicates minimum permitted nominal wall thickness in inches necessary to develop required strength (capacity) of connection. As a minimum, this nominal thickness shall occur in the portion of the wall indicated by the cross-hatching in Figure R608.9(12). For the remainder of the wall, see Note b.
e. Letter “B” indicates that a 5/8-inch-diameter anchor bolt is required.

### R608.9.1 Connections between concrete walls and light-framed floor, ceiling and roof systems.

Connections between concrete walls and light-framed floor, ceiling and roof systems using the prescriptive details of Figures R608.9(1) through R608.9(6) R608.9(12) shall comply with this section and Sections R608.9.2 and R608.9.3.

#### R608.9.1.1 Anchor bolts.

Anchor bolts used to connect light-framed floor, ceiling and roof systems to concrete walls in accordance with Figures R608.9(1) through R608.9(6) R608.9(12) shall have heads, or shall be rods with threads on both ends with a hex or square nut on the end embedded in the concrete. Bolts and threaded rods shall comply with Section R608.5.2.2. Anchor bolts with J- or L-hooks shall not be used where the connection details in these figures are used.

#### R608.9.1.2 Removal of stay-in-place form material at bolts.

Holes in stay-in-place forms for installing bolts for attaching face-mounted wood ledger boards to the wall shall be not less than 4 inches (102 mm) in diameter for forms not greater than \( \frac{1}{2} \) inch (38 mm) in thickness, and increased 1 inch (25 mm) in diameter for each \( \frac{1}{2} \) -inch (12.7 mm) increase in form thickness. Holes in stay-in-place forms for installing bolts for attaching face-mounted cold-formed steel tracks to the wall shall be not less than 4 inches (102 mm) square. The wood ledger board or steel track shall be in direct contact with the concrete at each bolt location.
**Exception:** A vapor retarder or other material less than or equal to $\frac{1}{16}$ inch (1.6 mm) in thickness is permitted to be installed between the wood ledger or cold-formed track and the concrete.

R608.9.2 Connections between concrete walls and light-framed floor systems.
Connections between concrete walls and light-framed floor systems shall be in accordance with one of the following:

1. For floor systems of wood frame construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(1) through R608.9(4), where permitted by the tables accompanying those figures. Portions of connections of wood-framed floor systems not noted in the figures shall be in accordance with Section R502, or AWC WFCM, if applicable. Wood framing members shall be of a species having a specific gravity equal to or greater than 0.42.

2. Deleted. For floor systems of cold-formed steel construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(5) through R608.9(8), where permitted by the tables accompanying those figures. Portions of connections of cold-formed steel framed floor systems not noted in the figures shall be in accordance with Section R505, or AISI S230, if applicable.

3. Proprietary connectors selected to resist loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.

4. An engineered design using loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.

5. An engineered design using loads and material design provisions in accordance with this code, or in accordance with ASCE 7, ACI 318, and AWC NDS for wood frame construction or AISI S100 for cold-formed steel frame construction.

R608.9.3 Connections between concrete walls and light-framed ceiling and roof systems.
Connections between concrete walls and light-framed ceiling and roof systems shall be in accordance with one of the following:

1. For ceiling and roof systems of wood frame construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(95) and R608.9(106), where permitted by the tables accompanying those figures. Portions of connections of wood-framed ceiling and roof systems not noted in the figures shall be in accordance with Section R802, or AWC WFCM, if applicable. Wood framing members shall be of a species having a specific gravity equal to or greater than 0.42.

2. Deleted. For ceiling and roof systems of cold-formed steel construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(11) and R608.9(12), where permitted by the tables accompanying those figures. Portions of connections of cold-formed steel framed ceiling and roof systems not noted in the figures shall be in accordance with Section R804, or AISI S230, if applicable.
3. Proprietary connectors selected to resist loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.

4. An engineered design using loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.

5. An engineered design using loads and material design provisions in accordance with this code, or in accordance with ASCE 7, ACI 318, and AWC NDS for wood-frame construction or AISI S100 for cold-formed steel frame construction.

R608.10 Floor, roof and ceiling diaphragms.
Floors and roofs in buildings with exterior walls of concrete shall be designed and constructed as diaphragms. Where gable-end walls occur, ceilings shall be designed and constructed as diaphragms. The design and construction of floors, roofs and ceilings of wood framing or cold-formed steel framing serving as diaphragms shall comply with the applicable requirements of this code, or AWC WFCM or AISI S230, if applicable. Wood framing members shall be of a species having a specific gravity equal to or greater than 0.42.

SECTION R609
EXTERIOR WINDOWS AND DOORS

R609.1 General.
This section prescribes performance and construction requirements for exterior windows and doors installed in walls. Windows and doors shall be installed and flashed in accordance with the fenestration manufacturer’s written instructions. Window and door openings shall be flashed in accordance with Section R703.4. Written installation instructions shall be provided by the fenestration manufacturer for each window or door.

R609.2 Performance.
Exterior windows and doors shall be designed to resist the design wind loads specified in Table R301.2(2) adjusted for height and exposure in accordance with Table R301.2(3) or determined in accordance with ASCE 7 using the allowable stress design load combinations of ASCE 7. Design wind loads for exterior glazing not part of a labeled assembly shall be permitted to be determined in accordance with Chapter 24 of the International Building Code.

Exception: Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall not be required to be protected provided the spaces are separated from the building interior by a wall and all openings in the wall separating the unit from the balcony, deck or porch are protected in accordance with this section. Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

R609.3 Testing and labeling.
Exterior windows and sliding doors shall be tested by an approved independent laboratory, and bear a label identifying manufacturer, performance characteristics and approved inspection agency to indicate compliance with AAMA/WDMA/CSA 101/I.S.2/A440. Exterior side-hinged doors shall be tested and labeled as conforming to AAMA/WDMA/CSA 101/I.S.2/A440 or AMD 100, or comply with Section R609.5.
Exception: Decorative glazed openings.

R609.3.1 Comparative analysis.
Structural wind load design pressures for window and door units different than the size tested in accordance with Section R609.3 shall be permitted to be different than the design value of the tested unit where determined in accordance with one of the following comparative analysis methods:

1. Structural wind load design pressures for window and door units smaller than the size tested in accordance with Section R609.3 shall be permitted to be higher than the design value of the tested unit provided such higher pressures are determined by accepted engineering analysis. Components of the smaller unit shall be the same as those of the tested unit. Where such calculated design pressures are used, they shall be validated by an additional test of the window or door unit having the highest allowable design pressure.

2. In accordance with WDMA I.S.11.

R609.4 Garage doors.
Garage doors shall be tested in accordance with either ASTM E 330 or ANSI/DASMA 108, and shall meet the acceptance criteria of ANSI/DASMA 108.

R609.5 Other exterior window and door assemblies.
Exterior windows and door assemblies not included within the scope of Section R609.3 or R609.4 shall be tested in accordance with ASTM E 330. Glass in assemblies covered by this exception shall comply with Section R308.5.

R609.6 Wind-borne debris protection.
Protection of exterior windows and glass doors in buildings located in wind-borne debris regions shall be in accordance with Section R301.2.1.2.

R609.6.1 Fenestration testing and labeling.
Fenestration shall be tested by an approved independent laboratory, listed by an approved entity, and bear a label identifying manufacturer, performance characteristics, and approved inspection agency to indicate compliance with the requirements of the following specification(s):

1. ASTM E 1886 and ASTM E 1996; or

2. AAMA 506.

R609.7 Anchorage methods.
The methods cited in this section apply only to anchorage of window and glass door assemblies to the main force-resisting system.

R609.7.1 Anchoring requirements.
Window and glass door assemblies shall be anchored in accordance with the published manufacturer’s recommendations to achieve the design pressure specified. Substitute anchoring systems used for substrates not specified by the fenestration manufacturer shall

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provide equal or greater anchoring performance as demonstrated by accepted engineering practice.

R609.7.2 Anchorage details.
Products shall be anchored in accordance with the minimum requirements illustrated in Figures R609.7.2(1), R609.7.2(2), R609.7.2(3), R609.7.2(4), R609.7.2(5), R609.7.2(6), R609.7.2(7) and R609.7.2(8).
FIGURE R609.7.2(3)
THROUGH THE FRAME

FIGURE R609.7.2(4)
FRAME CLIP
FIGURE R609.7.2(5)
THROUGH THE FLANGE

FIGURE R609.7.2(6)
THROUGH THE FLANGE
R609.7.2.1 Masonry, concrete or other structural substrate.

Where the wood shim or buck thickness is less than $1\frac{1}{2}$ inches (38 mm), window and glass door assemblies shall be anchored through the jamb, or by jamb clip and anchors shall be embedded directly into the masonry, concrete or other substantial substrate material. Anchors shall adequately transfer load from the window or door frame into the rough opening substrate [see Figures R609.7.2(1) and R609.7.2(2)]
Where the wood shim or buck thickness is $1\frac{1}{2}$ inches (38 mm) or more, the buck is securely fastened to the masonry, concrete or other substantial substrate, and the buck extends beyond the interior face of the window or door frame, window and glass door assemblies shall be anchored through the jamb, or by jamb clip, or through the flange to the secured wood buck. Anchors shall be embedded into the secured wood buck to adequately transfer load from the window or door frame assembly [see Figures R609.7.2(3), R6097.2(4) and R609.7.2(5)].

R609.7.2.2 Wood or other approved framing material. Where the framing material is wood or other approved framing material, window and glass door assemblies shall be anchored through the frame, or by frame clip, or through the flange. Anchors shall be embedded into the frame construction to adequately transfer load [see Figures R609.7.2(6), R609.7.2(7) and R609.7.2(8)].

R609.8 Mullions. Mullions shall be tested by an approved testing laboratory in accordance with AAMA 450, or be engineered in accordance with accepted engineering practice. Mullions tested as stand-alone units or qualified by engineering shall use performance criteria cited in Sections R609.8.1, R609.8.2 and R609.8.3. Mullions qualified by an actual test of an entire assembly shall comply with Sections R609.8.1 and R609.8.3.

R609.8.1 Load transfer. Mullions shall be designed to transfer the design pressure loads applied by the window and door assemblies to the rough opening substrate.

R609.8.2 Deflection. Mullions shall be capable of resisting the design pressure loads applied by the window and door assemblies to be supported without deflecting more than $L/175$, where $L$ is the span of the mullion in inches.

R609.8.3 Structural safety factor. Mullions shall be capable of resisting a load of 1.5 times the design pressure loads applied by the window and door assemblies to be supported without exceeding the appropriate material stress levels. If tested by an approved laboratory, the 1.5 times the design pressure load shall be sustained for 10 seconds, and the permanent deformation shall not exceed 0.4 percent of the mullion span after the 1.5 times design pressure load is removed.

SECTION R610
STRUCTURAL INSULATED PANEL WALL
CONSTRUCTION

R610.1 General. Structural insulated panel (SIP) walls shall be designed in accordance with the provisions of this section. Where the provisions of this section are used to design structural insulated panel walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the state law of the jurisdiction having authority.
R610.2 Applicability limits.
The provisions of this section shall control the construction of exterior structural insulated panel walls and interior load-bearing structural insulated panel walls for buildings not greater than 60 feet (18 288 mm) in length perpendicular to the joist or truss span, not greater than 40 feet (12 192 mm) in width parallel to the joist or truss span and not greater than two stories in height with each wall not greater than 10 feet (3048 mm) high. Exterior walls installed in accordance with the provisions of this section shall be considered as load-bearing walls. Structural insulated panel walls constructed in accordance with the provisions of this section shall be limited to sites where the ultimate design wind speed \( V_{ult} \) is not greater than 155 miles per hour (69 m/s), Exposure B or 140 miles per hour (63 m/s) Exposure C, the ground snow load is not greater than 70 pounds per foot (3.35 kPa), and the seismic design category is A, B or C.

R610.3 Materials.
SIPs shall comply with the following criteria:

R610.3.1 Core.
The core material shall be composed of foam plastic insulation meeting one of the following requirements:

1. ASTM C 578 and have a minimum density of 0.90 pounds per cubic foot (14.4 kg/m³).

2. Polyurethane meeting the physical properties shown in Table R610.3.1.

3. An approved alternative.

All cores shall meet the requirements of Section R316.

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTY</th>
<th>POLYURETHANE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, core nominal (ASTM D 1622)</td>
<td>2.2 lb/ft³</td>
</tr>
<tr>
<td>Compressive resistance at yield or 10% deformation, whichever occurs first (ASTM D 1621)</td>
<td>19 psi (perpendicular to rise)</td>
</tr>
<tr>
<td>Flexural strength, min. (ASTM C 203)</td>
<td>30 psi</td>
</tr>
<tr>
<td>Tensile strength, min. (ASTM D 1623)</td>
<td>35 psi</td>
</tr>
<tr>
<td>Shear strength, min. (ASTM C 273)</td>
<td>25 psi</td>
</tr>
<tr>
<td>Substrate adhesion, min. (ASTM D 1623)</td>
<td>22 psi</td>
</tr>
<tr>
<td>Water vapor permeance of 1.00-in. thickness, max. (ASTM E 96)</td>
<td>2.3 perm</td>
</tr>
<tr>
<td>Water absorption by total immersion, max. (ASTM C 272)</td>
<td>4.3% (volume)</td>
</tr>
<tr>
<td>Dimensional stability (change in dimensions), max. [ASTM D 2126 (7 days at 158°F/100% humidity and 7 days at -20°F)]</td>
<td>2%</td>
</tr>
</tbody>
</table>

For SI: 1 pound per cubic foot = 16.02 kg/m³, 1 pound per square inch = 6.895 kPa, °C = [(°F) - 32]1.8.

R610.3.2 Facing.
Facing materials for SIPs shall be wood structural panels conforming to DOC PS 1 or DOC PS 2, each having a minimum nominal thickness of 7/16 inch (11 mm) and shall meet the...
additional minimum properties specified in Table R610.3.2. Facing shall be identified by a grade mark or certificate of inspection issued by an approved agency.

**TABLE R610.3.2**
**MINIMUM PROPERTIES\(^a\) FOR ORIENTED STRAND BOARD FACER MATERIAL IN SIP WALLS**

<table>
<thead>
<tr>
<th>THICKNESS (in.)</th>
<th>PRODUCT</th>
<th>FLATWISE STIFFNESS(^b) (lbf-in(^2)/ft)</th>
<th>FLATWISE STRENGTH(^c) (lbf-in/ft)</th>
<th>TENSION(^c) (lbf/ft)</th>
<th>DENSITY(^d) (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Along</td>
<td>Across</td>
<td>Along</td>
<td>Across</td>
</tr>
<tr>
<td>7/16</td>
<td>Sheathing</td>
<td>55,600</td>
<td>16,500</td>
<td>1,040</td>
<td>460</td>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 lbf-in\(^2\)/ft = 9.415 \times 10\(^{-6}\) kPa/m, 1 lbf-in/ft = 3.707 \times 10\(^{-4}\) kN/m, 1 lbf/ft = 0.0146 N/mm, 1 pound per cubic foot = 16.018 kg/m\(^3\).

a. Values listed in Table R610.3.2 are qualification test values and are not to be used for design purposes.
b. Mean test value shall be in accordance with Section 7.6 of DOC PS 2.
c. Characteristic test value (5th percent with 75% confidence).
d. Density shall be based on oven-dry weight and oven-dry volume.

**R610.3.3 Adhesive.**
Adhesives used to structurally laminate the foam plastic insulation core material to the structural wood facers shall conform to ASTM D 2559 or approved alternative specifically intended for use as an adhesive used in the lamination of structural insulated panels. Each container of adhesive shall bear a label with the adhesive manufacturer's name, adhesive name and type and the name of the quality assurance agency.

**R610.3.4 Lumber.**
The minimum lumber framing material used for SIPs prescribed in this document is NLGA graded No. 2 Spruce-pine-fir. Substitution of other wood species/grades that meet or exceed the mechanical properties and specific gravity of No. 2 Spruce-pine-fir shall be permitted.

**R610.3.5 SIP screws.**
Screws used for the erection of SIPs as specified in Section R610.5 shall be fabricated from steel, shall be provided by the SIP manufacturer and shall be sized to penetrate the wood member to which the assembly is being attached by not less than 1 inch (25 mm). The screws shall be corrosion resistant and have a minimum shank diameter of 0.188 inch (4.7 mm) and a minimum head diameter of 0.620 inch (15.5 mm).

**R610.3.6 Nails.**
Nails specified in Section R610 shall be common or galvanized box unless otherwise stated.

**R610.4 SIP wall panels.**
SIPs shall comply with Figure R610.4 and shall have minimum panel thickness in accordance with Tables R610.5(1) and R610.5(2) for above-grade walls. SIPs shall be identified by grade mark or certificate of inspection issued by an approved agency.

---

2018 North Carolina Residential Code
R610.4.1 Labeling.
Panels shall be identified by grade mark or certificate of inspection issued by an approved agency. Each (SIP) shall bear a stamp or label with the following minimum information:

1. Manufacturer name/logo.
2. Identification of the assembly.
3. Quality assurance agency.

R610.5 Wall construction.
Exterior walls of SIP construction shall be designed and constructed in accordance with the provisions of this section and Tables R610.5(1) and R610.5(2) and Figures R610.5(1) through R610.5(5). SIP walls shall be fastened to other wood building components in accordance with Tables R602.3(1) through R602.3(4).

Framing shall be attached in accordance with Table R602.3(1) unless otherwise provided for in Section R610.

TABLE R610.5(1)
MINIMUM THICKNESS FOR SIP WALL SUPPORTING SIP OR LIGHT-FRAME ROOF ONLY
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s.

DR = design required.

a. Design assumptions:
Maximum deflection criteria: L/240.
Maximum roof dead load: 10 psf.
Maximum roof live load: 70 psf.
Maximum ceiling dead load: 5 psf.
Maximum ceiling live load: 20 psf.
Wind loads based on Table R301.2 (2).
Strength axis of facing material applied vertically.

### TABLE R610.5(2)
**MINIMUM THICKNESS FOR SIP WALL SUPPORTING SIP OR LIGHT-FRAME ONE STORY AND ROOF ONLY (inches)^a\)**

<table>
<thead>
<tr>
<th>ULTIMATE DESIGN WIND SPEED $V_{ult}$ (mph)</th>
<th>BUILDING WIDTH (ft)</th>
<th>24</th>
<th>28</th>
<th>32</th>
<th>36</th>
<th>40</th>
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<tbody>
<tr>
<td>Exp.</td>
<td>Exp. C</td>
<td>Wall Height (feet)</td>
<td>Wall Height (feet)</td>
<td>Wall Height (feet)</td>
<td>Wall Height (feet)</td>
<td>Wall Height (feet)</td>
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<td>110</td>
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<td>20</td>
<td>4.5</td>
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<td>110</td>
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2018 North Carolina Residential Code
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<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
<td>DR</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s.

DR = Design required.

a. Design assumptions:
   Maximum deflection criteria: $L/240$.
   Maximum roof dead load: 10 psf.
   Maximum roof live load: 70 psf.
   Maximum ceiling dead load: 5 psf.
   Maximum ceiling live load: 20 psf.
   Maximum second-floor dead load: 10 psf.
   Maximum second-floor live load: 30 psf.
   Maximum second-floor dead load from walls: 10 psf.
   Maximum first-floor dead load: 10 psf.
   Maximum first-floor live load: 40 psf.
   Wind loads based on Table R301.2 (2).
   Strength axis of facing material applied vertically.
FIGURE R610.5(1)
MAXIMUM ALLOWABLE HEIGHT OF SIP WALLS

For SI: 1 foot = 304.8 mm.
FIGURE R610.5(2)
MAXIMUM ALLOWABLE HEIGHT OF SIP WALLS

FIGURE R610.5(3)
TRUSSED ROOF TO TOP PLATE CONNECTION
For SI: 1 inch = 25.4 mm.
Note: Figures illustrate SIP-specific attachment requirements. Other connections shall be made in accordance with Tables R602.3(1) and (2) as appropriate.

**FIGURE R610.5(4)**
SIP WALL-TO-WALL PLATFORM FRAME CONNECTION
R610.5.1 Top plate connection.
SIP walls shall be capped with a double top plate installed to provide overlapping at corner, intersections and splines in accordance with Figure R610.5.1. The double top plates shall be made up of a single 2 by top plate having a width equal to the width of the panel core, and shall be recessed into the SIP below. Over this top plate a cap plate shall be placed. The cap plate width shall match the SIP thickness and overlap the facers on both sides of the panel. End joints in top plates shall be offset not less than 24 inches (610 mm).

For SI: 1 inch = 25.4 mm.

Notes:
1. Top plates shall be continuous over header.
2. Lower 2x top plate shall have a width equal to the SIP core width and shall be recessed into the top edge of the panel. Cap plate shall be placed over the recessed top plate and shall have a width equal to the SIPs width.
3. SIP facing surfaces shall be nailed to framing and cripples with 8d common or galvanized box nails spaced 6 inches on center.
4. Galvanized nails shall be hot-dipped or tumbled. Framing shall be attached in accordance to Section R602.3(1) unless otherwise provide for in Section R610.
R610.5.2 Bottom (sole) plate connection.
SIP walls shall have full bearing on a sole plate having a width equal to the nominal width of the foam core. Where SIP walls are supported directly on continuous foundations, the wall wood sill plate shall be anchored to the foundation in accordance with Figure R610.5.2 and Section R403.1.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE R610.5.2
SIP WALL TO CONCRETE SLAB FOR FOUNDATION WALL ATTACHMENT

R610.5.3 Wall bracing.
SIP walls shall be braced in accordance with Section R602.10. SIP walls shall be considered continuous wood structural panel sheathing for purposes of computing required bracing. SIP walls shall meet the requirements of Section R602.10.4.23 except that SIP corners shall be fabricated as shown in Figure R610.9. Where SIP walls are used for wall bracing, the SIP bottom plate shall be attached to wood framing below in accordance with Table R602.3(1).

R610.6 Interior load-bearing walls.
Interior load-bearing walls shall be constructed as specified for exterior walls.

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R610.7 Drilling and notching.
The maximum vertical chase penetration in SIPs shall have a maximum side dimension of 2 inches (51 mm) centered in the panel. Vertical chases shall have a minimum spacing of 24 inches (610 mm) on center. A maximum of two horizontal chases shall be permitted in each wall panel—one at 14 inches (360 mm) plus or minus 2 inches (51 mm) from the bottom of the panel and one at 48 inches (1220 mm) plus or minus 2 inches (51 mm) from the bottom edge of the SIPs panel. Additional penetrations are permitted where justified by analysis.

R610.8 Connection.
SIPs shall be connected at vertical in-plane joints in accordance with Figure R610.8 or by other approved methods.

For SI: 1 inch = 25.4 mm.

FIGURE R610.8
TYPICAL SIP CONNECTION DETAILS FOR VERTICAL IN-PLANE JOINTS

R610.9 Corner framing.
Corner framing of SIP walls shall be constructed in accordance with Figure R610.9.

For SI: 1 inch = 25.4 mm.

FIGURE R610.9
SIP CORNER FRAMING DETAIL

R610.10 Headers.
SIP headers shall be designed and constructed in accordance with Table R610.10 and Figure R610.5.1. SIP headers shall be continuous sections without splines. Headers shall be not less than $11\frac{7}{8}$ inches (302 mm) deep. Headers longer than 4 feet (1219 mm) shall be constructed in accordance with Section R602.7.

TABLE R610.10
MAXIMUM SPANS FOR $11\frac{7}{8}$-INCH-DEEP SIP HEADERS (feet)$^a$
<table>
<thead>
<tr>
<th>LOAD CONDITION</th>
<th>SNOW LOAD (psf)</th>
<th>BUILDING width (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>24 28 32 36 40</td>
</tr>
<tr>
<td>Supporting roof only</td>
<td>20</td>
<td>4 4 4 4 2</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>4 4 4 2 2</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>2 2 2 2 2</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>2 2 2 N/A N/A</td>
</tr>
<tr>
<td>Supporting roof and one-story</td>
<td>20</td>
<td>2 2 N/A N/A N/A</td>
</tr>
<tr>
<td></td>
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<td>2 2 N/A N/A N/A</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>2 N/A N/A N/A N/A</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>N/A N/A N/A N/A N/A</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
N/A = Not Applicable.

a. Design assumptions:
   Maximum deflection criterion: L/360.
   Maximum roof dead load: 10 psf.
   Maximum ceiling load: 5 psf.
   Maximum second-floor live load: 30 psf.
   Maximum second-floor dead load: 10 psf.
   Maximum second-floor dead load from walls: 10 psf.

**R610.10.1 Wood structural panel box headers.**
Wood structural panel box headers shall be allowed where SIP headers are not applicable. Wood structural panel box headers shall be constructed in accordance with Figure R602.7.3 and Table R602.7.3.
CHAPTER 7
WALL COVERING

SECTION R701
GENERAL

R701.1 Application.
The provisions of this chapter shall control the design and construction of the interior and exterior wall covering for buildings.

R701.2 Installation.
Products sensitive to adverse weather shall not be installed until adequate weather protection for the installation is provided. Exterior sheathing shall be dry before applying exterior cover.

SECTION R702
INTERIOR COVERING

R702.1 General.
Interior coverings or wall finishes shall be installed in accordance with this chapter and Table R702.1(1), Table R702.1(2), Table R702.1(3) and Table R702.3.5. Interior masonry veneer shall comply with the requirements of Section R703.78.1 for support and Section R703.78.4 for anchorage, except an airspace is not required. Interior finishes and materials shall conform to the flame spread and smoke-development requirements of Section R302.9.

TABLE R702.1(1)
THICKNESS OF PLASTER

<table>
<thead>
<tr>
<th>PLASTER BASE</th>
<th>FINISHED THICKNESS OF PLASTER FROM FACE OF LATH, MASONRY, CONCRETE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gypsum Plaster</td>
</tr>
<tr>
<td></td>
<td>Cement Plaster</td>
</tr>
<tr>
<td>Expanded metal lath</td>
<td>5/8, minimum</td>
</tr>
<tr>
<td></td>
<td>5/8, minimum</td>
</tr>
<tr>
<td>Wire lath</td>
<td>5/8, minimum</td>
</tr>
<tr>
<td></td>
<td>3/4, minimum (interior)</td>
</tr>
<tr>
<td>Gypsum lath</td>
<td>1/2, minimum</td>
</tr>
<tr>
<td></td>
<td>3/4, minimum (interior)</td>
</tr>
<tr>
<td>Masonry walls</td>
<td>1/2, minimum</td>
</tr>
<tr>
<td></td>
<td>1/2, minimum</td>
</tr>
<tr>
<td>Monolithic concrete walls</td>
<td>5/8, maximum</td>
</tr>
<tr>
<td>c,d</td>
<td>7/8, maximum</td>
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<td>Monolithic concrete ceilings</td>
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<td>Gypsum veneer base</td>
<td>1/16, minimum</td>
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<tr>
<td>f,g</td>
<td>3/4, minimum (interior)</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm.

a. Where measured from back plane of expanded metal lath, exclusive of ribs, or self-furring lath, plaster thickness shall be \( \frac{3}{4} \) inch minimum.

b. Where measured from face of support or backing.

c. Because masonry and concrete surfaces vary in plane, thickness of plaster need not be uniform.

d. Where applied over a liquid bonding agent, finish coat shall be permitted to be applied directly to concrete surface.

e. Approved acoustical plaster shall be permitted to be applied directly to concrete or over base coat plaster, beyond the maximum plaster thickness shown.

f. Attachment shall be in accordance with Table R702.3.5.

g. Where gypsum board is used as a base for cement plaster, a water-resistive barrier complying with Section R703.2 shall be provided.

### TABLE R702.1(2)

**GYPSUM PLASTER PROPORTIONS**

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>COAT</th>
<th>PLASTER BASE OR LATH</th>
<th>MAXIMUM VOLUME AGGREGATE PER 100 POUNDS NEAT PLASTER ( \text{cubic feet} )</th>
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<tr>
<td><strong>Two-coat work</strong></td>
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<td><strong>Three-coat work</strong></td>
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<td>First coat</td>
<td>Lath</td>
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<tr>
<td>First and second coats</td>
<td>Masonry</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 cubic foot = 0.0283 \( m^3 \), 1 pound = 0.454 kg.

a. Wood-fibered gypsum plaster shall be mixed in the proportions of 100 pounds of gypsum to not more than 1 cubic foot of sand where applied on masonry or concrete.

b. Where determining the amount of aggregate in set plaster, a tolerance of 10 percent shall be allowed.

c. Combinations of sand and lightweight aggregate shall be permitted to be used, provided the volume and weight relationship of the combined aggregate to gypsum plaster is maintained.

d. If used for both first and second coats, the volume of aggregate shall be permitted to be 2.5 cubic feet.

e. Where plaster is 1 inch or more in total thickness, the proportions for the second coat may be increased to 3 cubic feet.

### TABLE R702.1(3)

**CEMENT PLASTER PROPORTIONS, PARTS BY VOLUME**
<table>
<thead>
<tr>
<th>COAT</th>
<th>CEMENT PLASTER TYPE</th>
<th>CEMENTITIOUS MATERIALS</th>
<th>VOLUME OF AGGREGATE PER SUM OF SEPARATE VOLUMES OF CEMENTITIOUS MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Portland or blended</td>
<td>Portland Cement Type I, II or III or Blended Cement Type IP, I (PM), IS or I (SM)</td>
<td>Plastic Cement</td>
</tr>
<tr>
<td>First</td>
<td>Portland or blended</td>
<td>1</td>
<td>3/4 - 1/a</td>
</tr>
<tr>
<td></td>
<td>Masonry</td>
<td>1</td>
<td>2/2 - 4</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>1</td>
<td>2/2 - 4</td>
</tr>
<tr>
<td>Second</td>
<td>Portland or blended</td>
<td>1</td>
<td>3/4 - 1/2</td>
</tr>
<tr>
<td></td>
<td>Masonry</td>
<td>1</td>
<td>3 - 5</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>1</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Finish</td>
<td>Portland or blended</td>
<td>1</td>
<td>3/4 - 2</td>
</tr>
<tr>
<td></td>
<td>Masonry</td>
<td>1</td>
<td>1/2 - 3</td>
</tr>
<tr>
<td></td>
<td>Plastic</td>
<td>1</td>
<td>1/2 - 3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg.

a. Lime by volume of 0 to 3/4 shall be used where the plaster will be placed over low-absorption surfaces such as dense clay tile or brick.

b. The same or greater sand proportion shall be used in the second coat than used in the first coat.

**R702.2 Interior plaster.**

**R702.2.1 Gypsum plaster.**
Gypsum plaster materials shall conform to ASTM C 5, C 22, C 28, C 35, C 59, C 61, C 587,
Gypsum lath or gypsum base for veneer plaster shall conform to ASTM C 1396. Plaster shall be not less than three coats where applied over metal lath and not less than two coats where applied over other bases permitted by this section, except that veneer plaster shall be applied in one coat not to exceed $\frac{3}{16}$ inch (4.76 mm) thickness, provided the total thickness is in accordance with Table R702.1(1).

**R702.2.2 Cement plaster.**
Cement plaster materials shall conform to ASTM C 91 (Type M, S or N), C 150 (Type I, II and III), C 595 [Type IP, I (PM), IS and I (SM)], C 847, C 897, C 926, C 933, C 1032, C 1047 and C 1328, and shall be installed or applied in compliance with ASTM C 1063. Gypsum lath shall conform to ASTM C 1396. Plaster shall be not less than three coats where applied over metal lath and not less than two coats where applied over other bases permitted by this section, except that veneer plaster shall be applied in one coat not to exceed $\frac{3}{16}$ inch (4.76 mm) thickness, provided the total thickness is in accordance with Table R702.1(1).

**R702.2.2.1 Application.**
Each coat shall be kept in a moist condition for not less than 24 hours prior to application of the next coat.

**Exception:** Applications installed in accordance with ASTM C 926.

**R702.2.2.2 Curing.**
The finish coat for two-coat cement plaster shall not be applied sooner than 48 hours after application of the first coat. For three-coat cement plaster, the second coat shall not be applied sooner than 24 hours after application of the first coat. The finish coat for three-coat cement plaster shall not be applied sooner than 48 hours after application of the second coat.

**R702.2.3 Support.**
Support spacing for gypsum or metal lath on walls or ceilings shall not exceed 16 inches (406 mm) for $\frac{3}{8}$-inch-thick (9.5 mm) or 24 inches (610 mm) for $\frac{1}{2}$-inch-thick (12.7 mm) plain gypsum lath. Gypsum lath shall be installed at right angles to support framing with end joints in adjacent courses staggered by not less than one framing space.

**R702.3 Gypsum board and gypsum panel products.**

**R702.3.1 Materials.**
Gypsum board and gypsum panel product materials and accessories shall conform to ASTM C 22, C 475, C 514, C 1002, C 1047, C 1177, C 1178, C 1278, C 1396 or C 1658 and shall be installed in accordance with the provisions of this section. Adhesives for the installation of gypsum board and gypsum panel products shall conform to ASTM C 557.

**R702.3.2 Wood framing.**
Wood framing supporting gypsum board and gypsum panel products shall be not less than 2 inches (51 mm) nominal thickness in the least dimension except that wood furring strips not less than 1-inch by 2-inch (25 mm by 51 mm) nominal dimension shall be permitted to be used over solid backing or framing spaced not more than 24 inches (610 mm) on center.
R702.3.3 Cold-formed steel framing. Deleted. Cold-formed steel framing supporting gypsum board and gypsum panel products shall be not less than 1 1/4 inches (32 mm) wide in the least dimension. Nonload-bearing cold-formed steel framing shall comply with AISI S220 and ASTM C645, Section 10. Load-bearing cold-formed steel framing shall comply with AISI S200 and ASTM C 955, Section 8.

R702.3.4 Insulating concrete form walls. Foam plastics for insulating concrete form walls constructed in accordance with Sections R404.1.2 and R608 on the interior of habitable spaces shall be protected in accordance with Section R316.4. Use of adhesives in conjunction with mechanical fasteners is permitted. Adhesives used for interior and exterior finishes shall be compatible with the insulating form materials.

R702.3.5 Application. Supports and fasteners used to attach gypsum board and gypsum panel products shall comply with Table R702.3.5. Gypsum sheathing shall be attached to exterior walls in accordance with Table R602.3(1). Gypsum board and gypsum panel products shall be applied at right angles or parallel to framing members. All edges and ends of gypsum board and gypsum panel products shall occur on the framing members, except those edges and ends that are perpendicular to the framing members. Interior gypsum board shall not be installed where it is directly exposed to the weather or to water.

**TABLE R702.3.5**
MINIMUM THICKNESS AND APPLICATION OF GYPSUM BOARD AND GYPSUM PANEL PRODUCTS

<table>
<thead>
<tr>
<th>THICKNESS OF GYPSUM BOARD OR GYPSUM PANEL PRODUCTS (inches)</th>
<th>APPLICATION</th>
<th>ORIENTATION OF GYPSUM BOARD OR GYPSUM PANEL PRODUCTS TO FRAMING</th>
<th>MAXIMUM SPACING OF FRAMING MEMBERS (inches o.c.)</th>
<th>MAXIMUM SPACING OF FASTENERS (inches)</th>
<th>SIZE OF NAILS FOR APPLICATION TO WOOD FRAMING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ceiling d</td>
<td>Perpendicular</td>
<td>16</td>
<td>7</td>
<td>13 gage, 1 1/4 / &quot; long, 0.098&quot; diameter, 4 annular-ringed; or 4d cooler nail, 0.080&quot; diameter, 3 1/8 long, / &quot; head.</td>
</tr>
<tr>
<td>3/8</td>
<td>Wall</td>
<td>Either direction</td>
<td>16</td>
<td>8</td>
<td>16</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>Either direction</th>
<th>16</th>
<th>7</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ceiling</strong></td>
<td>Perpendicular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ceiling</strong></td>
<td>Perpendicular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wall</strong></td>
<td>Either direction</td>
<td>24</td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>

### Perpendicular

- **Ceiling**
  - 13 gage, 3/8" long, 19/64" head; 0.098" diameter, 1/4" long, annular-ringed; 5d cooler nail, 0.086" diameter, 5/8" long, 15/64" head; or gypsum board nail, 0.086" diameter, 5/8" long, 9/32" head.

- **Wall**
  - 13 gage, 5/8" long, 19/64" head; 0.098" diameter, 1/3" long, annular-ringed; 6d coated nails or equivalent drywall screws. Screws shall comply with Section R702.3.5.1.

### Either direction

- **Ceiling**
  - 13 gage, 5/8" long, 19/64" head; 0.098" diameter, 1/3" long, annular-ringed; 6d coated nails or equivalent drywall screws. Screws shall comply with Section R702.3.5.1.
<table>
<thead>
<tr>
<th>Layer</th>
<th>Application</th>
<th>Ceiling</th>
<th>Wall</th>
<th>Perpendicular</th>
<th>Either direction</th>
<th>16</th>
<th>8</th>
<th>16</th>
<th>16</th>
<th>24</th>
<th>24</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8</td>
<td>Same as above for 3/8&quot; gypsum board and gypsum panel products.</td>
<td>3/8</td>
<td>Either direction</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>1/2 or 5/8</td>
<td>Same as above for 1/2&quot; and 5/8&quot; gypsum board and gypsum panel products, respectively.</td>
<td>1/2 or 5/8</td>
<td>Either direction</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td>Face ply installed with adhesive.</td>
<td>Two</td>
<td>Perpendicular</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>3/8 layers</td>
<td></td>
<td>3/8 layers</td>
<td>Either direction</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. For application without adhesive, a pair of nails spaced not less than 2 inches apart or more than 2 1/2 inches apart shall be permitted to be used with the pair of nails spaced 12 inches on center.

b. Screws shall be in accordance with Section R702.3.5.1. Screws for attaching gypsum board or gypsum panel products to structural insulated panels shall penetrate the wood structural panel facing not less than 7/16 inch.

c. Where cold-formed steel framing is used with a clinching design to receive nails by two edges of metal, the nails shall be not less than 5/8 inch longer than the gypsum board or gypsum panel product.
thickness and shall have ringed shanks. Where the cold-formed steel framing has a nailing groove formed to receive the nails, the nails shall have barbed shanks or be 5d, 13 gage, \( \frac{1}{16} \) inches long, \( \frac{1}{6} \) inch head for \( \frac{1}{2} \) inch gypsum board or gypsum panel product; and 6d, 13 gage, \( \frac{1}{4} \) inches long, \( \frac{1}{6} \) inch head for \( \frac{5}{8} \) inch gypsum board or gypsum panel product. Deleted.

d. Three-eighths-inch-thick single-ply gypsum board or gypsum panel product shall not be used on a ceiling where a water-based textured finish is to be applied, or where it will be required to support insulation above a ceiling. On ceiling applications to receive a water-based texture material, either hand or spray applied, the gypsum board or gypsum panel product shall be applied perpendicular to framing. Where applying a water-based texture material, the minimum gypsum board thickness shall be increased from \( \frac{3}{8} \) inch to \( \frac{1}{2} \) inch for 16-inch on center framing, and from \( \frac{1}{2} \) inch to \( \frac{5}{8} \) inch for 24-inch on center framing or \( \frac{1}{2} \)-inch sag-resistant gypsum ceiling board shall be used.

R702.3.5.1 Screw fastening.
Screws for attaching gypsum board and gypsum panel products to wood framing shall be Type W or Type S in accordance with ASTM C 1002 and shall penetrate the wood not less than \( \frac{5}{8} \) inch (15.9 mm). Gypsum board and gypsum panel products shall be attached to cold-formed steel framing with minimum No. 6 screws. Screws for attaching gypsum board and gypsum panel products to cold-formed steel framing less than 0.033 inch (1 mm) thick shall be Type S in accordance with ASTM C 1002 or bugle head style in accordance with ASTM C 1513 and shall penetrate the steel not less than \( \frac{3}{8} \) inch (9.5 mm). Screws for attaching gypsum board and gypsum panel products to cold-formed steel framing 0.033 inch to 0.112 inch (1 mm to 3 mm) thick shall be in accordance with ASTM C 954 or bugle head style in accordance with ASTM C 1513.
Screws for attaching gypsum board and gypsum panel products to structural insulated panels shall penetrate the wood structural panel facing not less than \( \frac{7}{16} \) inch (11.1 mm).

R702.3.6 Horizontal gypsum board diaphragm ceilings.
Gypsum board and gypsum panel products shall be permitted on wood joists to create a horizontal diaphragm in accordance with Table R702.3.6. Gypsum board and gypsum panel products shall be installed perpendicular to ceiling framing members. End joints of adjacent courses of board and panels shall not occur on the same joist. The maximum allowable diaphragm proportions shall be \( \frac{1}{2} : 1 \) between shear resisting elements. Rotation or cantilever conditions shall not be permitted. Gypsum board or gypsum panel products shall not be used in diaphragm ceilings to resist lateral forces imposed by masonry or concrete construction. Perimeter edges shall be blocked using wood members not less than 2-inch by 6-inch (51 mm by 152 mm) nominal dimension. Blocking material shall be installed flat over the top plate of the wall to provide a nailing surface not less than 2 inches (51 mm) in width for the attachment of the gypsum board or gypsum panel product.

### TABLE R702.3.6

<table>
<thead>
<tr>
<th>SHEAR CAPACITY FOR HORIZONTAL WOOD-FRAMED GYPSUM BOARD DIAPHRAGM CEILING ASSEMBLIES</th>
</tr>
</thead>
</table>

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<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>THICKNESS OF MATERIAL (min.) (inch)</th>
<th>SPACING OF FRAMING MEMBERS (max.) (inch)</th>
<th>SHEAR VALUE a, b (plf of ceiling)</th>
<th>MINIMUM FASTENER SIZE c, d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum board or gypsum panel product</td>
<td>$\frac{1}{2}$</td>
<td>16 o.c.</td>
<td>90</td>
<td>5d cooler or wallboard nail; $\frac{5}{16}$-inch long; 0.086-8 inch shank; $\frac{15}{64}$-inch head</td>
</tr>
<tr>
<td>Gypsum board or gypsum panel product</td>
<td>$\frac{1}{2}$</td>
<td>24 o.c.</td>
<td>70</td>
<td>5d cooler or wallboard nail; $\frac{5}{16}$-inch long; 0.086-8 inch shank; $\frac{15}{64}$-inch head</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per linear foot = 1.488 kg/m.

a. Values are not cumulative with other horizontal diaphragm values and are for short-term loading caused by wind or seismic loading. Values shall be reduced 25 percent for normal loading.

b. Values shall be reduced 50 percent in Seismic Design Categories D, D, D, and E. Deleted.

c. $\frac{1}{4}$-inch, No. 6 Type S or W screws shall be permitted to be substituted for the listed nails.

d. Fasteners shall be spaced not more than 7 inches on center at all supports, including perimeter blocking, and not less than $\frac{3}{8}$ inch from the edges and ends of the gypsum board.

R702.3.7 Water-resistant gypsum backing board.
Gypsum board used as the base or backer for adhesive application of ceramic tile or other required nonabsorbent finish material shall conform to ASTM C 1396, C 1178 or C 1278. Use of water-resistant gypsum backing board shall be permitted on ceilings. Use of water-resistant gypsum backing board shall be permitted on ceilings where framing spacing does not exceed 12 inches (305 mm) on center for 1/2-inch (12.7 mm) thick or 16 inches (406 mm) for 5/8-inch (16 mm) thick gypsum board. Water-resistant gypsum board shall not be installed over a Class I or II vapor retarder in a shower or tub compartment. Cut or exposed edges, including those at wall intersections, shall be sealed as recommended by the manufacturer.

R702.3.7.1 Limitations.
Water-resistant gypsum backing board shall not be used where there will be direct exposure to water, or in areas subject to continuous high humidity.

R702.4 Ceramic tile.

R702.4.1 General.
Ceramic tile surfaces shall be installed in accordance with ANSI A108.1, A108.4, A108.5, A108.6, A108.11, A118.1, A118.3, A136.1 and A137.1.
R702.4.2 Backer boards.
Materials used as backers for wall tile in tub and shower areas and wall panels in shower areas shall be of materials listed in Table R702.4.2, and installed in accordance with the manufacturer’s recommendations.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass mat gypsum backing panel</td>
<td>ASTM C 1178</td>
</tr>
<tr>
<td>Fiber-reinforced gypsum panels</td>
<td>ASTM C 1278</td>
</tr>
<tr>
<td>Nonasbestos fiber-cement backer board</td>
<td>ASTM C 1288 or ISO 8336, Category C</td>
</tr>
<tr>
<td>Nonasbestos fiber mat reinforced cementitious backer units</td>
<td>ASTM C 1325</td>
</tr>
</tbody>
</table>

R702.5 Other finishes.
Wood veneer paneling and hardboard paneling shall be placed on wood or cold-formed steel framing spaced not more than 16 inches (406 mm) on center. Wood veneer and hard board paneling less than 1/4-inch (6 mm) nominal thickness shall not have less than a 3/8-inch (10 mm) gypsum board or gypsum panel product backer. Wood veneer paneling not less than 1/4-inch (6 mm) nominal thickness shall conform to ANSI/HPVA HP-1. Hardboard paneling shall conform to CPA/ANSI A135.5.

R702.6 Wood shakes and shingles.
Wood shakes and shingles shall conform to CSSB Grading Rules for Wood Shakes and Shingles and shall be permitted to be installed directly to the studs with maximum 24 inches (610 mm) on-center spacing.

R702.6.1 Attachment.
Nails, staples or glue are permitted for attaching shakes or shingles to the wall, and attachment of the shakes or shingles directly to the surface shall be permitted provided the fasteners are appropriate for the type of wall surface material. Where nails or staples are used, two fasteners shall be provided and shall be placed so that they are covered by the course above.

R702.6.2 Furring strips.
Where furring strips are used, they shall be 1 inch by 2 inches or 1 inch by 3 inches (25 mm by 51 mm or 25 mm by 76 mm), spaced a distance on center equal to the desired exposure, and shall be attached to the wall by nailing through other wall material into the studs.

R702.7 Vapor retarders.
Class I or II vapor retarders are required on the interior side of frame walls in Climate Zones 5, 6, 7, 8 and Marine 4.

Exceptions:
1. Basement walls.
2. Below-grade portion of any wall.

3. Construction where moisture or its freezing will not damage the materials.

R702.7.1 Class III vapor retarders.
Class III vapor retarders shall be permitted where any one of the conditions in Table R702.7.1 is met.

**TABLE R702.7.1**
CLASS III VAPOR RETARDERS

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>CLASS III VAPOR RETARDERS PERMITTED FOR:</th>
</tr>
</thead>
</table>
| Marine 4     | Vented cladding over wood structural panels.  
Vented cladding over fiberboard.  
Vented cladding over gypsum.  
Continuous insulation with $R$-value $\geq 2.5$ over 2 × 4 wall.  
Continuous insulation with $R$-value $\geq 3.75$ over 2 × 6 wall. |
| 5            | Vented cladding over wood structural panels.  
Vented cladding over fiberboard.  
Vented cladding over gypsum.  
Continuous insulation with $R$-value $\geq 5$ over 2 × 4 wall.  
Continuous insulation with $R$-value $\geq 7.5$ over 2 × 6 wall. |
| 6            | Vented cladding over fiberboard.  
Vented cladding over gypsum.  
Continuous insulation with $R$-value $\geq 7.5$ over 2 × 4 wall.  
Continuous insulation with $R$-value $\geq 11.25$ over 2 × 6 wall. |
| 7 and 8      | Continuous insulation with $R$-value $\geq 10$ over 2 × 4 wall.  
Continuous insulation with $R$-value $\geq 15$ over 2 × 6 wall. |

For SI: 1 pound per cubic foot = 16 kg/m$^3$.

a. Spray foam with a maximum permeance of 1.5 perms at the installed thickness, applied to the interior cavity side of wood structural panels, fiberboard, insulating sheathing or gypsum is deemed to meet the continuous insulation requirement where the spray foam $R$-value meets or exceeds the specified continuous insulation $R$-value.

R702.7.2 Material vapor retarder class.
The vapor retarder class shall be based on the manufacturer’s certified testing or a tested assembly.

The following shall be deemed to meet the class specified:

- **Class I**: Sheet polyethylene, unperforated aluminum foil.
- **Class II**: Kraft-faced fiberglass batts.
- **Class III**: Latex or enamel paint.

R702.7.3 Minimum clear airspaces and vented openings for vented cladding.
For the purposes of this section, vented cladding shall include the following minimum clear airspaces. Other openings with the equivalent vent area shall be permitted.
1. Vinyl lap or horizontal aluminum siding applied over a weather-resistive barrier as specified in Table R703.3(1).

2. Brick veneer with a clear airspace as specified in Table R703.8.4.

3. Other approved vented claddings.

SECTION R703
EXTERIOR COVERING

R703.1 General.
Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing as described in Section R703.4.

Exception: Log walls designed and constructed in accordance with the provisions of ICC 400.

R703.1.1 Water resistance.
The exterior wall envelope shall be designed and constructed in a manner that prevents the accumulation of water within the wall assembly by providing a water-resistant barrier behind the exterior veneer as required by Section R703.2 and a means of draining to the exterior water that enters the assembly. Protection against condensation in the exterior wall assembly shall be provided in accordance with Section R702.7 of this code.

Exceptions:

1. A weather-resistant exterior wall envelope shall not be required over concrete or masonry walls designed in accordance with Chapter 6 and flashed in accordance with Section R703.4 or R703.8.

2. Compliance with the requirements for a means of drainage, and the requirements of Sections R703.2 and R703.4, shall not be required for an exterior wall envelope that has been demonstrated to resist wind-driven rain through testing of the exterior wall envelope, including joints, penetrations and intersections with dissimilar materials, in accordance with ASTM E 331 under the following conditions:

2.1. Exterior wall envelope test assemblies shall include at least one opening, one control joint, one wall/eave interface and one wall sill. All tested openings and penetrations shall be representative of the intended end-use configuration.

2.2. Exterior wall envelope test assemblies shall be at least 4 feet by 8 feet (1219 mm by 2438 mm) in size.

2.3. Exterior wall assemblies shall be tested at a minimum differential pressure of 6.24 pounds per square foot (299 Pa).
2.4. Exterior wall envelope assemblies shall be subjected to the minimum test exposure for a minimum of 2 hours.

The exterior wall envelope design shall be considered to resist wind-driven rain where the results of testing indicate that water did not penetrate control joints in the exterior wall envelope, joints at the perimeter of openings penetration or intersections of terminations with dissimilar materials.

**R703.1.2 Wind resistance.**
Wall coverings, backing materials and their attachments shall be capable of resisting wind loads in accordance with Tables R301.2(2) and R301.2(3). Wind-pressure resistance of the siding and backing materials shall be determined by ASTM E 330 or other applicable standard test methods. Where wind-pressure resistance is determined by design analysis, data from approved design standards and analysis conforming to generally accepted engineering practice shall be used to evaluate the siding and backing material and its fastening. All applicable failure modes including bending rupture of siding, fastener withdrawal and fastener head pull-through shall be considered in the testing or design analysis. Where the wall covering and the backing material resist wind load as an assembly, use of the design capacity of the assembly shall be permitted.

**R703.2 Water-resistive barrier.**
One layer of No. 15 asphalt felt, free from holes and breaks, complying with ASTM D 226 for Type 1 felt or other approved water-resistive barrier shall be applied over studs or sheathing of all exterior walls. Such felt or material shall be applied horizontally, with the upper layer lapped over the lower layer not less than 2 inches (51 mm). Where joints occur, felt shall be lapped not less than 6 inches (152 mm). The felt or other approved material shall be continuous to the top of walls and terminated at penetrations and building appendages in a manner to meet the requirements of the exterior wall envelope as described in Section R703.1. The water-resistive barrier is not required for detached accessory buildings.

**R703.3 Nominal thickness and attachments.**
The nominal thickness and attachment of exterior wall coverings shall be in accordance with Table R703.3(1), the wall covering material requirements of this section, and the wall covering manufacturer's installation instructions. Cladding attachment over foam sheathing shall comply with the additional requirements and limitations of Sections R703.15 through and R703.17. Nominal material thicknesses in Table R703.3(1) are based on a maximum stud spacing of 16 inches (406 mm) on center. Where specified by the siding manufacturer's instructions and supported by a test report or other documentation, attachment to studs with greater spacing is permitted. Fasteners for exterior wall coverings attached to wood framing shall be in accordance with Section R703.3.2 and Table R703.3(1). Exterior wall coverings shall be attached to cold-formed steel light frame construction in accordance with the cladding manufacturer's installation instructions, the requirements of Table R703.3(1) using screw fasteners substituted for the nails specified in accordance with Table R703.3(2), or an approved design.

**TABLE R703.3(1)**
**SIDING MINIMUM ATTACHMENT AND MINIMUM THICKNESS**

<table>
<thead>
<tr>
<th>SIDING MATERIAL</th>
<th>TYPE OF SUPPORTS FOR THE SIDING MATERIAL AND FASTENERS</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>NOMINAL THICKNESS (inches)</th>
<th>JOINT TREATMENT</th>
<th>Wood or wood structural panel sheathing into stud</th>
<th>Fiberboard sheathing into stud</th>
<th>Gypsum sheathing into stud</th>
<th>Foam plastic sheathing into stud</th>
<th>Direct to studs</th>
<th>Number or spacing of fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchored veneer: brick, concrete, masonry or stone (see Section R703.8)</td>
<td>2</td>
<td>Section R703.8</td>
<td>Section R703.8</td>
<td>Section R703.8</td>
<td>Section R703.8</td>
<td>Section R703.8</td>
<td>Section R703.8</td>
</tr>
<tr>
<td>Adhered veneer: concrete, stone or masonry (see Section R703.12)</td>
<td>—</td>
<td>Section R703.12</td>
<td>Section R703.12</td>
<td>Section R703.12</td>
<td>Section R703.12</td>
<td>Section R703.12</td>
<td>Section R703.12</td>
</tr>
<tr>
<td>Fiber cement siding Panel siding (see Section R703.10.1)</td>
<td>5/16</td>
<td>Section R703.10.1</td>
<td>6d common (2” x 0.113”)</td>
<td>6d common (2” x 0.113”)</td>
<td>6d common (2” x 0.113”)</td>
<td>6d common (2” x 0.113”)</td>
<td>4d common (1/2” x 0.099”)</td>
</tr>
<tr>
<td>Lap siding (see Section R703.10.2)</td>
<td>5/16</td>
<td>Section R703.10.2</td>
<td>6d common (2” x 0.113”)</td>
<td>6d common (2” x 0.113”)</td>
<td>6d common (2” x 0.113”)</td>
<td>6d common (2” x 0.113”)</td>
<td>6d common (2” x 0.113”)</td>
</tr>
<tr>
<td>Hardboard panel siding (see Section R703.3)</td>
<td>7/16</td>
<td>Section R703.3</td>
<td>—</td>
<td>0.120” nail (shank) with 0.225” head</td>
<td>0.120” nail (shank) with 0.225” head</td>
<td>0.120” nail (shank) with 0.225” head</td>
<td>0.120” nail (shank) with 0.225” head</td>
</tr>
<tr>
<td>Hardboard lap siding (see Section R703.3)</td>
<td>7/16</td>
<td>Note e</td>
<td>0.099” nail (shank) with 0.240” head</td>
<td>0.099” nail (shank) with 0.240” head</td>
<td>0.099” nail (shank) with 0.240” head</td>
<td>0.099” nail (shank) with 0.240” head</td>
<td>0.099” nail (shank) with 0.240” head</td>
</tr>
<tr>
<td>Horizontal aluminum Without insulation</td>
<td>0.019</td>
<td>Lap</td>
<td>Siding nail 1/2” x 0.120”</td>
<td>Siding nail 2” x 0.120”</td>
<td>Siding nail 2” x 0.120”</td>
<td>Siding nail 2” x 0.120”</td>
<td>Not allowed</td>
</tr>
<tr>
<td>With insulation</td>
<td>0.019</td>
<td>Lap</td>
<td>Siding nail 1/2” x 0.120”</td>
<td>Siding nail 2” x 0.120”</td>
<td>Siding nail 2” x 0.120”</td>
<td>Siding nail 2” x 0.120”</td>
<td>Siding nail 2” x 0.120”</td>
</tr>
</tbody>
</table>

Note: The table details various sheathing materials and their respective joint treatments and fastener requirements. For example, fiber cement siding requires 6d common nails (2” x 0.113”) directly to studs. Hardboard panel siding requires 0.120” nails with 0.225” shank heads. Without insulation, horizontal aluminum requires a 0.024” lap with Siding nail 1/2” x 0.120” meeting the same spacing as stud spacing. With insulation, a similar setup applies with a thickness of 0.019”.
<table>
<thead>
<tr>
<th>Insulated vinyl siding</th>
<th>Lap</th>
<th>0.120 nail (shank) with a 0.313 head or 16-gage crown</th>
<th>0.120 nail (shank) with a 0.313 head or 16-gage crown</th>
<th>0.120 nail (shank) with a 0.313 head or 16-gage crown</th>
<th>0.120 nail (shank) with a 0.313 head or 16-gage crown</th>
<th>Not allowed</th>
<th>16 inches on center or specified by manufacturer instructions, test report or other sections of this code</th>
</tr>
</thead>
<tbody>
<tr>
<td>j 0.035 (vinyl siding layer only)</td>
<td>—</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>Not allowed</td>
<td>6&quot; panel edges 12&quot; inter. sup.</td>
</tr>
<tr>
<td>Particleboard panels</td>
<td>3/8</td>
<td>—</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
</tr>
<tr>
<td></td>
<td>1/2</td>
<td>—</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
</tr>
<tr>
<td></td>
<td>5/8</td>
<td>—</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>8d box nail (2&quot; × 0.113&quot;)</td>
<td>8d box nail (2&quot; × 0.113&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
<td>6d box nail (2&quot; × 0.099&quot;)</td>
</tr>
<tr>
<td>Polypropylene siding</td>
<td>Not applicable</td>
<td>Lap</td>
<td>Section 703.14.1</td>
<td>Section 703.14.1</td>
<td>Section 703.14.1</td>
<td>Section 703.14.1</td>
<td>Not allowed</td>
</tr>
</tbody>
</table>

*(continued)*
### TABLE R703.3(1)—continued

<table>
<thead>
<tr>
<th>SIDING MATERIAL</th>
<th>NOMINAL THICKNESS (inches)</th>
<th>JOINT TREATMENT</th>
<th>TYPE OF SUPPORTS FOR THE SIDING MATERIAL AND FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>29 ga.</td>
<td>Lap</td>
<td>Siding nail (2 / &quot; x 4 0.113&quot;) Staple= 3 / &quot; 1 / &quot; 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Siding nail (2 / &quot; x 0.113&quot;) Staple= 3 / &quot; 1 / &quot; 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Siding nail (2 / &quot; x 0.113&quot;) Staple= 3 / &quot; 1 / &quot; 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not allowed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Same as stud spacing</td>
</tr>
<tr>
<td>Vinyl siding</td>
<td>0.035</td>
<td>Lap</td>
<td>0.120&quot; nail (shank) with a 0.313&quot; head or 16-gage staple with 3 / 8 - to 1 / 2 -inch crown</td>
</tr>
<tr>
<td>(see Section</td>
<td></td>
<td></td>
<td>0.120&quot; nail (shank) with a 0.313&quot; head or 16-gage staple with 3 / 8 - to 1 / 2 -inch crown</td>
</tr>
<tr>
<td>R703.11)</td>
<td></td>
<td></td>
<td>0.120&quot; nail (shank) with a 0.313&quot; head or 16-gage staple with 3 / 8 - to 1 / 2 -inch crown</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not allowed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16 inches on center or as specified by the manufacturer instructions or test report</td>
</tr>
<tr>
<td>Wood siding</td>
<td></td>
<td>6d box or siding nail (2&quot; x 0.099&quot;)</td>
<td>6d box or siding nail (2&quot; x 0.099&quot;)</td>
</tr>
<tr>
<td>(see Section</td>
<td></td>
<td></td>
<td>6d box or siding nail (2&quot; x 0.099&quot;)</td>
</tr>
<tr>
<td>R703.3</td>
<td></td>
<td></td>
<td>6d box or siding nail (2&quot; x 0.099&quot;)</td>
</tr>
<tr>
<td>R703.3</td>
<td></td>
<td></td>
<td>8d box or siding nail (2 / &quot; x 0.113&quot;)</td>
</tr>
<tr>
<td>R703.5</td>
<td></td>
<td></td>
<td>8d box or siding nail (2 / &quot; x 0.113&quot;)</td>
</tr>
<tr>
<td>R703.5</td>
<td></td>
<td></td>
<td>8d box or siding nail (2 / &quot; x 0.113&quot;)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Face nailing up to 6” widths, 1 nail per bearing; 8” widths and over, 2 nails per bearing</td>
</tr>
<tr>
<td>Wood structural</td>
<td></td>
<td>2” x 0.099” siding nail</td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>panel</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>ANS/APA PRP-</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>210 siding</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>(see Section</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>R703.3</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>R703.5</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>R703.5</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>Wood structural</td>
<td></td>
<td>2” x 0.099” siding nail</td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>panel</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>lap siding</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>(see Section</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>R703.3</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>R703.5</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
<tr>
<td>R703.5</td>
<td></td>
<td></td>
<td>2” x 0.099” siding nail</td>
</tr>
</tbody>
</table>

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For SI: 1 inch = 25.4 mm.

a. Aluminum nails shall be used to attach aluminum siding.

b. Aluminum (0.019 inch) shall be unbacked only where the maximum panel width is 10 inches and the maximum flat area is 8 inches. The tolerance for aluminum siding shall be +0.002 inch of the nominal dimension.

c. Shall be of approved type.

d. Where used to resist shear forces, the spacing must be 4 inches at panel edges and 8 inches on interior supports.

e. Vertical end joints shall occur at studs and shall be covered with a joint cover or shall be caulked.

f. Face nailing: one 6d common nail through the overlapping planks at each stud. Concealed nailing:

- one 11-gage $1\frac{1}{2}$-inch-long galv. roofing nail through the top edge of each plank at each stud in accordance with the manufacturer’s installation instructions.

- Vertical joints, if staggered, shall be permitted to be away from studs if applied over wood structural panel sheathing.

h. Minimum fastener length must be sufficient to penetrate sheathing other nailable substrate and framing a total of a minimum of $1\frac{1}{4}$ inches or in accordance with the manufacturer’s installation instructions.

i. Where specified by the manufacturer’s instructions and supported by a test report, fasteners are permitted to penetrate into or fully through nailable sheathing or other nailable substrate of minimum thickness specified by the instructions or test report, without penetrating into framing.

j. Insulated vinyl siding shall comply with ASTM D 7793.

k. Polypropylene siding shall comply with ASTM D 7254.

l. Cladding attachment over foam sheathing shall comply with the additional requirements and limitations of Sections R703.15, R703.16, and R703.17.

### TABLE R703.3(2)

**SCREW FASTENER SUBSTITUTION FOR SIDING ATTACHMENT TO COLD-FORMED STEEL LIGHT FRAME CONSTRUCTION**

<table>
<thead>
<tr>
<th>NAIL DIAMETER PER TABLE R703.3(1)</th>
<th>MINIMUM SCREW FASTENER SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.099&quot;</td>
<td>No. 6</td>
</tr>
<tr>
<td>0.113&quot;</td>
<td>No. 7</td>
</tr>
<tr>
<td>0.120&quot;</td>
<td>No. 8</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm

a. Screws shall comply with ASTM C 1513 and shall penetrate a minimum of three threads through minimum 33 mil (20 gage) cold-formed steel frame construction.

b. Screw head diameter shall be not less than the nail head diameter required by Table R703.3(1).

c. Number and spacing of screw fasteners shall comply with Table R703.3(1).

d. Pan head, hex washer head, modified truss head or other screw head types with a flat attachment surface under the head shall be used for vinyl siding attachment.

e. Aluminum siding shall not be fastened directly to cold-formed steel light frame construction.

### R703.3.1 Wind limitations. Deleted.

Where the design wind pressure exceeds 30 psf or where the limits of Table R703.3.1 are exceeded, the attachment of wall coverings shall be designed to resist the component and cladding loads specified in Table R301.2(2), adjusted for height and exposure in accordance with Table R301.2(3). For the determination of wall covering attachment, component and cladding loads shall be determined using an effective wind area of 10 square feet ($0.93 \text{ m}^2$).
TABLE R703.3.1
LIMITS FOR ATTACHMENT PER TABLE R703.3(1)

MAXIMUM MEAN ROOF HEIGHT

<table>
<thead>
<tr>
<th>Ultimate Wind Speed (mph 3-second gust)</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>115</td>
<td>NL</td>
</tr>
<tr>
<td>120</td>
<td>NL</td>
</tr>
<tr>
<td>130</td>
<td>60'</td>
</tr>
<tr>
<td>140</td>
<td>20'</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.
NL = Not limited by Table R703.3.1, DR = Design required.

R703.3.2 Fasteners.
Exterior wall coverings shall be securely fastened with aluminum, galvanized, stainless steel or rust-preventative coated nails or staples in accordance with Table R703.3(1) or with other approved corrosion-resistant fasteners in accordance with the wall covering manufacturer’s installation instructions. Nails and staples shall comply with ASTM F 1667. Nails shall be T-head, modified round head, or round head with smooth or deformed shanks. Staples shall have a minimum crown width of \(\frac{7}{16}\) inch (11.1 mm) outside diameter and be manufactured of minimum 16-gage wire. Where fiberboard, gypsum, or foam plastic sheathing backing is used, nails or staples shall be driven into the studs. Where wood or wood structural panel sheathing is used, fasteners shall be driven into studs unless otherwise permitted to be driven into sheathing in accordance with either the siding manufacturer’s installation instructions or Table R703.3.2.

Exception: Openings for exterior balconies, decks, or porches under roofs enclosed with screen or removable vinyl or acrylic wind break panels shall not be required to be protected provided the spaces are separated from the building interior by a wall and all openings in the wall separating the unit from the balcony, deck or porch are protected in accordance with this section. Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

TABLE R703.3.2
OPTIONAL SIDING ATTACHMENT SCHEDULE FOR FASTENERS WHERE NO STUD PENETRATION NECESSARY

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING OF FASTENERS</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior wall covering (weighing 3 psf or less) attachment to wood structural panel sheathing, either direct or over foam sheathing a maximum of 2 inches thick. Note: Does not apply to vertical siding.</td>
<td>Ring shank roofing nail (0.120” min. dia.)</td>
<td>12” o.c.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ring shank nail (0.148” min. dia.)</td>
<td>15” o.c.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. 6 screw (0.138” min. dia.)</td>
<td>12” o.c.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. 8 screw (0.164” min. dia.)</td>
<td>16” o.c.</td>
<td></td>
</tr>
</tbody>
</table>

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a. Fastener length shall be sufficient to penetrate back side of the wood structural panel sheathing by at least $\frac{1}{4}$ inch. The wood structural panel sheathing shall be not less than $\frac{7}{16}$ inch in thickness.

b. Spacing of fasteners is per 12 inches of siding width. For other siding widths, multiply “Spacing of Fasteners” above by a factor of $\frac{12}{s}$, where “$s$” is the siding width in inches. Fastener spacing shall never be greater than the manufacturer’s minimum recommendations.

**R703.3.3 Minimum fastener length and penetration.**  
Fasteners shall have the greater of the minimum length specified in Table R703.3(1) or as required to provide a minimum penetration into framing as follows:

1. Fasteners for horizontal aluminum siding, steel siding, particleboard panel siding, wood structural panel siding in accordance with ANSI/APA-PRP 210, fiber-cement panel siding and fiber-cement lap siding installed over foam plastic sheathing shall penetrate not less than $\frac{1}{2}$ inches (38 mm) into framing or shall be in accordance with the manufacturer’s installation instructions.

2. Fasteners for hardboard panel and lap siding shall penetrate not less than $\frac{1}{2}$ inches (38 mm) into framing.

3. Fasteners for vinyl siding and insulated vinyl siding installed over wood or wood structural panel sheathing shall penetrate not less than $\frac{1}{4}$ inches (32 mm) into sheathing and framing combined. Vinyl siding and insulated vinyl siding shall be permitted to be installed with fasteners penetrating into or through wood or wood structural sheathing of minimum thickness as specified by the manufacturer’s instructions or test report, with or without penetration into the framing. Where the fastener penetrates fully through the sheathing, the end of the fastener shall extend not less than $\frac{1}{4}$ inch (6.4 mm) beyond the opposite face of the sheathing.

Fasteners for vinyl siding and insulated vinyl siding installed over foam plastic sheathing shall be in accordance with Section R703.11.2. Fasteners for vinyl siding and insulated vinyl siding installed over fiberboard or gypsum sheathing shall penetrate not less than $\frac{1}{4}$ inches (32 mm) into framing.

4. Fasteners for vertical or horizontal wood siding shall penetrate not less than $\frac{1}{2}$ inches (38 mm) into studs, studs and wood sheathing combined, or blocking.

5. Fasteners for siding material installed over foam plastic sheathing shall have sufficient length to accommodate foam plastic sheathing thickness and to penetrate framing or sheathing and framing combined, as specified in Items 1 through 4.

**R703.4 Flashing.**  
Approved corrosion-resistant flashing shall be applied shingle-fashion in a manner to prevent entry of water into the wall cavity or penetration of water to the building structural framing.
components. Self-adhered membranes used as flashing shall comply with AAMA 711. Fluid-applied membranes used as flashing in exterior walls shall comply with AAMA 714. The flashing shall extend to the surface of the exterior wall finish. Aluminum flashing shall not be used in contact with cementitious material, except at counter flashing. Approved corrosion-resistant flashings shall be installed at the following locations:

1. Exterior window and door openings. Flashing at exterior window and door openings shall extend to the surface of the exterior wall finish or to the water-resistive barrier complying with Section 703.2 for subsequent drainage. Mechanically attached flexible flashings shall comply with AAMA 712. Flashing at exterior window and door openings shall be installed in accordance with one or more of the following:

   1.1. The fenestration manufacturer’s installation and flashing instructions, or for applications not addressed in the fenestration manufacturer’s instructions, in accordance with the flashing manufacturer’s instructions. Where flashing instructions or details are not provided, pan flashing shall be installed at the sill of exterior window and door openings. Pan flashing shall be sealed or sloped in such a manner as to direct water to the surface of the exterior wall finish or to the water-resistive barrier for subsequent drainage. Openings using pan flashing shall incorporate flashing or protection at the head and sides.

   1.2. In accordance with the flashing design or method of a registered design professional.

   1.3. In accordance with other approved methods.

2. At the intersection of chimneys or other masonry construction with frame or stucco walls, with projecting lips on both sides under stucco copings.

3. Under and at the ends of masonry, wood or metal copings and sills.

4. Continuously above all projecting wood trim.

5. Where exterior porches, decks or stairs attach to a wall or floor assembly of wood-frame construction.

6. At wall and roof intersections.

7. At built-in gutters.

R703.5 Wood, hardboard and wood structural panel siding.
Wood, hardboard, and wood structural panel siding shall be installed in accordance with this section and Table R703.3. Hardboard siding shall comply with CPA/ANSI A135.6. Hardboard siding used as architectural trim shall comply with CPA/ANSI A 135.7.

R703.5.1 Vertical wood siding.
Wood siding applied vertically shall be nailed to horizontal nailing strips or blocking set not more than 24 inches (610 mm) on center.
R703.5.2 Panel siding.

3/8-inch (9.5 mm) wood structural panel siding shall not be applied directly to studs spaced more than 16 inches (406 mm) on center where long dimension is parallel to studs. Wood structural panel siding 7/16-inch (11.1 mm) or thinner shall not be applied directly to studs spaced more than 24 inches (610 mm) on center. The stud spacing shall not exceed the panel span rating provided by the manufacturer unless the panels are installed with the face grain perpendicular to the studs or over sheathing approved for that stud spacing.

Joints in wood, hardboard or wood structural panel siding shall be made as follows unless otherwise approved. Vertical joints in panel siding shall occur over framing members, unless wood or wood structural panel sheathing is used, and shall be shiplapped or covered with a batten. Horizontal joints in panel siding shall be lapped not less than 1 inch (25 mm) or shall be shiplapped or flashed with Z-flashing and occur over solid blocking, wood or wood structural panel sheathing.

R703.5.3 Horizontal wood siding.

Horizontal lap siding shall be installed in accordance with the manufacturer’s recommendations. Where there are no recommendations the siding shall be lapped not less than 1 inch (25 mm), or 1/2 inch (12.7 mm) if rabbeted, and shall have the ends caulked, covered with a batten or sealed and installed over a strip of flashing.

R703.6 Wood shakes and shingles.

Wood shakes and shingles shall conform to CSSB Grading Rules for Wood Shakes and Shingles.

R703.6.1 Application.

Wood shakes or shingles shall be applied either single course or double course over nominal 1/2-inch (12.7 mm) wood-based sheathing or to furring strips over nominal nonwood sheathing. A water-resistant barrier shall be provided over all sheathing, with horizontal overlaps in the membrane of not less than 2 inches (51 mm) and vertical overlaps of not less than 6 inches (152 mm). Where horizontal furring strips are used, they shall be 1 inch by 3 inches or 1 inch by 4 inches (25 mm by 76 mm or 25 mm by 102 mm) and shall be fastened to the studs with minimum 7d or 8d box nails and shall be spaced a distance on center equal to the actual weather exposure of the shakes or shingles, not to exceed the maximum exposure specified in Table R703.6.1. When installing shakes or shingles over a nonpermeable water-resistant barrier, furring strips shall be placed first vertically over the barrier and in addition, horizontal furring strips shall be fastened to the vertical furring strips prior to attaching the shakes or shingles to the horizontal furring strips. The spacing between adjacent shingles to allow for expansion shall be 1/8-inch (3.2 mm) to 1/4-inch (6.4 mm) apart, and between adjacent shakes shall be 3/8-inch (9.5 mm) to 1/2-inch (12.7 mm) apart. The offset spacing between joints in adjacent courses shall be not less than 1 1/2 inches (38 mm).

TABLE R703.6.1
MAXIMUM WEATHER EXPOSURE FOR WOOD SHAKES AND SHINGLES ON EXTERIOR WALLS

(Dimensions are in inches)

<table>
<thead>
<tr>
<th>LENGTH</th>
<th>EXPOSURE FOR SINGLE COURSE</th>
<th>EXPOSURE FOR DOUBLE COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>18</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>24</td>
<td>$10\frac{1}{2}$</td>
<td>$16$</td>
</tr>
<tr>
<td>Shakes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>24</td>
<td>$10\frac{1}{2}$</td>
<td>18</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. Dimensions given are for No. 1 grade.
b. A maximum 9-inch exposure is permitted for No. 2 grade.
c. A maximum 10-inch exposure is permitted for No. 2 grade.
d. A maximum 14-inch exposure is permitted for No. 2 grade.

R703.6.2 Weather exposure.
The maximum weather exposure for shakes and shingles shall not exceed that specified in Table 703.6.1.

R703.6.3 Attachment.
Wood shakes or shingles shall be installed according to this chapter and the manufacturer's instructions. Each shake or shingle shall be held in place by two stainless steel Type 304, Type 316 or hot-dipped zinc-coated galvanized corrosion-resistant box nails in accordance with Table R703.6.3(1) or R703.6.3(2). The hot-dipped zinc-coated galvanizing shall conform to minimum standard ASTM A 153D, 1.0 ounce per square foot. Alternatively, 16-gage stainless steel Type 304 or Type 316 staples with crown widths $\frac{7}{16}$ inch (11 mm) minimum, $\frac{3}{4}$ inch (19 mm) maximum, shall be used and the crown of the staple shall be placed parallel with the butt of the shake or the shingle. In single-course application, the fasteners shall be concealed by the course above and shall be driven approximately 1 inch (25 mm) above the butt line of the succeeding course and $\frac{3}{4}$ inch (19 mm) from the edge.

In double-course applications, the exposed shake or shingle shall be face-nailed with two fasteners, driven approximately 2 inches (51 mm) above the butt line and $\frac{3}{4}$ inch (19 mm) from each edge. Fasteners installed within 15 miles (24 km) of salt water coastal areas shall be stainless steel Type 316. Fasteners for fire-retardant-treated shakes or shingles in accordance with Section R902 or pressure-impregnated-preservative-treated shakes or shingles in accordance with AWPA U1 shall be stainless steel Type 316. The fasteners shall
penetrate the sheathing or furring strips by not less than $\frac{1}{2}$ inch (13 mm) and shall not be overdriven. Fasteners for untreated (natural) and treated products shall comply with ASTM F 1667.

### TABLE R703.6.3(1)
SINGLE COURSE SIDEWALL FASTENERS

<table>
<thead>
<tr>
<th>Product type</th>
<th>Nail type and minimum length (inches)</th>
<th>Minimum head diameter (inches)</th>
<th>Minimum shank thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R &amp; R and sanded shingles</td>
<td>3d box $1\frac{1}{4}$</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>16” and 18” shingles</td>
<td>4d box $1\frac{1}{2}$</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>Grooved shingles</td>
<td>3d box $1\frac{1}{4}$</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>24” shingles</td>
<td>4d box $1\frac{1}{2}$</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>Split and sawn shakes</td>
<td>5d box $1\frac{3}{4}$</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>18” straight-split shakes</td>
<td>6d box 2</td>
<td>0.19</td>
<td>0.0915</td>
</tr>
<tr>
<td>18” and 24” handsplit shakes</td>
<td>5d box $1\frac{3}{4}$</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>24” tapersplit shakes</td>
<td>6d box 2</td>
<td>0.19</td>
<td>0.0915</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

### TABLE R703.6.3(2)
DOUBLE COURSE SIDEWALL FASTENERS

<table>
<thead>
<tr>
<th>Product type</th>
<th>Nail type and minimum length (inches)</th>
<th>Minimum head diameter (inches)</th>
<th>Minimum shank thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R &amp; R and sanded shingles</td>
<td>5d box $1\frac{3}{4}$, or same size casing nails</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>Grooved shingles</td>
<td>5d box $1\frac{3}{4}$</td>
<td>0.19</td>
<td>0.08</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Split and sawn shakes</th>
<th>7d box 2 1/4 or 8d 2 1/2</th>
<th>0.19</th>
<th>0.099</th>
</tr>
</thead>
<tbody>
<tr>
<td>18” straight-split shakes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18” and 24” handsplit shakes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24” tapersplit shakes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18” and 24” tapersawn shakes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

**R703.6.4 Bottom courses.**
The bottom courses shall be doubled.

**R703.7 Exterior plaster.**
Installation of these materials shall be in compliance with ASTM C 926, ASTM C 1063 and the provisions of this code.

**R703.7.1 Lath.**
Lath and lath attachments shall be of corrosion-resistant materials. Expanded metal or woven wire lath shall be attached with 1 1/2-inch-long (38 mm), 11 gage nails having a 7/16-inch (11.1 mm) head, or 7/8-inch-long (22.2 mm), 16 gage staples, spaced not less than 6 inches (152 mm), or as otherwise approved.

**R703.7.2 Plaster.**
Plastering with portland cement plaster shall be not less than three coats where applied over metal lath or wire lath and shall be not less than two coats where applied over masonry, concrete, pressure-preservative-treated wood or decay-resistant wood as specified in Section R317.1 or gypsum backing. If the plaster surface is completely covered by veneer or other facing material or is completely concealed, plaster application need be only two coats, provided the total thickness is as set forth in Table R702.1(1).

On wood-frame construction with an on-grade floor slab system, exterior plaster shall be applied to cover, but not extend below, lath, paper and screed.

The proportion of aggregate to cementitious materials shall be as set forth in Table R702.1(3).

**R703.7.2.1 Weep screeds.**
A minimum 0.019-inch (0.5 mm) (No. 26 galvanized sheet gage), corrosion-resistant weep screed or plastic weep screed, with a minimum vertical attachment flange of 3 1/2 inches (89 mm) shall be provided at or below the foundation plate line on exterior stud walls in accordance with ASTM C 926. The weep screed shall be placed not less than 4 inches (102 mm) above the earth or 2 inches (51 mm) above paved areas and shall be of a type that will allow trapped water to drain to the exterior of the building. The
weather-resistant barrier shall lap the attachment flange. The exterior lath shall cover and terminate on the attachment flange of the weep screed.

R703.7.3 Water-resistive barriers.
Water-resistive barriers shall be installed as required in Section R703.2 and, where applied over wood-based sheathing, shall include a water-resistive vapor-permeable barrier with a performance at least equivalent to two layers of Grade D paper. The individual layers shall be installed independently such that each layer provides a separate continuous plane and any flashing (installed in accordance with Section R703.4) intended to drain to the water-resistive barrier is directed between the layers.

Exception: Where the water-resistive barrier that is applied over wood-based sheathing has a water resistance equal to or greater than that of 60-minute Grade D paper and is separated from the stucco by an intervening, substantially nonwater-absorbing layer or designed drainage space.

R703.7.4 Application.
Each coat shall be kept in a moist condition for at least 48 hours prior to application of the next coat.

Exception: Applications installed in accordance with ASTM C 926.

R703.7.5 Curing.
The finish coat for two-coat cement plaster shall not be applied sooner than seven days after application of the first coat. For three-coat cement plaster, the second coat shall not be applied sooner than 48 hours after application of the first coat. The finish coat for three-coat cement plaster shall not be applied sooner than seven days after application of the second coat.

R703.8 Anchored stone and masonry veneer, general.
Anchored stone and masonry veneer shall be installed in accordance with this chapter, and Table R703.3(1) and Figure R703.8. These veneers installed over a backing of wood or cold-formed steel shall be limited to the first story above grade plane and shall not exceed 5 inches (127 mm) in thickness. See Section R602.10 for wall bracing requirements for masonry veneer for wood-framed construction and Section R603.9.5 for wall bracing requirements for masonry veneer for cold-formed steel construction.

Exceptions:

1. For buildings in Seismic Design Categories A, B and C, exterior stone or masonry veneer, as specified in Table R703.8(1), with a backing of wood or steel framing shall be permitted to the height specified in Table R703.8(1) above a noncombustible foundation.

2. For detached one- or two-family dwellings in Seismic Design Categories D₀, D₁ and D₂ exterior stone or masonry veneer, as specified in Table R703.8(2), with a backing of wood framing shall be permitted to the height specified in Table R703.8(2) above a noncombustible foundation. Deleted.
FIGURE R703.8
TYPICAL MASONRY VENEER WALL DETAILS
(continued)
For SI: 1 inch = 25.4 mm.
a— See Sections R703.8.5, R703.8.6 and R703.4.
b— See Sections R703.2 and R703.8.4.
c— See Section R703.8.4.2 and Table R703.8.4.
d— See Section R703.8.3.
e— Figure R703.8 illustrates typical construction details for a masonry veneer wall. For the actual mandatory requirements of this code, see the indicated sections of text. Other details of masonry veneer wall construction shall be permitted provided the requirements of the indicated sections of text are met.

**FIGURE R703.8—continued**
### TABLE R703.8(1)
STONE OR MASONRY VENEER LIMITATIONS AND REQUIREMENTS, WOOD OR STEEL FRAMING, SEISMIC DESIGN CATEGORIES A, B AND C

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>NUMBER OF WOOD- OR STEEL-FRAMED STORIES</th>
<th>MAXIMUM HEIGHT OF VENEER ABOVE NONCOMBUSTIBLE FOUNDATION&lt;sup&gt;a&lt;/sup&gt; (feet)</th>
<th>MAXIMUM NOMINAL THICKNESS OF VENEER (inches)</th>
<th>MAXIMUM WEIGHT OF VENEER&lt;sup&gt;b&lt;/sup&gt; (psf)</th>
<th>WOOD- OR STEEL-FRAMED STORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A or B</td>
<td>Steel: 1 or 2</td>
<td>30</td>
<td>5</td>
<td>50</td>
<td>all</td>
</tr>
<tr>
<td></td>
<td>Wood: 1, 2 or 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>30</td>
<td>5</td>
<td>50</td>
<td>1 only</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>30</td>
<td>5</td>
<td>50</td>
<td>top, bottom</td>
</tr>
<tr>
<td></td>
<td>Wood only: 3</td>
<td>30</td>
<td>5</td>
<td>50</td>
<td>top, middle, bottom</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.479 kPa.

a. An additional 8 feet is permitted for gable end walls. See also story height limitations of Section R301.3.

b. Maximum weight is installed weight and includes weight of mortar, grout, lath and other materials used for installation. Where veneer is placed on both faces of a wall, the combined weight shall not exceed that specified in this table.

### TABLE R703.8(2)
STONE OR MASONRY VENEER LIMITATIONS AND REQUIREMENTS, ONE- AND TWO-FAMILY DETACHED DWELLINGS, SEISMIC DESIGN CATEGORIES D<sub>0</sub>, D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub>

| SEISMIC DESIGN CATEGORY | NUMBER OF WOOD-FRAMED STORIES<sup>a</sup> | MAXIMUM HEIGHT OF VENEER ABOVE NONCOMBUSTIBLE FOUNDATION OR FOUNDATION WALL<sup>a</sup> (feet) | MAXIMUM NOMINAL THICKNESS OF VENEER (inches) | MAXIMUM WEIGHT OF VENEER<sup>b</sup> (psf) |
|-------------------------|----------------------------------------|---------------------------------|---------------------------------|---------------------------------|-------------------|
| D<sub>0</sub>           | 1                                      | 20<sup>6</sup>                  | 4                               | 40                              |
|                         | 2                                      | 20<sup>6</sup>                  | 4                               | 40                              |
|                         | 3                                      | 30<sup>d</sup>                  | 4                               | 40                              |
| D<sub>1</sub>           | 1                                      | 20<sup>6</sup>                  | 4                               | 40                              |
|                         | 2                                      | 20<sup>c</sup>                  | 4                               | 40                              |
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.479 kPa, 1 pound-force = 4.448 N.

<table>
<thead>
<tr>
<th>D&lt;sub&gt;2&lt;/sub&gt;</th>
<th>3</th>
<th>20&lt;sup&gt;6&lt;/sup&gt;</th>
<th>4</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20&lt;sup&gt;6&lt;/sup&gt;</td>
<td>3</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>20&lt;sup&gt;6&lt;/sup&gt;</td>
<td>3</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

### a. Cripple walls are not permitted in Seismic Design Categories D<sub>0</sub>, D<sub>1</sub>, and D<sub>2</sub>.

### b. Maximum weight is installed weight and includes weight of mortar, grout and lath, and other materials used for installation.

### c. The veneer shall not exceed 20 feet in height above a noncombustible foundation, with an additional 8 feet permitted for gable end walls, or 30 feet in height with an additional 8 feet for gable end walls where the lower 10 feet have a backing of concrete or masonry wall. See story height limitations of Section R301.3.

### d. The veneer shall not exceed 30 feet in height above a noncombustible foundation, with an additional 8 feet permitted for gable end walls. See story height limitations of Section R301.3.

### R703.8.1 Interior veneer support.

Veneers used as interior wall finishes shall be permitted to be supported on wood or cold-formed steel floors that are designed to support the loads imposed.

### R703.8.2 Exterior veneer support.

Except in Seismic Design Categories D<sub>0</sub>, D<sub>1</sub>, and D<sub>2</sub>, exterior masonry veneers having an installed weight of 40 pounds per square foot (195 kg/m²) or less shall be permitted to be supported on wood or cold-formed steel construction. Where masonry veneer supported by wood or cold-formed steel construction adjoins masonry veneer supported by the foundation, there shall be a movement joint between the veneer supported by the wood or cold-formed steel construction and the veneer supported by the foundation. The wood or cold-formed steel construction supporting the masonry veneer shall be designed to limit the deflection to \(1/600\) of the span for the supporting members. The design of the wood or cold-formed steel construction shall consider the weight of the veneer and any other loads.

### R703.8.2.1 Support by steel angle.

A minimum 6-inch by 4-inch by \(\frac{5}{16}\) -inch (152 mm by 102 mm by 8 mm) steel angle, with the long leg placed vertically, shall be anchored to double 2-inch by 4-inch (51 mm by 102 mm) wood studs or double 350S162 cold-formed steel studs at a maximum on-center spacing of 16 inches (406 mm). Anchorage of the steel angle at every double stud spacing shall be not less than two \(\frac{7}{16}\) -inch-diameter (11 mm) by 4-inch (102 mm) lag screws for wood construction or two \(\frac{7}{16}\) -inch (11.1 mm) bolts with washers for cold-formed steel construction. The steel angle shall have a minimum clearance to underlying construction of \(\frac{1}{16}\) inch (1.6 mm). Not less than two-thirds the width of the masonry veneer thickness shall bear on the steel angle. Flashing and weep holes shall be located in the masonry veneer in accordance with Figure R703.8.2.1. The maximum height of masonry veneer above the steel angle support shall be 12 feet 8 inches (3861 mm). The airspace separating the masonry veneer from the wood backing shall be in accordance.
with Sections R703.8.4 and R703.8.4.2. The method of support for the masonry veneer on wood construction shall be constructed in accordance with Figure R703.8.2.1.

The maximum slope of the roof construction without stops shall be 7:12. Roof construction with slopes greater than 7:12 but not more than 12:12 shall have stops of a minimum 3-inch by 3-inch by \( \frac{1}{8} \) -inch (76 mm by 76 mm by 6.4 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as approved by the building official.

![Diagram of exterior masonry veneer support by steel angles]

**FIGURE R703.8.2.1**
**EXTERIOR MASONRY VENEER SUPPORT BY STEEL ANGLES**

**R703.8.2.2 Support by roof construction.**
A steel angle shall be placed directly on top of the roof construction. The roof supporting construction for the steel angle shall consist of not fewer than three 2-inch by 6-inch (51 mm by 152 mm) wood members for wood construction or three 550S162 cold-formed steel members for cold-formed steel light frame construction. A wood member abutting the vertical wall stud construction shall be anchored with not fewer than three \( \frac{5}{8} \) -inch (15.9 mm) diameter by 5-inch (127 mm) lag screws to every wood stud spacing. Each additional wood roof member shall be anchored by the use of two 10d nails at every wood stud spacing. A cold-formed steel member abutting the vertical wall stud shall be anchored with not fewer than nine No. 8 screws to every cold-formed steel stud. Each additional cold-formed steel roof member shall be anchored to the adjoining roof.
member using two No. 8 screws at every stud spacing. Not less than two-thirds the width of the masonry veneer thickness shall bear on the steel angle. Flashing and weep holes shall be located in the masonry veneer wythe in accordance with Figure R703.8.2.2. The maximum height of the masonry veneer above the steel angle support shall be 12 feet 8 inches (38.61 mm). The airspace separating the masonry veneer from the wood backing shall be in accordance with Sections R703.8.4 and R703.8.4.2. The support for the masonry veneer shall be constructed in accordance with Figure R703.8.2.2.

The maximum slope of the roof construction without stops shall be 7:12. Roof construction with slopes greater than 7:12 but not more than 12:12 shall have stops of a minimum 3-inch by 3-inch by \( \frac{1}{4} \) -inch (76 mm by 76 mm by 6.4 mm) steel plate welded to the angle at 24 inches (610 mm) on center along the angle or as approved by the building official.

**FIGURE R703.8.2.2**
**EXTERIOR MASONRY VENEER SUPPORT BY ROOF MEMBERS**

**R703.8.3 Lintels.**
Masonry veneer shall not support any vertical load other than the dead load of the veneer above. Veneer above openings shall be supported on lintels of noncombustible materials. The lintels shall have a length of bearing not less than 4 inches (102 mm). Steel lintels shall be shop coated with a rust-inhibitive paint, except for lintels made of corrosion-resistant steel or steel treated with coatings to provide corrosion resistance. Construction of openings shall comply with either Section R703.8.3.1 or 703.8.3.2.
R703.8.3.1 Allowable span.
The allowable span shall not exceed the values set forth in Table R703.8.3.1.

### TABLE R703.8.3.1
ALLOWABLE SPANS FOR LINTELS SUPPORTING MASONRY VENEER \(^{a,b,c,d,e}\)

<table>
<thead>
<tr>
<th>SIZE OF STEEL ANGLE (^{a,c,d}) (inches)</th>
<th>NO STORY ABOVE</th>
<th>ONE STORY ABOVE</th>
<th>TWO STORIES ABOVE</th>
<th>NO. OF (\frac{1}{2})-INCH OR EQUVALENT REINFORCING BARS IN REINFORCED LINTEL (^{b,d})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 × 3 × (\frac{1}{4})</td>
<td>6'-0&quot;</td>
<td>4'-6&quot;</td>
<td>3'-0&quot;</td>
<td>1</td>
</tr>
<tr>
<td>4 × 3 × (\frac{1}{4})</td>
<td>8'-0&quot;</td>
<td>6'-0&quot;</td>
<td>4'-6&quot;</td>
<td>1</td>
</tr>
<tr>
<td>5 × 3 (\frac{1}{2}) × (\frac{5}{16})</td>
<td>10'-0&quot;</td>
<td>8'-0&quot;</td>
<td>6'-0&quot;</td>
<td>2</td>
</tr>
<tr>
<td>6 × 3 (\frac{1}{2}) × (\frac{5}{16})</td>
<td>14'-0&quot;</td>
<td>9'-6&quot;</td>
<td>7'-0&quot;</td>
<td>2</td>
</tr>
<tr>
<td>2-6 × 3 (\frac{1}{2}) × (\frac{5}{16})</td>
<td>20'-0&quot;</td>
<td>12'-0&quot;</td>
<td>9'-6&quot;</td>
<td>4</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Long leg of the angle shall be placed in a vertical position.
b. Depth of reinforced lintels shall be not less than 8 inches and all cells of hollow masonry lintels shall be grouted solid. Reinforcing bars shall extend not less than 8 inches into the support.
c. Steel members indicated are adequate typical examples; other steel members meeting structural design requirements shall be permitted to be used.
d. Either steel angle or reinforced lintel shall span opening.
e. Spans over 4 feet (1219 mm) shall be shored up until cured.

R703.8.3.2 Maximum span.
The allowable span shall not exceed 18 feet 3 inches (5562 mm) and shall be constructed to comply with Figure R703.8.3.2 and the following:

1. Provide a minimum length of 18 inches (457 mm) of masonry veneer on each side of opening as shown in Figure R703.8.3.2.

2. Provide a minimum 5-inch by \(\frac{3}{2}\)-inch by \(\frac{5}{16}\)-inch (127 mm by 89 mm by 7.9 mm) steel angle above the opening and shore for a minimum of 7 days after installation.

3. Provide double-wire joint reinforcement extending 12 inches (305 mm) beyond each side of the opening. Lap splices of joint reinforcement not less than 12 inches (305 mm). Comply with one of the following:
3.1. Double-wire joint reinforcement shall be $\frac{3}{16}$-inch (4.8 mm) diameter and shall be placed in the first two bed joints above the opening.

3.2. Double-wire joint reinforcement shall be 9 gauge (0.144 inch or 3.66 mm diameter) and shall be placed in the first three bed joints above the opening.

4. Provide the height of masonry veneer above opening, in accordance with Table R703.8.3.2.

### TABLE R703.8.3.2
HEIGHT OF MASONRY VENEER ABOVE OPENING

<table>
<thead>
<tr>
<th>MINIMUM HEIGHT OF MASONRY VENEER ABOVE OPENING (INCH)</th>
<th>MAXIMUM HEIGHT OF MASONRY VENEER ABOVE OPENING (FEET)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>24</td>
<td>5 to &lt; 12</td>
</tr>
<tr>
<td>60</td>
<td>12 to height above support allowed by Section R703.8</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

### FIGURE R703.8.3.2
MASONRY VENEER OPENING

**R703.8.4 Anchorage.**
Masonry veneer shall be anchored to the supporting wall studs with corrosion-resistant metal ties embedded in mortar or grout and extending into the veneer a minimum of $1\frac{1}{2}$
inches (38 mm), with not less than \( \frac{5}{8} \) -inch (15.9 mm) mortar or grout cover to outside face. Masonry veneer shall conform to Table R703.8.4.

**TABLE R703.8.4**

**TIE ATTACHMENT AND AIRSPACE REQUIREMENTS**

<table>
<thead>
<tr>
<th>BACKING AND TIE</th>
<th>MINIMUM TIE</th>
<th>MINIMUM TIE FASTENER(^a)</th>
<th>AIRSPACE(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood stud backing with corrugated sheet metal</td>
<td>22 U.S. gage (0.0299 in.) ( \times \frac{7}{8} ) in. wide</td>
<td>8d common nail (^b) ((\frac{2}{1} \text{ in. } \times 0.131 \text{ in.}))</td>
<td>Nominal 1 in. between sheathing and veneer</td>
</tr>
<tr>
<td>Wood stud backing with metal strand wire</td>
<td>W1.7 (No. 9 U.S. gage; 0.148 in.) with hook embedded in mortar joint</td>
<td>8d common nail (^b) ((\frac{1}{2} \text{ in. } \times 0.131 \text{ in.}))</td>
<td>Minimum nominal 1 in. between sheathing and veneer</td>
</tr>
<tr>
<td>Cold-formed steel stud backing with adjustable metal strand wire</td>
<td>W1.7 (No. 9 U.S. gage; 0.148 in.) with hook embedded in mortar joint</td>
<td>No. 10 screw extending through the steel framing a minimum of three exposed threads</td>
<td>Minimum nominal 1 in. between sheathing and veneer</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. In Seismic Design Category D\(_0\), D\(_1\) or D\(_2\), the minimum tie fastener shall be an 8d ring-shank nail \((\frac{2}{1} \text{ in. } \times \frac{1}{2} \text{ in.})\) or a No. 10 screw extending through the steel framing a minimum of three exposed threads. An airspace that provides drainage and contains mortar from construction shall be permitted.

b. All fasteners shall have rust-inhibitive coating suitable for the installation in which they are being used, or be manufactured from material not susceptible to corrosion.

**R703.8.4.1 Size and spacing.**

Veneer ties, if strand wire, shall be not less in thickness than No. 9 U.S. gage \([0.148 \text{ inch} \ (4 \text{ mm})]\) wire and shall have a hook embedded in the mortar joint, or if sheet metal, shall be not less than No. 22 U.S. gage by \([0.0299 \text{ inch} \ (0.76 \text{ mm})]\) \( \frac{7}{8} \) -inch (22 mm) corrugated. Each tie shall support not more than 2.67 square feet \((0.25 \text{ m}^2)\) of wall area and shall be spaced not more than 32 inches \((813 \text{ mm})\) on center horizontally and 24 inches \((635 \text{ mm})\) on center vertically.

**Exception:** In Seismic Design Category D\(_0\), D\(_1\) or D\(_2\) or townhouses in Seismic Design Category C or in wind areas of more than 30 pounds per square foot pressure \((1.44 \text{ kPa})\), each tie shall support not more than 2 square feet \((0.2 \text{ m}^2)\) of wall area.

**R703.8.4.1.1 Veneer ties around wall openings.**

Additional metal ties shall be provided around wall openings greater than 16 inches \((406 \text{ mm})\) in either dimension. Metal ties around the perimeter of openings shall be
spaced not more than 3 feet (9144 mm) on center and placed within 12 inches (305 mm) of the wall opening.

R703.8.4.2 Grout fill.
As an alternative to the airspace required by Table R703.8.4, grout shall be permitted to fill the airspace. Where the airspace is filled with grout, a water-resistant barrier is required over studs or sheathing. Where the airspace is filled, replacing the sheathing and water-resistant barrier with a wire mesh and approved water-resistant barrier or an approved water-resistant barrier-backed reinforcement attached directly to the studs is permitted.

R703.8.5 Flashing.
Flashing of 6 mil (0.152 mm) poly or other corrosions resistive material shall be located beneath the first course of masonry above finished ground level above the foundation wall or slab and at other points of support, including structural floors, shelf angles and lintels where masonry veneers are designed in accordance with Section R703.8. Top of base flashing shall be installed with a minimum 2 inch (51 mm) lap behind building paper or water repellant sheathing. See Section R703.4 for additional requirements.

R703.8.6 Weepholes.
Weepholes shall be provided in the outside wythe of masonry walls at a maximum spacing of \( \frac{33}{48} \) inches (838 1219 mm) on center. Weepholes shall be not less than \( \frac{3}{16} \) inch (5 mm) in diameter. Weepholes shall be located immediately above the flashing.

R703.9 Exterior insulation and finish system (EIFS)/EIFS with drainage.
Exterior insulation and finish systems (EIFS) shall comply with this chapter and Section R703.9.1. EIFS with drainage shall comply with this chapter and Section R703.9.2.

R703.9.1 Exterior insulation and finish systems (EIFS).
EIFS shall comply with the following:

1. ASTM E-2568.

2. EIFS shall be limited to applications over substrates of concrete or masonry wall assemblies.

3. Flashing of EIFS shall be provided in accordance with the requirements of Section R703.8.

4. EIFS shall be installed in accordance with the manufacturer’s instructions.

5. EIFS shall terminate not less than 6 inches (152 mm) above the finished ground level.

6. Decorative trim shall not be face-nailed through the EIFS.

R703.9.2 Exterior insulation and finish system (EIFS) with drainage.
EIFS with drainage shall comply with the following:
1. ASTM E 2568.

2. EIFS with drainage shall be required over all wall assemblies with the exception of substrates of concrete or masonry wall assemblies.

3. EIFS with drainage shall have an average minimum drainage efficiency of 90 percent when tested in accordance with ASTM E 2273.

4. The water-resistive barrier shall comply with Section R703.2 or ASTM E 2570.

5. The water-resistive barrier shall be applied between the EIFS and the wall sheathing.

6. Flashing of EIFS with drainage shall be provided in accordance with the requirements of Section R703.8.

7. EIFS with drainage shall be installed in accordance with the manufacturer’s instructions.

8. EIFS with drainage shall terminate not less than 6 inches (152 mm) above the finished ground level.

9. Decorative trim shall not be face-nailed through the EIFS with drainage.

R703.10 Fiber cement siding.

R703.10.1 Panel siding.
Fiber-cement panels shall comply with the requirements of ASTM C 1186, Type A, minimum Grade II or ISO 8336, Category A, minimum Class 2. Panels shall be installed with the long dimension either parallel or perpendicular to framing. Vertical and horizontal joints shall occur over framing members and shall be protected with caulking, or with battens or flashing, or be vertical or horizontal shiplap, or otherwise designed to comply with Section R703.1. Panel siding shall be installed with fasteners in accordance with Table R703.3(1) or the approved manufacturer’s instructions.

R703.10.2 Lap siding.
Fiber-cement lap siding having a maximum width of 12 inches (305 mm) shall comply with the requirements of ASTM C 1186, Type A, minimum Grade II or ISO 8336, Category A, minimum Class 2. Lap siding shall be lapped a minimum of $\frac{1}{4}$ inches (32 mm) and lap siding not having tongue-and-groove end joints shall have the ends protected with caulking, covered with an H-section joint cover, located over a strip of flashing, or shall be designed to comply with Section R703.1. Lap siding courses shall be installed with the fastener heads exposed or concealed, in accordance with Table R703.3(1) or approved manufacturer’s instructions.

R703.11 Vinyl siding.
Vinyl siding shall be certified and labeled as conforming to the requirements of ASTM D 3679 by an approved quality control agency.

2018 North Carolina Residential Code
**R703.11.1 Installation.**
Vinyl siding, soffit and accessories shall be installed in accordance with the manufacturer’s instructions.

**R703.11.1.1 Fasteners.** Deleted.
Unless specified otherwise by the manufacturer’s instructions, fasteners for vinyl siding shall be 0.120-inch (3 mm) shank diameter nail with a 0.313-inch (8 mm) head or 16-gage staple with a $\frac{3}{8}$-inch (9.5 mm) to $\frac{1}{2}$-inch (12.7 mm) crown.

**R703.11.1.2 Penetration depth.** Deleted.
Unless specified otherwise by the manufacturer’s instructions, fasteners shall penetrate into building framing. The total penetration into sheathing, furring framing or other nailable substrate shall be a minimum $\frac{1}{4}$ inches (32 mm). Where specified by the manufacturer’s instructions and supported by a test report, fasteners are permitted to penetrate into or fully through nailable sheathing or other nailable substrate of minimum thickness specified by the instructions or test report without penetrating into framing. Where the fastener penetrates fully through the sheathing, the end of the fastener shall extend a minimum of $\frac{1}{4}$ inch (6.4 mm) beyond the opposite face of the sheathing or nailable substrate.

**R703.11.1.3 Spacing.** Deleted.
Unless specified otherwise by the manufacturer’s instructions, the maximum spacing between fasteners for horizontal siding shall be 16 inches (406 mm), and for vertical siding 12 inches (305 mm) both horizontally and vertically. Where specified by the manufacturer’s instructions and supported by a test report, greater fastener spacing is permitted.

**R703.11.1.4 Vinyl soffit panels.**
Soffit panels shall be individually fastened to a supporting component such as a nailing strip, fascia or subfascia component or as specified by the manufacturer’s instructions.

**R703.11.2 Foam plastic sheathing.**
Vinyl siding and insulated vinyl siding used with foam plastic sheathing shall be installed in accordance with Section R703.11.2.1, R703.11.2.2 or R703.11.2.3.

**Exception:** Where the foam plastic sheathing is applied directly over wood structural panels, fiberboard, gypsum sheathing or other approved backing capable of independently resisting the design wind pressure, the vinyl siding shall be installed in accordance with Section R703.11.1.

**R703.11.2.1 Basic wind speed not exceeding 115 miles per hour and Exposure Category B.**
Where the ultimate design wind speed does not exceed 115 miles per hour (51 m/s), the exposure category is B and gypsum board, gypsum panel product or equivalent is installed on the side of the wall opposite the foam plastic sheathing, the minimum siding fastener penetration into wood framing shall be $1\frac{1}{4}$ inches (32 mm) using minimum 0.120-inch-diameter (3 mm) nail (shank) with a minimum 0.313-inch-diameter head, 16...
inches (406 mm) on center. The foam plastic sheathing shall be minimum 1\(\text{/}_2\) -inch-thick (12.7 mm) (nominal) extruded polystyrene in accordance with ASTM C 578, 1\(\text{/}_2\) -inch-thick (12.7 mm) (nominal) polyisocyanurate in accordance with ASTM C 1289 or 1-inch-thick (25 mm) (nominal) expanded polystyrene in accordance with ASTM C 578.

R703.11.2.2 Basic wind speed exceeding 115 miles per hour or Exposure Categories C and D.
Where the ultimate design wind speed exceeds 115 miles per hour (51 m/s), the exposure category is C or D, or all conditions of Section R703.11.2.1 are not met, the adjusted design pressure rating for the assembly shall meet or exceed the loads listed in Table R301.2(2) adjusted for height and exposure using Table R301.2(3). The design wind pressure rating of the vinyl siding for installation over solid sheathing as provided in the vinyl siding manufacturer’s product specifications shall be adjusted for the following wall assembly conditions:

1. For wall assemblies with foam plastic sheathing on the exterior side and gypsum wall board, gypsum panel product or equivalent on the interior side of the wall, the vinyl siding’s design wind pressure rating shall be multiplied by 0.39.

2. For wall assemblies with foam plastic sheathing on the exterior side and without gypsum wall board, gypsum panel product or equivalent on the interior side of wall, the vinyl siding’s design wind pressure rating shall be multiplied by 0.27.

R703.11.2.3 Manufacturer specification.
Where the vinyl siding manufacturer’s product specifications provide an approved design wind pressure rating for installation over foam plastic sheathing, use of this design wind pressure rating shall be permitted and the siding shall be installed in accordance with the manufacturer’s instructions.

R703.12 Adhered masonry veneer installation.
Adhered masonry veneer shall comply with the requirements of Section R703.7.3 and the requirements in Sections 12.1 and 12.3 of TMS 402/ACI 530/ASCE 5. Adhered masonry veneer shall be installed in accordance with Section R703.7.1, Article 3.3C of TMS 602/ACI 530.1/ASCE 6 or the manufacturer’s instructions.

R703.12.1 Clearances.
On exterior stud walls, adhered masonry veneer shall be installed:

1. Minimum of 4 inches (102 mm) above the earth;

2. Minimum of 2 inches (51 mm) above paved areas; or

3. Minimum of 1\(\text{/}_2\) inch (12.7 mm) above exterior walking surfaces that are supported by the same foundation that supports the exterior wall.

R703.12.2 Flashing at foundation.
A corrosion-resistant screed or flashing of a minimum 0.019-inch (0.48 mm) or 26-gage...
R703.12.2 Galvanized or plastic with a minimum vertical attachment flange of \(3\frac{1}{2}\) inches (89 mm) shall be installed to extend a minimum of 1 inch (25 mm) below the foundation plate line on exterior stud walls in accordance with Section R703.4.

R703.12.3 Water-resistant barrier.
A water-resistant barrier shall be installed as required by Section R703.2 and shall comply with the requirements of Section R703.6.3-R703.7.3. The water-resistant barrier shall lap over the exterior of the attachment flange of the screed or flashing provided in accordance with Section R703.12.2.

R703.13 Insulated vinyl siding.
Insulated vinyl siding shall be certified and labeled as conforming to the requirements of ASTM D 7793 by an approved quality control agency.

R703.13.1 Insulated vinyl siding and accessories.
Insulated vinyl siding and accessories shall be installed in accordance with manufacturer’s instructions.

R703.14 Polypropylene siding.
Polypropylene siding shall be certified and labeled as conforming to the requirements of ASTM D 7254 by an approved quality control agency.

R703.14.1 Polypropylene siding and accessories.
Polypropylene siding and accessories shall be installed in accordance with manufacturer’s installation instructions.

R703.14.1.1 Installation.
Polypropylene siding shall be installed over and attached to wood structural panel sheathing with minimum thickness of \(7/16\) inch (11.1 mm), or other substrate, composed of wood or wood-based material and fasteners having equivalent withdrawal resistance.

R703.14.1.2 Fastener requirements.
Unless otherwise specified in the approved manufacturer’s instructions, nails shall be corrosion resistant, with a minimum 0.120-inch (3 mm) shank and minimum 0.313-inch (8 mm) head diameter. Nails shall be a minimum of \(1\frac{1}{4}\) inches (32 mm) long or as necessary to penetrate sheathing or substrate not less than \(3/4\) inch (19.1 mm). Where the nail fully penetrates the sheathing or nailable substrate, the end of the fastener shall extend not less than \(1/4\) inch (6.4 mm) beyond the opposite face of the sheathing or substrate. Staples are not permitted.

R703.14.2 Fire separation.
Polypropylene siding shall not be installed on walls with a fire separation distance of less than 5 feet (1524 mm) and walls closer than 10 feet (3048 mm) to a building on another lot.

**Exception:** Walls perpendicular to the line used to determine the fire separation distance.
R703.15 Cladding attachment over foam sheathing to wood framing.
Cladding shall be specified and installed in accordance with Section R703, the cladding manufacturer’s approved instructions, including any limitations for use over foam plastic sheathing, or an approved design. In addition, the cladding or furring attachments through foam sheathing to framing shall meet or exceed the minimum fastening requirements of Section R703.15.1, Section R703.15.2, or an approved design for support of cladding weight.

Exceptions:

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing, those requirements shall apply.

2. For exterior insulation and finish systems, refer to Section R703.9.

3. For anchored masonry or stone veneer installed over foam sheathing, refer to Section R703.7.

R703.15.1 Direct attachment.
Where cladding is installed directly over foam sheathing without the use of furring, cladding minimum fastening requirements to support the cladding weight shall be as specified in Table R703.15.1.

**TABLE R703.15.1**
CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDI NG WEIGHT

<table>
<thead>
<tr>
<th>CLADDING FASTENER THROUGH FOAM SHEATHING</th>
<th>CLADDING FASTENER TYPE AND MINIMUM SIZE</th>
<th>CLADDING FASTENER VERTICAL SPACING (inches)</th>
<th>MAXIMUM THICKNESS OF FOAM SHEATHING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Framing (minimum 1/4-inch penetration)</td>
<td>0.113&quot; diameter nail</td>
<td>6</td>
<td>16&quot; o.c. Fastener Horizontal Spacing</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3 psf</td>
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<tr>
<td></td>
<td>0.120&quot; diameter nail</td>
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<td></td>
<td>0.131&quot; diameter nail</td>
<td>6</td>
<td>4</td>
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<tr>
<td></td>
<td>0.162&quot; diameter nail</td>
<td>6</td>
<td>4</td>
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<td>12</td>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa. DR = Design required. o.c. = on center.
a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.
c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

R703.15.2 Furred cladding attachment.
Where wood furring is used to attach cladding over foam sheathing, furring minimum fastening requirements to support the cladding weight shall be as specified in Table R703.15.2. Where placed horizontally, wood furring shall be preservative-treated wood in accordance with Section R317.1 or naturally durable wood and fasteners shall be corrosion resistant in accordance Section R317.3.

| TABLE R703.15.2  
FURRING MINIMUM FASTENING REQUIREMENTS FOR APPLICATION OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT\(^a, b\) |
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>FURRING MATERIAL</td>
<td>FRAMING MEMBER</td>
<td>FASTENER TYPE AND MINIMUM SIZE</td>
<td>MINIMUM PENETRATION INTO WALL FRAMING (inches)</td>
<td>FASTENER SPACING IN FURRING (inches)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16&quot; o.c.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Furring</td>
</tr>
<tr>
<td>Minimum 1× Wood Furring(^c)</td>
<td>Minimum 2× Wood Stud</td>
<td>0.131&quot; diameter nail</td>
<td>(1 \div 4)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.162&quot; diameter nail</td>
<td>(1 \div 4)</td>
<td>8</td>
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<tr>
<td></td>
<td></td>
<td>No.10 wood screw</td>
<td>1</td>
<td>16</td>
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<td></td>
<td></td>
<td>1/4 &quot; lag screw</td>
<td>1</td>
<td>12</td>
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<td>16</td>
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<td>24</td>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
DR = Design required.
o.c. = on center.
a. Wood framing and furring shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.
c. Where the required cladding fastener penetration into wood material exceeds \(\frac{3}{4}\) inch and is not more than \(\frac{1}{2}\) inches, a minimum 2´ wood furring or an approved design shall be used.
d. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

e. Furring shall be spaced not more than 24 inches on center, in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the indicated 8-inch and 12-inch fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches and 24 inches on center, respectively.

**R703.16 Cladding attachment over foam sheathing to cold-formed steel framing.** Deleted.

Cladding shall be specified and installed in accordance with Section R703, the cladding manufacturer’s approved instructions, including any limitations for use over foam plastic sheathing, or an approved design. In addition, the cladding or furring attachments through foam sheathing to framing shall meet or exceed the minimum fastening requirements of Section R703.16.1, Section R703.16.2 or an approved design for support of cladding weight.

**Exceptions:**

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing, those requirements shall apply.

2. For exterior insulation and finish systems, refer to Section R703.9.

3. For anchored masonry or stone veneer installed over foam sheathing, refer to Section R703.7.

**R703.16.1 Direct attachment.**

Where cladding is installed directly over foam sheathing without the use of furring, cladding minimum fastening requirements to support the cladding weight shall be as specified in Table R703.16.1.

**TABLE R703.16.1**

<table>
<thead>
<tr>
<th>CLADDING FASTENER THROUGH FOAM SHEATHING INTO: Steel Framing (minimum penetration of steel thickness +3 threads)</th>
<th>CLADDING FASTENER TYPE AND MINIMUM SIZE</th>
<th>CLADDING FASTENER VERTICAL SPACING (inches)</th>
<th>MAXIMUM THICKNESS OF FOAM SHEATHING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>16” o.c. Fastener Horizontal Spacing</strong></td>
<td><strong>24” o.c. Fastener Horizontal Spacing</strong></td>
<td>Cladding Weight:</td>
<td>Cladding Weight:</td>
</tr>
<tr>
<td>3 psf</td>
<td>11 psf</td>
<td>25 psf</td>
<td>3 psf</td>
</tr>
<tr>
<td>No. 8 screw into 33 mil steel or thicker</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>1.5</td>
<td>DR</td>
</tr>
<tr>
<td>No. 10 screw into 33 mil steel</td>
<td>6</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>2</td>
<td>DR</td>
</tr>
<tr>
<td>No. 10 screw into 43 mil steel or thicker</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>3</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Steel framing shall be minimum 33 ksi steel for 33 mil and 43 mil steel, and 50 ksi steel for 54 mil steel or thicker.

Screws shall comply with the requirements of ASTM C 1513.

Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

### R703.16.2 Furred cladding attachment.

Where steel or wood furring is used to attach cladding over foam sheathing, furring minimum fastening requirements to support the cladding weight shall be as specified in Table R703.16.2. Where placed horizontally, wood furring shall be preservative treated wood in accordance with Section R317.1 or naturally durable wood and fasteners shall be corrosion resistant in accordance with Section R317.3. Steel furring shall have a minimum G60 galvanized coating.

#### TABLE R703.16.2

Furring Minimum Fastening Requirements for Application over Foam Plastic Sheathing to Support Cladding Weight

<table>
<thead>
<tr>
<th>Furring Material</th>
<th>Framing Member</th>
<th>Fastener Type and Minimum Size</th>
<th>Minimum Penetration into Wall Framing (inches)</th>
<th>Fastener Spacing in Furring (inches)</th>
<th>Maximum Thickness of Foam Sheathing (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum 33 mil Steel Stud</td>
<td>No. 8 screw</td>
<td>Steel thickness + 3 threads</td>
<td>12</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Minimum 33 mil Steel Stud</td>
<td>No. 10 screw</td>
<td>Steel thickness + 3 threads</td>
<td>24</td>
<td>2</td>
<td>DR</td>
</tr>
<tr>
<td>43 mil or thicker Steel Stud</td>
<td>No. 8 Screw</td>
<td>Steel thickness + 3 threads</td>
<td>12</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>43 mil or thicker Steel Stud</td>
<td>No. 10 screw</td>
<td>Steel thickness + 3 threads</td>
<td>24</td>
<td>2</td>
<td>DR</td>
</tr>
</tbody>
</table>
a. Wood furring shall be Spruce-pine-fir or any softwood species with a specific gravity of 0.42 or greater. Steel furring shall be minimum 33 ksi steel. Steel studs shall be minimum 33 ksi steel for 33mil and 43 mil thickness, and 50 ksi steel for 54 mil steel or thicker.

b. Screws shall comply with the requirements of ASTM C 1513.

c. Where the required cladding fastener penetration into wood material exceeds $\frac{3}{4}$ inch and is not more than 1 $\frac{1}{2}$ inches, a minimum 2-inch nominal wood furring or an approved design shall be used.

d. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

e. Furring shall be spaced not more than 24 inches (610 mm) on center, in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the indicated 8-inch and 12-inch fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches and 24 inches on center, respectively.

R703.17 Cladding attachment over foam sheathing to masonry or concrete wall construction.

Cladding shall be specified and installed in accordance with Section 703.3 and the cladding manufacturer’s instructions or an approved design. Foam sheathing shall be attached to masonry or concrete construction in accordance with the insulation manufacturer’s installation instructions or an approved design. Furring and furring attachments through foam sheathing into concrete or masonry substrate shall be designed to resist design loads determined in accordance with Section R301, including support of cladding weight as applicable. Fasteners used to attach cladding or furring through foam sheathing to masonry or concrete substrates shall be approved for application into masonry or concrete material and shall be installed in accordance with the fastener manufacturer’s instructions.

Exceptions:

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing and connection to a masonry or concrete substrate, those requirements shall apply.

2. For exterior insulation and finish systems, refer to Section R703.9.

3. For anchored masonry or stone veneer installed over foam sheathing, refer to Section R703.7
CHAPTER 8
ROOF-CEILING CONSTRUCTION

SECTION R801
GENERAL

R801.1 Application.
The provisions of this chapter shall control the design and construction of the roof-ceiling system for buildings.

R801.2 Requirements.
Roof and ceiling construction shall be capable of accommodating all loads imposed in accordance with Section R301 and of transmitting the resulting loads to the supporting structural elements.

R801.3 Roof drainage.
In areas where expansive or collapsible soils are known to exist, all dwellings shall have a controlled method of water disposal from roofs that will collect and discharge roof drainage to the ground surface not less than 5 feet (1524 mm) from foundation walls or to an approved drainage system.

SECTION R802
WOOD ROOF FRAMING

R802.1 General.
Wood and wood-based products used for load-supporting purposes shall conform to the applicable provisions of this section.

R802.1.1 Sawn lumber.
Sawn lumber shall be identified by a grade mark of an accredited lumber grading or inspection agency and have design values certified by an accreditation body that complies with DOC PS 20. In lieu of a grade mark, a certificate of inspection issued by a lumber grading or inspection agency meeting the requirements of this section shall be accepted.

R802.1.1.1 End-jointed lumber.
Approved end-jointed lumber identified by a grade mark conforming to Section R802.1 shall be permitted to be used interchangeably with solid-sawn members of the same species and grade. End-jointed lumber used in an assembly required elsewhere in this code to have a fire-resistance rating shall have the designation “Heat-Resistant Adhesive” or “HRA” included in its grade mark.

R802.1.2 Structural glued laminated timbers.
Glued laminated timbers shall be manufactured and identified as required in ANSI/AITC A190.1 and ASTM D 3737.

R802.1.3 Structural log members.
Structural log members shall comply with the provisions of ICC 400.
R802.1.4 Structural composite lumber.
Structural capacities for structural composite lumber shall be established and monitored in accordance with ASTM D 5456.

R802.1.5 Fire-retardant-treated wood.
Fire-retardant-treated wood (FRTW) is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E 84 or UL 723, a listed flame spread index of 25 or less and shows no evidence of significant progressive combustion where the test is continued for an additional 20-minute period. In addition, the flame front shall not progress more than 10.5 feet (3200 mm) beyond the center line of the burners at any time during the test.

R802.1.5.1 Pressure process.
For wood products impregnated with chemicals by a pressure process, the process shall be performed in closed vessels under pressures not less than 50 pounds per square inch gauge (psig) (344.7 kPa).

R802.1.5.2 Other means during manufacture.
For wood products produced by other means during manufacture the treatment shall be an integral part of the manufacturing process of the wood product. The treatment shall provide permanent protection to all surfaces of the wood product.

R802.1.5.3 Testing.
For wood products produced by other means during manufacture, other than a pressure process, all sides of the wood product shall be tested in accordance with and produce the results required in Section R802.1.3. Testing of only the front and back faces of wood structural panels shall be permitted.

R802.1.5.4 Labeling.
Fire-retardant-treated lumber and wood structural panels shall be labeled. The label shall contain:

1. The identification mark of an approved agency in accordance with Section 1703.5 of the International Building Code.

2. Identification of the treating manufacturer.

3. The name of the fire-retardant treatment.

4. The species of wood treated.

5. Flame spread index and smoke-developed index.


7. Conformance to applicable standards in accordance with Sections R802.1.5.5 through R802.1.5.10.
8. For FRTW exposed to weather, or a damp or wet location, the words “No increase in the listed classification when subjected to the Standard Rain Test” (ASTM D 2898).

R802.1.5.5 Strength adjustments.
Design values for untreated lumber and wood structural panels as specified in Section R802.1 shall be adjusted for fire-retardant-treated wood. Adjustments to design values shall be based upon an approved method of investigation that takes into consideration the effects of the anticipated temperature and humidity to which the fire-retardant-treated wood will be subjected, the type of treatment and redrying procedures.

R802.1.5.6 Wood structural panels.
The effect of treatment and the method of redrying after treatment, and exposure to high temperatures and high humidities on the flexure properties of fire-retardant-treated softwood plywood shall be determined in accordance with ASTM D 5516. The test data developed by ASTM D 5516 shall be used to develop adjustment factors, maximum loads and spans, or both for untreated plywood design values in accordance with ASTM D 6305. Each manufacturer shall publish the allowable maximum loads and spans for service as floor and roof sheathing for their treatment.

R802.1.5.7 Lumber.
For each species of wood treated, the effect of the treatment and the method of redrying after treatment and exposure to high temperatures and high humidities on the allowable design properties of fire-retardant-treated lumber shall be determined in accordance with ASTM D 5664. The test data developed by ASTM D 5664 shall be used to develop modification factors for use at or near room temperature and at elevated temperatures and humidity in accordance with ASTM D 6841. Each manufacturer shall publish the modification factors for service at temperatures of not less than 80°F (27°C) and for roof framing. The roof framing modification factors shall take into consideration the climatological location.

R802.1.5.8 Exposure to weather.
Where fire-retardant-treated wood is exposed to weather or damp or wet locations, it shall be identified as “Exterior” to indicate there is not an increase in the listed flame spread index as defined in Section R802.1.5 when subjected to ASTM D 2898.

R802.1.5.9 Interior applications.
Interior fire-retardant-treated wood shall have a moisture content of not over 28 percent when tested in accordance with ASTM D 3201 procedures at 92-percent relative humidity. Interior fire-retardant-treated wood shall be tested in accordance with Section R802.1.5.6 or R802.1.5.7. Interior fire-retardant-treated wood designated as Type A shall be tested in accordance with the provisions of this section.

R802.1.5.10 Moisture content.
Fire-retardant-treated wood shall be dried to a moisture content of 19 percent or less for lumber and 15 percent or less for wood structural panels before use. For wood kiln dried after treatment (KDAT) the kiln temperatures shall not exceed those used in kiln drying the lumber and plywood submitted for the tests described in Section R802.1.5.6 for plywood and R802.1.5.7 for lumber.
R802.1.6 Cross-laminated timber.
Cross-laminated timber shall be manufactured and identified as required by ANSI/APA PRG 320.

R802.1.7 Engineered wood rim board.
Engineered wood rim boards shall conform to ANSI/APA PRR 410 or shall be evaluated in accordance with ASTM D 7672. Structural capacities shall be in accordance with ANSI/APA PRR 410 or established in accordance with ASTM D 7672. Rim boards conforming to ANSI/APA PRR 410 shall be marked in accordance with that standard.

R802.2 Design and construction.
The framing details required in Section R802 apply to roofs having a minimum slope of three units vertical in 12 units horizontal (25-percent slope) or greater. Roof-ceilings shall be designed and constructed in accordance with the provisions of this chapter and Figures R606.11(1), R606.11(2) and R606.11(3) or in accordance with AWC NDS. Components of roof-ceilings shall be fastened in accordance with Table R602.3(1).

R802.3 Framing details.
Rafters shall be framed not more than 1\frac{1}{2}-inch (38 mm) offset from each other to ridge board or directly opposite from each other with a gusset plate as a tie. Ridge board shall be not less than 1-inch (25 mm) nominal thickness and not less in depth than the cut end of the rafter. Opposing rafters at the ridge must align within the thickness of the ridge member. Regularly spaced hip and valley rafters need not align. At valleys and hips there shall be a valley or hip rafter not less than 2-inch (51 mm) nominal thickness and not less in depth than the cut end of the rafter. Hip and valley rafters shall be supported at the ridge by a brace to a bearing partition or be designed to carry and distribute the specific load at that point. Where the roof pitch is less than three units vertical in 12 units horizontal (25-percent slope), structural members that support rafters and ceiling joists, such as ridge beams, hips and valleys, shall be designed as beams.

R802.3.1 Ceiling joist and rafter connections.
Ceiling joists and rafters shall be nailed to each other in accordance with Table R802.5.1(9), and the rafter shall be nailed to the top wall plate in accordance with Table R602.3(1). Ceiling joists shall be continuous or securely joined in accordance with Table R802.5.1(9) where they meet over interior partitions and are nailed to adjacent rafters to provide a continuous tie across the building where such joists are parallel to the rafters.

Where ceiling joists are not connected to the rafters at the top wall plate, joists connected higher in the attic shall be installed as rafter ties, or rafter ties shall be installed to provide a continuous tie. Where ceiling joists are not parallel to rafters, subflooring or metal straps attached to the ends of the rafters shall be installed in a manner to provide a continuous tie across the building or rafter ties shall be installed. Rafter ties shall be not less than 2 inches by 4 inches (51 mm by 102 mm) (nominal), installed in accordance with the connection requirements in Table R802.5.1(9), or connections of equivalent capacities shall be provided. Where ceiling joists or rafter ties are not provided, the ridge formed by these rafters shall be supported by a wall or girder designed in accordance with accepted engineering practice.

Rafter ties shall be spaced not more than 4 feet (1219 mm) on center.

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Collar ties or ridge straps to resist wind uplift shall be connected in the upper third of the attic space in accordance with Table R602.3(1).

Collar ties shall be not less than 1 inch by 4 inches (25 mm by 102 mm) (nominal), spaced not more than 4 feet (1219 mm) on center.

**R802.3.2 Ceiling joists lapped.**
Ends of ceiling joists shall be lapped not less than 3 inches (76 mm) or butted over bearing partitions or beams and toenailed to the bearing member. Where ceiling joists are used to provide resistance to rafter thrust, lapped joists shall be nailed together in accordance with Table R802.5.1(9) and butted joists shall be tied together in a manner to resist such thrust. Joists that do not resist thrust shall be permitted to be nailed in accordance with Table R602.3(1).

**R802.3.3 Blocking.**
Blocking shall be a minimum of utility grade lumber.

**R802.4 Allowable ceiling joist spans.**
Spans for ceiling joists shall be in accordance with Tables R802.4(1) and R802.4(2). For other grades and species and for other loading conditions, refer to the AWC STJR.

**TABLE R802.4(1)**
CEILING JOIST SPANS FOR COMMON LUMBER SPECIES
(Uninhabitable attics without storage, live load = 10 psf, L/Δ = 240)

<table>
<thead>
<tr>
<th>CEILING JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 5 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(feet - inches)</td>
</tr>
<tr>
<td>12</td>
<td>Douglas fir-larch SS</td>
<td>13-2</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #1</td>
<td>12-8</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #2</td>
<td>12-5</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #3</td>
<td>11-1</td>
</tr>
<tr>
<td></td>
<td>Hem-fir SS</td>
<td>12-5</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #1</td>
<td>12-2</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #2</td>
<td>11-7</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #3</td>
<td>10-10</td>
</tr>
<tr>
<td></td>
<td>Southern pine SS</td>
<td>12-11</td>
</tr>
<tr>
<td></td>
<td>Southern pine #1</td>
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<td>11-10</td>
</tr>
<tr>
<td></td>
<td>Southern pine #3</td>
<td>10-1</td>
</tr>
<tr>
<td></td>
<td>Spruce-pine-fir SS</td>
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</tr>
<tr>
<td></td>
<td>Spruce-pine-fir #1</td>
<td>11-10</td>
</tr>
<tr>
<td></td>
<td>Spruce-pine-fir #2</td>
<td>11-10</td>
</tr>
<tr>
<td></td>
<td>Spruce-pine-fir #3</td>
<td>10-10</td>
</tr>
<tr>
<td>16</td>
<td>Douglas fir-larch SS</td>
<td>11-11</td>
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<td>11-3</td>
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<tr>
<td></td>
<td>Douglas fir-larch #3</td>
<td>9-7</td>
</tr>
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</table>
### TABLE R802.4(1)—continued

**CEILING JOIST SPANS FOR COMMON LUMBER SPECIES**

Uninhabitable attics without storage, live load = 10 psf, \( L/\Delta = 240 \)

<table>
<thead>
<tr>
<th>CEILING JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 5 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
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<tr>
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<td>(feet - inches)</td>
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<td>#2</td>
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<td>Douglas fir-larch</td>
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</tr>
<tr>
<td></td>
<td>Hem-fir</td>
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<tr>
<td></td>
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<td>#1</td>
</tr>
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<td></td>
<td>Hem-fir</td>
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<tr>
<td></td>
<td>Southern pine</td>
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<td></td>
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<td></td>
<td>Spruce-pine-fir</td>
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</tr>
<tr>
<td>24</td>
<td>Douglas fir-larch</td>
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<td>#2</td>
</tr>
<tr>
<td></td>
<td>Southern pine</td>
<td>#3</td>
</tr>
</tbody>
</table>
Spruce-pine-fir | #1 | 9-5 | 14-9 | 18-9 | 22-11 |
Spruce-pine-fir | #2 | 9-5 | 14-9 | 18-9 | 22-11 |
Spruce-pine-fir | #3 | 7-8 | 11-2 | 14-2 | 17-4 |

Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. Span exceeds 26 feet in length.

**TABLE R802.4(2)**
**CEILING JOIST SPANS FOR COMMON LUMBER SPECIES**
(Uninhabitable attics with limited storage, live load = 20 psf, L/Δ = 240)

<table>
<thead>
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<th>2 × 8</th>
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<tr>
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<td></td>
<td>(feet - inches)</td>
<td>(feet - inches)</td>
<td>(feet - inches)</td>
<td>(feet - inches)</td>
</tr>
<tr>
<td>12</td>
<td>Douglas fir-larch</td>
<td>10-5</td>
<td>16-4</td>
<td>21-7</td>
<td>Note a</td>
</tr>
<tr>
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<td>20-1</td>
<td>24-6</td>
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<tr>
<td></td>
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<td>15-0</td>
<td>19-1</td>
<td>23-3</td>
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<td>19-10</td>
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<td>14-5</td>
<td>18-6</td>
<td>22-7</td>
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<td>16-1</td>
<td>21-2</td>
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<tr>
<td></td>
<td>Southern pine</td>
<td>10-9</td>
<td>15-6</td>
<td>20-5</td>
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<tr>
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<td>14-9</td>
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<td>13-7</td>
<td>17-2</td>
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<td>12-8</td>
<td>16-0</td>
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</table>
### TABLE R802.4(2)—continued
CEILING JOIST SPANS FOR COMMON LUMBER SPECIES
(Uninhabitable attics with limited storage, live load = 20 psf, L/Δ = 240)

<table>
<thead>
<tr>
<th>CEILING JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
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<tr>
<td></td>
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<td>(feet - inches)</td>
</tr>
<tr>
<td>19.2</td>
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<tr>
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<td>8-7</td>
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<tr>
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<td>Hem-fir SS</td>
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</tr>
<tr>
<td></td>
<td>Hem-fir #1</td>
<td>8-3</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #2</td>
<td>7-10</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #3</td>
<td>6-1</td>
</tr>
<tr>
<td></td>
<td>Southern pine SS</td>
<td>8-9</td>
</tr>
<tr>
<td></td>
<td>Southern pine #1</td>
<td>8-5</td>
</tr>
<tr>
<td></td>
<td>Southern pine #2</td>
<td>7-4</td>
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<td></td>
<td>Southern pine #3</td>
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<td>Spruce-pine-fir SS</td>
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<td>Spruce-pine-fir #2</td>
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<td></td>
<td>Spruce-pine-fir #3</td>
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<tr>
<td>24</td>
<td>Douglas fir-larch SS</td>
<td>8-3</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #1</td>
<td>7-8</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #2</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #3</td>
<td>5-7</td>
</tr>
<tr>
<td></td>
<td>Hem-fir SS</td>
<td>7-10</td>
</tr>
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<tr>
<td></td>
<td>Hem-fir #2</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #3</td>
<td>5-5</td>
</tr>
<tr>
<td></td>
<td>Southern pine SS</td>
<td>8-1</td>
</tr>
<tr>
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<td></td>
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<td>5-1</td>
</tr>
<tr>
<td></td>
<td>Spruce-pine-fir SS</td>
<td>7-8</td>
</tr>
</tbody>
</table>
RAFTER SPANS FOR COMMON LUMBER SPECIES

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 × 4</td>
<td>2 × 6</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch</td>
<td>SS</td>
<td>11-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>11-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2</td>
<td>10-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>8-9</td>
</tr>
<tr>
<td></td>
<td>Hem-fir</td>
<td>SS</td>
<td>10-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>10-7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>8-7</td>
</tr>
<tr>
<td></td>
<td>Southern pine</td>
<td>SS</td>
<td>11-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>10-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2</td>
<td>10-4</td>
</tr>
<tr>
<td></td>
<td>Southern pine</td>
<td>#3</td>
<td>8-0</td>
</tr>
</tbody>
</table>

Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. Span exceeds 26 feet in length.

R802.5 Allowable rafter spans.
Spans for rafters shall be in accordance with Tables R802.5.1(1) through R802.5.1(8). For other grades and species and for other loading conditions, refer to the AWC STJR. The span of each rafter shall be measured along the horizontal projection of the rafter.

R802.5.1 Purlins.
Installation of purlins to reduce the span of rafters is permitted as shown in Figure R802.5.1. Purlins shall be sized not less than the required size of the rafters that they support. Purlins shall be continuous and shall be supported by 2-inch by 4-inch (51 mm by 102 mm) braces installed to bearing walls at a slope not less than 45 degrees (0.79 rad) from the horizontal. The braces shall be spaced not more than 4 feet (1219 mm) on center and the unbraced length of braces shall not exceed 8 feet (2438 mm).
| Thickness (inches) | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |

**Note:**
- **SS** indicates second story.
- **#1** indicates first story.
- **#2** indicates second story.
- **#3** indicates third story.
- **#4** indicates fourth story.
- **#5** indicates fifth story.
- **#6** indicates sixth story.
- **#7** indicates seventh story.
- **#8** indicates eighth story.
- **#9** indicates ninth story.
- **#10** indicates tenth story.
- **#11** indicates eleventh story.
- **#12** indicates twelfth story.
- **#13** indicates thirteenth story.
- **#14** indicates fourteenth story.
- **#15** indicates fifteenth story.
- **#16** indicates sixteenth story.
- **#17** indicates seventeenth story.
- **#18** indicates eighteenth story.
- **#19** indicates nineteenth story.
- **#20** indicates twentieth story.
- **#21** indicates twenty-first story.
- **#22** indicates twenty-second story.
- **#23** indicates twenty-third story.
- **#24** indicates twenty-fourth story.
- **#25** indicates twenty-fifth story.
- **#26** indicates twenty-sixth story.
- **#27** indicates twenty-seventh story.
- **#28** indicates twenty-eighth story.
- **#29** indicates twenty-ninth story.
- **#30** indicates thirtieth story.

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### TABLE R802.5.1(1)—continued

**RAFTER SPANS FOR COMMON LUMBER SPECIES**

(Roof live load = 20 psf, ceiling not attached to rafters, L/Δ = 180)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Douglas fir-larch SS</td>
<td>9-1</td>
<td>14-4</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #1</td>
<td>8-7</td>
<td>12-6</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #2</td>
<td>8-2</td>
<td>11-11</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #3</td>
<td>6-2</td>
<td>9-1</td>
</tr>
<tr>
<td></td>
<td>Hem-fir SS</td>
<td>8-7</td>
<td>13-6</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #1</td>
<td>8-5</td>
<td>12-4</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #2</td>
<td>7-11</td>
<td>11-7</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #3</td>
<td>6-1</td>
<td>8-10</td>
</tr>
<tr>
<td></td>
<td>Southern pine SS</td>
<td>8-11</td>
<td>14-1</td>
</tr>
<tr>
<td></td>
<td>Southern pine #1</td>
<td>8-7</td>
<td>12-9</td>
</tr>
<tr>
<td></td>
<td>Southern pine #2</td>
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<td></td>
<td>Southern pine #3</td>
<td>5-8</td>
<td>8-4</td>
</tr>
<tr>
<td></td>
<td>Spruce-fir SS</td>
<td>8-5</td>
<td>13-3</td>
</tr>
<tr>
<td></td>
<td>Spruce-fir #1</td>
<td>8-0</td>
<td>11-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-fir #2</td>
<td>8-0</td>
<td>11-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-fir #3</td>
<td>6-1</td>
<td>8-10</td>
</tr>
</tbody>
</table>
Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

<table>
<thead>
<tr>
<th>( \frac{H}{H_{CR}} )</th>
<th>Rafter Span Adjustment Factor</th>
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</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
</tr>
<tr>
<td>1/5</td>
<td>0.83</td>
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<td>1/6</td>
<td>0.90</td>
</tr>
<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
</tr>
</tbody>
</table>

where:

\( H_C \) = Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.

\( H_R \) = Height of roof ridge measured vertically above the top of the rafter support walls.

b. Span exceeds 26 feet in length.

### TABLE R802.5.1(2)

RAFTER SPANS FOR COMMON LUMBER SPECIES
(Roof live load = 20 psf, ceiling attached to rafters, \( L/\Delta = 240 \))

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4  2 x 6  2 x 8  2 x 10</td>
<td>2 x 4  2 x 6  2 x 8  2 x 10</td>
</tr>
<tr>
<td>12</td>
<td>Douglas fir-larch SS 9-10 16-4 21-7 Note b</td>
<td>Note b</td>
<td>10-5 16-4 21-7 Note b</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #1 9-10 15-9 20-10 Note b</td>
<td>Note b</td>
<td>10-0 15-4 19-5 23-9 Note b</td>
</tr>
<tr>
<td></td>
<td>Douglas fir-larch #2 9-10 15-6 20-5 26-0 Note b</td>
<td>Note b</td>
<td>9-10 14-7 18-5 22-6 26-0</td>
</tr>
<tr>
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<td>Douglas fir-larch #3 8-9 12-10 16-3 19-10 23-0</td>
<td>7-7 11-1 14-1 17-2 19-11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hem-fir SS 9-10 15-6 20-5 Note b</td>
<td>Note b</td>
<td>9-10 15-6 20-5 Note b</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #1 9-8 15-2 19-11 25-5 Note b</td>
<td>Note b</td>
<td>9-8 15-2 19-2 23-5 Note b</td>
</tr>
<tr>
<td></td>
<td>Hem-fir #2 9-2 14-5 19-0 24-3 Note b</td>
<td>Note b</td>
<td>9-2 14-2 17-11 21-11 25-5</td>
</tr>
<tr>
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<td>Hem-fir #3 8-7 12-6 15-10 19-5 22-6</td>
<td>7-5 10-10 13-9 16-9 19-6</td>
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<tr>
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<td>Southern pine SS 10-3 16-1 21-2 Note b</td>
<td>Note b</td>
<td>10-3 16-1 21-2 Note b</td>
</tr>
<tr>
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<td>Southern pine #1 9-10 15-6 20-5 Note b</td>
<td>Note b</td>
<td>9-10 15-6 19-10 23-2 Note b</td>
</tr>
<tr>
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<td>Southern pine #2 9-5 14-9 19-6 23-5 Note b</td>
<td>Note b</td>
<td>9-0 13-6 17-1 20-3 23-10</td>
</tr>
<tr>
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<td>Southern pine #3 8-0 11-9 14-10 18-0 21-4</td>
<td>6-11 10-2 12-10 15-7 18-6</td>
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</tbody>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Lumber Species</th>
<th>Spans</th>
<th>10 ft</th>
<th>15 ft</th>
<th>20 ft</th>
<th>25 ft</th>
<th>30 ft</th>
<th>35 ft</th>
<th>40 ft</th>
<th>45 ft</th>
<th>50 ft</th>
<th>55 ft</th>
<th>60 ft</th>
<th>65 ft</th>
<th>70 ft</th>
<th>75 ft</th>
<th>80 ft</th>
<th>85 ft</th>
<th>90 ft</th>
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</thead>
<tbody>
<tr>
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<td>#1</td>
<td>9-5</td>
<td>14-9</td>
<td>19-6</td>
<td>24-10</td>
<td>Note b</td>
<td>9-5</td>
<td>14-4</td>
<td>18-2</td>
<td>22-3</td>
<td>25-9</td>
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<tr>
<td>Spruce-pine-fir</td>
<td>#2</td>
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<td>14-9</td>
<td>19-6</td>
<td>24-10</td>
<td>Note b</td>
<td>9-5</td>
<td>14-4</td>
<td>18-2</td>
<td>22-3</td>
<td>25-9</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spruce-pine-fir</td>
<td>#3</td>
<td>8-7</td>
<td>12-6</td>
<td>15-10</td>
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<td>19-6</td>
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</tr>
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<td>19-7</td>
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<td>Note b</td>
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</tr>
<tr>
<td>Douglas fir-larch</td>
<td>#1</td>
<td>9-1</td>
<td>14-4</td>
<td>18-11</td>
<td>23-9</td>
<td>Note b</td>
<td>9-1</td>
<td>13-3</td>
<td>16-10</td>
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<td>23-10</td>
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<tr>
<td>Douglas fir-larch</td>
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<td>14-1</td>
<td>18-5</td>
<td>22-6</td>
<td>26-0</td>
<td>8-7</td>
<td>12-7</td>
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</tr>
<tr>
<td>Douglas fir-larch</td>
<td>#3</td>
<td>7-7</td>
<td>11-1</td>
<td>14-1</td>
<td>17-2</td>
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(continued)

TABLE R802.5.1(2)—continued
RAFTER SPANS FOR COMMON LUMBER SPECIES

2018 North Carolina Residential Code
Check sources for availability of lumber in lengths greater than 20 feet.

2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

<table>
<thead>
<tr>
<th>( \frac{H}{H_C} )</th>
<th>Rafter Span Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
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<tr>
<td>1/5</td>
<td>0.83</td>
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<tr>
<td>1/6</td>
<td>0.90</td>
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<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
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</tbody>
</table>

where:

\( H_C \) = Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.

\( H_R \) = Height of roof ridge measured vertically above the top of the rafter support walls.

b. Span exceeds 26 feet in length.

**TABLE R802.5.1(3)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES**

(Ground snow load = 30 psf, ceiling not attached to rafters, \( L/\Delta = 180 \))

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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<tbody>
<tr>
<td></td>
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<td>2 x 4</td>
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Note: Dead load = 10 psf, Ceiling not attached to rafters, \( \Delta/\Delta = 180 \).
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(continued)

**TABLE R802.5.1(3)—continued**

**RAFTER SPANS FOR COMMON LUMBER SPECIES**

(Ground snow load = 30 psf, ceiling not attached to rafters, L/Δ = 180)

2018 North Carolina Residential Code
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Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

2018 North Carolina Residential Code
a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

\[
\frac{H}{C} \quad \frac{H}{R}
\]

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<tr>
<th>Rafter Span Adjustment Factor</th>
<th>1/3</th>
<th>1/4</th>
<th>1/5</th>
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<td>0.90</td>
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where:

\[
H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.}
\]

\[
H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.}
\]

b. Span exceeds 26 feet in length.

**TABLE R802.5.1(4)**

**RAFTER SPANS FOR COMMON LUMBER SPECIES**

*Ground snow load = 50 psf, ceiling not attached to rafters, L/\Delta = 180*  

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<th>Species and Grade</th>
<th>Maximum Rafter Spans</th>
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(continued)

**TABLE R802.5.1(4)—continued**

RAFTER SPANS FOR COMMON LUMBER SPECIES

(Ground snow load = 50 psf, ceiling not attached to rafters, L/Δ = 180)

2018 North Carolina Residential Code
Check sources for availability of lumber in lengths greater than 20 feet.

2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or
   that some other method of resisting the outward push of the rafters on the bearing walls, such as
   rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic
   space, the rafter spans shall be multiplied by the following factors:

\[
\begin{array}{c|c}
\frac{H}{H} & \text{Rafter Span Adjustment Factor} \\
\hline
1/3 & 0.67 \\
1/4 & 0.76 \\
1/5 & 0.83 \\
1/6 & 0.90 \\
1/7.5 \text{ or less} & 1.00 \\
\end{array}
\]

where:

\( H_c \) = Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.

\( H_r \) = Height of roof ridge measured vertically above the top of the rafter support walls.

b. Span exceeds 26 feet in length.

**TABLE R802.5.1(5)**
RAFTER SPANS FOR COMMON LUMBER SPECIES
(Ground snow load = 30 psf, ceiling attached to rafters, L/\( \Delta \) = 240)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
<td>2 x 6</td>
</tr>
<tr>
<td>Douglas fir-larch</td>
<td>SS</td>
<td>9-1</td>
<td>14-4</td>
</tr>
<tr>
<td>Hem-fir</td>
<td>SS</td>
<td>8-7</td>
<td>13-6</td>
</tr>
<tr>
<td>Hem-fir</td>
<td>#1</td>
<td>8-5</td>
<td>13-3</td>
</tr>
<tr>
<td>Hem-fir</td>
<td>#2</td>
<td>8-0</td>
<td>12-7</td>
</tr>
<tr>
<td>Hem-fir</td>
<td>#3</td>
<td>7-1</td>
<td>10-5</td>
</tr>
<tr>
<td>Southern pine</td>
<td>SS</td>
<td>8-11</td>
<td>14-1</td>
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<tr>
<td>Southern pine</td>
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<td>8-7</td>
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<tr>
<td>Southern pine</td>
<td>#3</td>
<td>6-7</td>
<td>9-9</td>
</tr>
</tbody>
</table>

Note a: Maximum rafter spans

2018 North Carolina Residential Code
| Spruce-pine-fir | #1  | 8-3 | 12-11 | 17-0 | 21-4 | 24-8 | 8-3 | 12-4 | 15-7 | 19-1 | 22-1 |
| Spruce-pine-fir | #2  | 8-3 | 12-11 | 17-0 | 21-4 | 24-8 | 8-3 | 12-4 | 15-7 | 19-1 | 22-1 |
| Spruce-pine-fir | #3  | 7-1 | 10-5  | 13-2 | 16-1 | 18-8 | 6-4 | 9-4  | 11-9 | 14-5 | 16-8 |
| Douglas fir-larch | SS | 8-3 | 13-0  | 17-2 | 21-10 | Note b | 8-3 | 13-0 | 17-2 | 21-7 | 25-1 |
| Douglas fir-larch | #1 | 8-0 | 12-6  | 16-2 | 19-9 | 22-10 | 7-10 | 11-5 | 14-5 | 17-8 | 20-5 |
| Douglas fir-larch | #2 | 7-10 | 12-1 | 15-4 | 18-9 | 21-8 | 7-5 | 10-10 | 13-8 | 16-9 | 19-5 |
| Douglas fir-larch | #3 | 6-4 | 9-3   | 11-8 | 14-3 | 16-7 | 5-8 | 8-3  | 10-6 | 12-9 | 14-10 |
| Hem-fir | SS | 7-10 | 12-3 | 16-2 | 20-8 | 25-1 | 7-10 | 12-3 | 16-2 | 20-8 | 24-2 |
| Hem-fir | #1 | 7-8 | 12-0 | 15-10 | 19-6 | 22-7 | 7-8 | 11-3 | 14-3 | 17-5 | 20-2 |
| Hem-fir | #2 | 7-3 | 11-5 | 14-11 | 18-2 | 21-1 | 7-2 | 10-6 | 13-4 | 16-3 | 18-10 |
| Hem-fir | #3 | 6-2 | 9-0   | 11-5 | 13-11 | 16-2 | 5-6 | 8-1  | 10-3 | 12-6 | 14-6 |
| Southern pine | SS | 8-1 | 12-9 | 16-10 | 21-6 | Note b | 8-1 | 12-9 | 16-10 | 21-6 | 25-11 |
| Southern pine | #1 | 7-10 | 12-3 | 16-2 | 19-3 | 22-10 | 7-10 | 11-7 | 14-9 | 17-3 | 20-5 |
| Southern pine | #2 | 7-6 | 11-2 | 14-2 | 16-10 | 19-10 | 6-8 | 10-0 | 12-8 | 15-1 | 17-9 |
| Southern pine | #3 | 5-9 | 8-6  | 10-8 | 13-0 | 15-4 | 5-2 | 7-7  | 9-7  | 11-7 | 13-9 |
| Spruce-pine-fir | SS | 7-8 | 12-0 | 15-10 | 20-2 | 24-7 | 7-8 | 12-0 | 15-10 | 19-9 | 22-10 |
| Spruce-pine-fir | #1 | 7-6 | 11-9 | 15-1 | 18-5 | 21-5 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 |
| Spruce-pine-fir | #2 | 7-6 | 11-9 | 15-1 | 18-5 | 21-5 | 7-3 | 10-8 | 13-6 | 16-6 | 19-2 |
| Spruce-pine-fir | #3 | 6-2 | 9-0  | 11-5 | 13-11 | 16-2 | 5-6 | 8-1  | 10-3 | 12-6 | 14-6 |

19.2

| Douglas fir-larch | SS | 7-9 | 12-3 | 16-1 | 20-7 | 25-0 | 7-9 | 12-3 | 16-1 | 19-9 | 22-10 |
| Douglas fir-larch | #1 | 7-6 | 11-8 | 14-9 | 18-0 | 20-11 | 7-1 | 10-5 | 13-2 | 16-1 | 18-8 |
| Douglas fir-larch | #2 | 7-4 | 11-0 | 14-0 | 17-1 | 19-10 | 6-9 | 9-1  | 12-6 | 15-3 | 17-9 |
| Douglas fir-larch | #3 | 5-9 | 8-5  | 10-8 | 13-1 | 15-2 | 5-2 | 7-7  | 9-7  | 11-8 | 13-6 |
| Hem-fir | SS | 7-4 | 11-7 | 15-3 | 19-5 | 23-7 | 7-4 | 11-7 | 15-3 | 19-1 | 22-1 |
| Hem-fir | #1 | 7-2 | 11-4 | 14-7 | 17-9 | 20-7 | 7-0 | 14-3 | 15-11 | 18-5 |
| Hem-fir | #2 | 6-10 | 10-9 | 13-7 | 16-7 | 19-3 | 6-7 | 9-7  | 12-2 | 14-10 | 17-3 |
| Hem-fir | #3 | 5-7 | 8-3  | 10-5 | 12-9 | 14-9 | 5-0 | 7-4  | 9-4  | 11-5 | 13-2 |

(continued)

TABLE R802.5.1(5)—continued
RAFTER SPANS FOR COMMON LUMBER SPECIES
(Ground snow load = 30 psf, ceiling attached to rafters, L/Δ = 240)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>19.2</td>
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<td>Spruce-Pine-fir</td>
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</tr>
</tbody>
</table>

2018 North Carolina Residential Code
Check sources for availability of lumber in lengths greater than 20 feet. For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

\[
\frac{H_c}{H} = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.}
\]
\[
\frac{H_R}{H} = \text{Height of roof ridge measured vertically above the top of the rafter support walls.}
\]

b. Span exceeds 26 feet in length.

### TABLE R802.5.1(6)
**RAFTER SPANS FOR COMMON LUMBER SPECIES**

(Ground snow load = 50 psf, ceiling attached to rafters, L/\(\Delta\) = 240)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
<th>Maximum rafter spans *</th>
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<td>2 × 4</td>
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<td>2 × 8</td>
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<tr>
<td></td>
<td></td>
<td>2 × 10</td>
<td>2 × 12</td>
<td>2 × 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(feet - inches)</td>
<td>(feet - inches)</td>
<td>(feet - inches)</td>
</tr>
<tr>
<td>12</td>
<td>Douglas fir-larch</td>
<td>SS</td>
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* Maximum rafter spans and spans in feet for 
  Table R802.5.1(6) are subject to the limitations provided in Table R802.5.1(5).
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</table>

(continued)

**TABLE R802.5.1(6)—continued
RAFTER SPANS FOR COMMON LUMBER SPECIES**

2018 North Carolina Residential Code
(Ground snow load = 50 psf, ceiling attached to rafters, L/\Delta = 240)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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</table>

Check sources for availability of lumber in lengths greater than 20 feet.

2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

\[
R = \begin{cases} 
1 & \text{H}_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.} \\
1/7.5 & \text{H}_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.} 
\end{cases}
\]

### Table R802.5.1(7)
RAFTER SPANS FOR 70 PSF GROUND SNOW LOAD
(Ceiling not attached to rafters, L/Δ = 180)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>2 × 4</td>
<td>2 × 6</td>
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<tr>
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<td>Maximum Rafter Spans</td>
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<td>12</td>
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<td>Douglas fir-larch</td>
<td>#2</td>
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### Table 802.5.1(7)—continued

RAFTERS SPANS FOR 70 PSF GROUND SNOW LOAD

(Ceiling not attached to rafters, $L/\Delta = 180$)

<table>
<thead>
<tr>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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<tr>
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<td>$2 \times 4$</td>
<td>$2 \times 6$</td>
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2018 North Carolina Residential Code
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<th>RAFTER SPACING (inches)</th>
<th>Maximum Rafter Spans a</th>
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<td>Southern pine</td>
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<td></td>
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<td>Spruce-fir</td>
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<td></td>
<td>Spruce-fir</td>
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<tr>
<td></td>
<td>Spruce-fir</td>
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<tr>
<td>24</td>
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<td>Hem-fir</td>
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<td>Southern pine</td>
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<td>Spruce-fir</td>
</tr>
</tbody>
</table>

Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as
rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

\[
\frac{H_C}{H_R}
\]

<table>
<thead>
<tr>
<th>(\frac{H_C}{H_R})</th>
<th>Rafter Span Adjustment Factor</th>
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<tr>
<td>1/3</td>
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<td>1/5</td>
<td>0.83</td>
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<tr>
<td>1/6</td>
<td>0.90</td>
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<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
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</table>

where:

\(H_C\) = Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.

\(H_R\) = Height of roof ridge measured vertically above the top of the rafter support walls.

### TABLE R802.5.1(8)

**RAFTER SPANS FOR 70 PSF GROUND SNOW LOAD**  
(Ceiling attached to rafters, \(L/\Delta = 240\))

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>2 × 4 DEAD LOAD = 10 psf</th>
<th>2 × 6 DEAD LOAD = 10 psf</th>
<th>2 × 8 DEAD LOAD = 10 psf</th>
<th>2 × 10 DEAD LOAD = 10 psf</th>
<th>2 × 12 DEAD LOAD = 10 psf</th>
<th>2 × 4 DEAD LOAD = 20 psf</th>
<th>2 × 6 DEAD LOAD = 20 psf</th>
<th>2 × 8 DEAD LOAD = 20 psf</th>
<th>2 × 10 DEAD LOAD = 20 psf</th>
<th>2 × 12 DEAD LOAD = 20 psf</th>
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<tbody>
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</table>

(continued)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>2 x 6</td>
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<tr>
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<td>2 x 6</td>
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</tbody>
</table>

*Maximum rafter spans do not exceed 240 ft.*

2018 North Carolina Residential Code
### Table: Rafter Spans for Various Types of Lumber

<table>
<thead>
<tr>
<th>Material</th>
<th>(feet - inches)</th>
<th>(feet - inches)</th>
<th>(feet - inches)</th>
<th>(feet - inches)</th>
<th>(feet - inches)</th>
<th>(feet - inches)</th>
<th>(feet - inches)</th>
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<td>5-9</td>
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<td>13-11</td>
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<td>8-1</td>
<td>9-4</td>
<td>3-4</td>
</tr>
</tbody>
</table>

Check sources for availability of lumber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>$H_C$/$H_R$</th>
<th>Rafter Span Adjustment Factor</th>
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</thead>
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<tr>
<td>1/3</td>
<td>0.67</td>
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<tr>
<td>1/4</td>
<td>0.76</td>
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<td>0.83</td>
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<tr>
<td>1/7.5 or less</td>
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</table>

where:

$H_C$ = Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.

$H_R$ = Height of roof ridge measured vertically above the top of the rafter support walls.

### TABLE R802.5.1(9)

**RAFTER/CEILING JOIST HEEL JOINT CONNECTIONS**

<table>
<thead>
<tr>
<th>RAFTER SLOPE</th>
<th>RAFTER SPACING (inches)</th>
<th>GROUND SNOW LOAD (psf)</th>
<th>20g</th>
<th>30</th>
<th>50</th>
<th>70</th>
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<tr>
<td></td>
<td></td>
<td>Roof span (feet)</td>
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<td>12</td>
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<td>c,d,e,f</td>
<td>a,b</td>
<td>c,d,e,f</td>
<td>a,b</td>
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<td>4</td>
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<td>8</td>
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<td>4</td>
<td>5</td>
<td>6</td>
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<td>4</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. 40d box nails shall be permitted to be substituted for 16d common nails.
b. Nailing requirements shall be permitted to be reduced 25 percent if nails are clinched.
c. Heel joint connections are not required where the ridge is supported by a load-bearing wall, header or ridge beam.
d. Where intermediate support of the rafter is provided by vertical struts or purlins to a load-bearing wall, the tabulated heel joint connection requirements shall be permitted to be reduced proportionally to the reduction in span.
e. Equivalent nailing patterns are required for ceiling joist to ceiling joist lap splices.
f. Where rafter ties are substituted for ceiling joists, the heel joint connection requirement shall be taken as the tabulated heel joint connection requirement for two-thirds of the actual rafter slope.
g. Applies to roof live load of 20 psf or less.

h. Tabulated heel joint connection requirements assume that ceiling joists or rafter ties are located at the bottom of the attic space. Where ceiling joists or rafter ties are located higher in the attic, heel joint connection requirements shall be increased by the following factors:

<table>
<thead>
<tr>
<th>$H_C / H_R$</th>
<th>Heel Joint Connection Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>1.5</td>
</tr>
<tr>
<td>1/4</td>
<td>1.33</td>
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<tr>
<td>1/5</td>
<td>1.25</td>
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<td>1/6</td>
<td>1.2</td>
</tr>
<tr>
<td>1/10 or less</td>
<td>1.11</td>
</tr>
</tbody>
</table>

where:

$H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.}$

$H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.}$

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 degree = 0.018 rad.

**Note:** Where ceiling joists run perpendicular to the rafter, rafter ties shall be installed in accordance with Section R802.3.1. (Note: Break rafter span on left side.)

$H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.}$

$H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.}$

**FIGURE R802.5.1**
BRACED RAFTER CONSTRUCTION

R802.6 Bearing.
The ends of each rafter or ceiling joist shall have not less than $1 \frac{1}{2}$ inches (38 mm) of bearing on wood or metal and not less than 3 inches (76 mm) on masonry or concrete. The bearing on masonry or concrete shall be direct, or a sill plate of 2-inch (51 mm) minimum nominal thickness shall be provided under the rafter or ceiling joist. The sill plate shall provide a minimum nominal bearing area of 48 square inches (300.65 mm$^2$).

R802.6.1 Finished ceiling material.
If the finished ceiling material is installed on the ceiling prior to the attachment of the ceiling to the walls, such as in construction at a factory, a compression strip of the same thickness as the finished ceiling material shall be installed directly above the top plate of bearing walls if the compressive strength of the finished ceiling material is less than the loads it will be required to withstand. The compression strip shall cover the entire length of such top plate and shall be not less than one-half the width of the top plate. It shall be of material capable of transmitting the loads transferred through it.

R802.7 Cutting, drilling and notching.
Structural roof members shall not be cut, bored or notched in excess of the limitations specified in this section.

R802.7.1 Sawn lumber.
Cuts, notches and holes in solid lumber joists, rafters, blocking and beams shall comply with the provisions of Section R502.8.1 except that cantilevered portions of rafters shall be permitted in accordance with Section R802.7.1.1.

R802.7.1.1 Cantilevered portions of rafters.
Notches on cantilevered portions of rafters are permitted provided the dimension of the remaining portion of the rafter is not less than $3 \frac{1}{2}$ inches (89 mm) and the length of the cantilever does not exceed 24 inches (610 mm) in accordance with Figure R802.7.1.1.
FIGURE R802.7.1.1
RAFTERS NOTCH

R802.7.1.2 Ceiling joist taper cut.
Taper cuts at the ends of the ceiling joist shall not exceed one-fourth the depth of the member in accordance with Figure R802.7.1.2.
R802.7.2 Engineered wood products.
Cuts, notches and holes bored in trusses, structural composite lumber, structural glue-laminated members, cross-laminated timber members or I-joists are prohibited except where permitted by the manufacturer’s recommendations or where the effects of such alterations are specifically considered in the design of the member by a registered design professional.

R802.8 Lateral support.
Roof framing members and ceiling joists having a depth-to-thickness ratio exceeding 5 to 1 based on nominal dimensions shall be provided with lateral support at points of bearing to prevent rotation. For roof rafters with ceiling joists attached in accordance with Table R602.3(1), the depth-to-thickness ratio for the total assembly shall be determined using the combined thickness of the rafter plus the attached ceiling joist.

Exception: Roof trusses shall be braced in accordance with Section R802.10.3.

R802.8.1 Bridging.
Rafters and ceiling joists having a depth-to-thickness ratio exceeding 6 to 1 based on nominal dimensions shall be supported laterally by solid blocking, diagonal bridging (wood or metal) or a continuous 1-inch by 3-inch (25 mm by 76 mm) wood strip nailed across the rafters or ceiling joists at intervals not exceeding 8 feet (2438 mm).
R802.9 Framing of openings.
Openings in roof and ceiling framing shall be framed with header and trimmer joists. Where the header joist span does not exceed 4 feet (1219 mm), the header joist shall be permitted to be a single member the same size as the ceiling joist or rafter. Single trimmer joists shall be permitted to be used to carry a single header joist that is located within 3 feet (914 mm) of the trimmer joist bearing. Where the header joist span exceeds 4 feet (1219 mm), the trimmer joists and the header joist shall be doubled and of sufficient cross section to support the ceiling joists or rafter framing into the header. Approved hangers shall be used for the header joist to trimmer joist connections where the header joist span exceeds 6 feet (1829 mm). Tail joists over 12 feet (3658 mm) long shall be supported at the header by framing anchors or on ledger strips not less than 2 inches by 2 inches (51 mm by 51 mm).

R802.10 Wood trusses.

R802.10.1 Truss design drawings.
Truss design drawings, prepared in conformance to Section R802.10.1, shall be provided to the building official and approved prior to installation. Truss design drawings shall be provided with the shipment of trusses delivered to the job site. Truss design drawings shall include, at a minimum, the following information:

1. Slope or depth, span and spacing.
2. Location of all joints.
3. Required bearing widths.
4. Design loads as applicable.
   4.1. Top chord live load (as determined from Section R301.6).
   4.2. Top chord dead load.
   4.3. Bottom chord live load.
   4.4. Bottom chord dead load.
   4.5. Concentrated loads and their points of application.
   4.6. Controlling wind and earthquake loads.
5. Adjustments to lumber and joint connector design values for conditions of use.
6. Each reaction force and direction.
7. Joint connector type and description such as size, thickness or gage and the dimensioned location of each joint connector except where symmetrically located relative to the joint interface.
8. Lumber size, species and grade for each member.
9. Connection requirements for:
   9.1. Truss to girder-truss.
   9.2. Truss ply to ply.
   9.3. Field splices.

10. Calculated deflection ratio and/or maximum description for live and total load.

11. Maximum axial compression forces in the truss members to enable the building designer to design the size, connections and anchorage of the permanent continuous lateral bracing. Forces shall be shown on the truss design drawing or on supplemental documents.

12. Required permanent truss member bracing location.

R802.10.2 Design.
Wood trusses shall be designed in accordance with accepted engineering practice. The design and manufacture of metal-plate-connected wood trusses shall comply with ANSI/TPI 1. The truss design drawings shall be prepared by a registered professional where required by the statutes of the jurisdiction in which the project is to be constructed in accordance with Section R106.1.

R802.10.2.1 Applicability limits.
The provisions of this section shall control the design of truss roof framing when snow controls for buildings, not greater than 60 feet (18 288 mm) in length perpendicular to the joist, rafter or truss span, not greater than 36 feet (10 973 mm) in width parallel to the joist, rafter or truss span, not more than three stories above grade plane in height, and roof slopes not smaller than 3:12 (25 percent slope) or greater than 12:12 (100-percent slope). Truss roof framing constructed in accordance with the provisions of this section shall be limited to sites subjected to a maximum design wind speed of 140 miles per hour (63 m/s), Exposure B or C, and a maximum ground snow load of 70 psf (3352 Pa). For consistent loading of all truss types, roof snow load is to be computed as: \( 0.7 p_g \).

R802.10.3 Bracing.
Trusses shall be braced to prevent rotation and provide lateral stability in accordance with the requirements specified in the construction documents for the building and on the individual truss design drawings. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practice such as the SBCA Building Component Safety Information (BCSI) Guide to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses.

R802.10.4 Alterations to trusses.
Truss members shall not be cut, notched, drilled, spliced or otherwise altered in any way without the approval of a registered design professional. Alterations resulting in the addition of load such as HVAC equipment water heater that exceeds the design load for the truss shall not be permitted without verification that the truss is capable of supporting such additional loading.
### TABLE R802.11
RAFTER OR TRUSS UPLIFT CONNECTION FORCES FROM WIND (ASD) (POUNDS PER CONNECTION)

<table>
<thead>
<tr>
<th>Rafter or Truss Spacing (feet)</th>
<th>Roof Pitch</th>
<th>Roof Pitch</th>
<th>Roof Pitch</th>
<th>Roof Pitch</th>
<th>Roof Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(feet)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 5:12</td>
<td>≥ 5:12</td>
<td>&lt; 5:12</td>
<td>≥ 5:12</td>
<td>&lt; 5:12</td>
</tr>
<tr>
<td>12” o.c.</td>
<td>12</td>
<td>48</td>
<td>59</td>
<td>53</td>
<td>70</td>
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<td></td>
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<td>42</td>
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<td>48</td>
<td>118</td>
<td>102</td>
<td>151</td>
<td>134</td>
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<tr>
<td>16” o.c.</td>
<td>12</td>
<td>64</td>
<td>57</td>
<td>78</td>
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<td>48</td>
<td>157</td>
<td>136</td>
<td>201</td>
<td>178</td>
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<tr>
<td>24” o.c.</td>
<td>12</td>
<td>96</td>
<td>86</td>
<td>118</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>18</td>
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<td>132</td>
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<td>24</td>
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<td></td>
<td>42</td>
<td>212</td>
<td>184</td>
<td>270</td>
<td>240</td>
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<td></td>
<td>48</td>
<td>236</td>
<td>204</td>
<td>302</td>
<td>268</td>
</tr>
</tbody>
</table>

(continued)

### TABLE R802.11—continued
RAFTER OR TRUSS UPLIFT CONNECTION FORCES FROM WIND (POUNDS PER CONNECTION)

<table>
<thead>
<tr>
<th>Rafter or Truss Spacing (feet)</th>
<th>Roof Pitch</th>
<th>Roof Pitch</th>
<th>Roof Pitch</th>
<th>Roof Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(feet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 5:12</td>
<td>≥ 5:12</td>
<td>&lt; 5:12</td>
<td>≥ 5:12</td>
</tr>
<tr>
<td>12” o.c.</td>
<td>12</td>
<td>118</td>
<td>102</td>
<td>151</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>96</td>
<td>86</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>106</td>
<td>92</td>
<td>135</td>
</tr>
<tr>
<td>16” o.c.</td>
<td>12</td>
<td>64</td>
<td>57</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>78</td>
<td>69</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>94</td>
<td>82</td>
<td>118</td>
</tr>
<tr>
<td>24” o.c.</td>
<td>12</td>
<td>96</td>
<td>86</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>118</td>
<td>104</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>142</td>
<td>124</td>
<td>178</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
### Uplift Connection Forces

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound = 0.454 kg, 1 pound per square foot = 47.9 N/m², 1 plf = 14.6 N/m.

- **a.** The uplift connection forces are based on a maximum 33-foot mean roof height and Wind Exposure Category B or C. For Exposure D, the uplift connection force shall be selected from the Exposure C portion of the table using the next highest tabulated ultimate design wind speed. The adjustment coefficients in Table R301.2(3) shall not be used to multiply the tabulated forces for Exposures C and D or for other mean roof heights.

- **b.** The uplift connection forces include an allowance for roof and ceiling assembly dead load of 15 psf.

- **c.** The tabulated uplift connection forces are limited to a maximum roof overhang of 24 inches.

- **d.** The tabulated uplift connection forces shall be permitted to be multiplied by 0.75 for connections not located within 8 feet of building corners.

- **e.** For buildings with hip roofs with 5:12 and greater pitch, the tabulated uplift connection forces shall be permitted to be multiplied by 0.70. This reduction shall not be combined with any other reduction in tabulated forces.

- **f.** For wall-to-wall and wall-to-foundation connections, the uplift connection force shall be permitted to be reduced by 60 plf for each full wall above.

- **g.** Linear interpolation between tabulated roof spans and wind speeds shall be permitted.

- **h.** The tabulated forces for a 12-inch on-center spacing shall be permitted to be used to determine the uplift load in pounds per linear foot.

### R802.11.1 Uplift resistance

Roof assemblies shall have uplift resistance in accordance with Sections R802.11.1.1 and R802.11.1.2.
Where the uplift force does not exceed 200 pounds (90.8 kg), rafters and trusses spaced not more than 24 inches (610 mm) on center shall be permitted to be attached to their supporting wall assemblies in accordance with Table R602.3(1).

Where the basic wind speed does not exceed 115 mph, the Wind Exposure Category is B, the roof pitch is 5:12 or greater, and the roof span is 32 feet (9754 mm) or less, rafters and trusses spaced not more than 24 inches (610 mm) on center shall be permitted to be attached to their supporting wall assemblies in accordance with Table R602.3(1).

R802.11.1.1 Truss uplift resistance.
Trusses shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as specified on the Truss Design Drawings for the ultimate design wind speed as determined by Figure R301.2(4)A Table R301.2(4) and listed in Table R301.2(1) or as shown on the construction documents. Uplift forces shall be permitted to be determined as specified by Table R802.11, if applicable, or as determined by accepted engineering practice.

R802.11.1.2 Rafter uplift resistance.
Individual rafters shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as determined by Table R802.11 or as determined by accepted engineering practice. Connections for beams used in a roof system shall be designed in accordance with accepted engineering practice.

SECTION R803
ROOF SHEATHING

R803.1 Lumber sheathing.
Allowable spans for lumber used as roof sheathing shall conform to Table R803.1. Spaced lumber sheathing for wood shingle and shake roofing shall conform to the requirements of Sections R905.7 and R905.8. Spaced lumber sheathing is not allowed in Seismic Design Category D.

TABLE R803.1
MINIMUM THICKNESS OF LUMBER ROOF SHEATHING

<table>
<thead>
<tr>
<th>RAFTER OR BEAM SPACING (inches)</th>
<th>MINIMUM NET THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>5/8</td>
</tr>
<tr>
<td>48a</td>
<td>1 1/2 T &amp; G</td>
</tr>
<tr>
<td>60b</td>
<td></td>
</tr>
<tr>
<td>72c</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
a. Minimum 270 $F$ , 340,000 $E$.
b. Minimum 420 $F$ , 660,000 $E$. 

2018 North Carolina Residential Code
c. Minimum $600F_b$, 1,150,000 E.

R803.2 Wood structural panel sheathing.

R803.2.1 Identification and grade.
Wood structural panels shall conform to DOC PS 1, DOC PS 2, CSA O437 or CSA O325, and shall be identified for grade, bond classification and performance category by a grade mark or certificate of inspection issued by an approved agency. Wood structural panels shall comply with the grades specified in Table R503.2.1.1(1).

R803.2.1.1 Exposure durability.
Wood structural panels, when designed to be permanently exposed in outdoor applications, shall be of an exterior exposure durability. Wood structural panel roof sheathing exposed to the underside shall be permitted to be of interior type bonded with exterior glue, identified as Exposure 1.

R803.2.1.2 Fire-retardant-treated plywood.
The allowable unit stresses for fire-retardant-treated plywood, including fastener values, shall be developed from an approved method of investigation that considers the effects of anticipated temperature and humidity to which the fire-retardant-treated plywood will be subjected, the type of treatment and redrying process. The fire-retardant-treated plywood shall be graded by an approved agency.

R803.2.2 Allowable spans.
The maximum allowable spans for wood structural panel roof sheathing shall not exceed the values set forth in Table R503.2.1.1(1), or APA E30.

R803.2.3 Installation.
Wood structural panel used as roof sheathing shall be installed with joints staggered or not staggered in accordance with Table R602.3(1), APA E30 for wood roof framing or Table R804.3 for cold-formed steel roof framing.

SECTION R804
COLD-FORMED STEEL ROOF FRAMING
Deleted

R804.1 General.
Elements shall be straight and free of any defects that would significantly affect their structural performance. Cold-formed steel roof framing members shall be in accordance with the requirements of this section.

R804.1.1 Applicability limits.
The provisions of this section shall control the construction of cold-formed steel roof framing for buildings not greater than 60 feet (18 288 mm) perpendicular to the joist, rafter or truss span, not greater than 40 feet (12 192 mm) in width parallel to the joist span or truss, less than or equal to three stories above grade plane and with roof slopes not less than 3:12 (25-percent slope) or greater than 12:12 (100-percent slope). Cold-formed steel roof framing constructed in accordance with the provisions of this section shall be limited to sites where the ultimate design wind speed is less than 139 miles per hour (62 m/s), Exposure Category.
R804.1.2 In-line framing.
Cold-formed steel roof framing constructed in accordance with Section R804 shall be located in line with load-bearing studs in accordance with Figure R804.1.2 and the tolerances specified as follows:

1. The maximum tolerance shall be \( \frac{3}{4} \) inch (19.1 mm) between the centerline of the horizontal framing member and the centerline of the vertical framing member.

2. Where the centerline of the horizontal framing member and bearing stiffener are located to one side of the centerline of the vertical framing member, the maximum tolerance shall be \( \frac{1}{8} \) inch (3.2 mm) between the web of the horizontal framing member and the edge of the vertical framing member.

For SI: 1 inch = 25.4 mm.

FIGURE R804.1.2
IN-LINE FRAMING

R804.2 Structural framing.
Load-bearing, cold-formed steel roof framing members shall be in accordance with this section.
R804.2.1 Material.
Load-bearing, cold-formed steel framing members shall be cold formed to shape from structural quality sheet steel complying with the requirements of ASTM A 1003, Structural Grades 33 Type H and 50 Type H.

R804.2.2 Corrosion protection.
Load-bearing, cold-formed steel framing shall have a metallic coating complying with ASTM A 1003 and one of the following:

1. A minimum of G 60 in accordance with ASTM A 653.
2. A minimum of AZ 50 in accordance with ASTM A 792.

R804.2.3 Dimension, thickness and material grade.
Load-bearing, cold-formed steel roof framing members shall comply with Figure R804.2.3(1) and with the dimensional and thickness requirements specified in Table R804.2.3. Additionally, C-shaped sections shall have a minimum flange width of 1.625 inches (41 mm) and a maximum flange width of 2 inches (51 mm). The minimum lip size for C-shaped sections shall be \( \frac{1}{2} \) inch (12.7 mm). Tracks shall comply with Figure R804.2.3(2) and shall have a minimum flange width of \( \frac{1}{4} \) inch (32 mm). Minimum Grade 33 ksi steel shall be used wherever 33 mil and 43 mil thicknesses are specified. Minimum Grade 50 ksi steel shall be used wherever 54 and 68 mil thicknesses are specified.

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION (^a)</th>
<th>WEB DEPTH (inches)</th>
<th>MINIMUM BASE STEEL THICKNESS (mil, inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>350S162-1</td>
<td>3.5</td>
<td>33 (0.0329), 43 (0.0428), 54 (0.0538)</td>
</tr>
<tr>
<td>550S162-1</td>
<td>5.5</td>
<td>33 (0.0329), 43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
<tr>
<td>800S162-1</td>
<td>8</td>
<td>33 (0.0329), 43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
<tr>
<td>1000S162-1</td>
<td>10</td>
<td>43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
<tr>
<td>1200S162-1</td>
<td>12</td>
<td>43 (0.0428), 54 (0.0538), 68 (0.0677)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm

\(^a\) The member designation is defined by the first number representing the member depth in hundredths of an inch, the letter “s” representing a stud or joist member, the second number representing the flange width in hundredths of an inch and the letter “t” shall be a number representing the minimum base metal thickness in mils.
FIGURE R804.2.3(1)
C-SHAPED SECTION
R804.2.4 Identification.
Load-bearing, cold-formed steel framing members shall have a legible label, stencil, stamp or embossment with the following information as a minimum:

1. Manufacturer’s identification.

2. Minimum base steel thickness in inches (mm).


4. Minimum yield strength, in kips per square inch (ksi) (MPa).

R804.2.5 Fastening requirements.
Screws for steel-to-steel connections shall be installed with a minimum edge distance and center-to-center spacing of \( \frac{1}{2} \) inch (12.7 mm), shall be self-drilling tapping and shall conform to ASTM C 1513. Structural sheathing shall be attached to cold-formed steel roof rafters with minimum No. 8 self-drilling tapping screws that conform to ASTM C 1513. Screws for attaching structural sheathing to cold-formed steel roof framing shall have a minimum head diameter of 0.292 inch (7.4 mm) with countersunk heads and shall be installed with a minimum edge distance of \( \frac{3}{8} \) inch (9.5 mm). Gypsum board ceilings shall be attached to cold-formed steel joists with minimum No. 6 screws conforming to ASTM C 954 or ASTM C
1513 with a bugle-head style and shall be installed in accordance with Section R805. For all connections, screws shall extend through the steel a minimum of three exposed threads. Fasteners shall have rust-inhibitive coating suitable for the installation in which they are being used, or be manufactured from material not susceptible to corrosion.

R804.2.6 Web holes, web hole reinforcing and web hole patching.
Web holes, web hole reinforcing and web hole patching shall be in accordance with this section.

R804.2.6.1 Web holes.
Web holes in roof framing members shall comply with all of the following conditions:

1. Holes shall conform to Figure R804.2.6.1.

2. Holes shall be permitted only along the centerline of the web of the framing member.

3. Center-to-center spacing of holes shall not be less than 24 inches (610 mm).

4. The web hole width shall be not greater than one-half the member depth, or $2\frac{1}{2}$ inches (64 mm).

5. Holes shall have a web hole length not exceeding $4\frac{1}{2}$ inches (114 mm).

6. The minimum distance between the edge of the bearing surface and the edge of the web hole shall be not less than 10 inches (254 mm).

Framing members with web holes not conforming to Items 1 though 6 shall be reinforced in accordance with Section R804.2.6.2, patched in accordance with Section R804.2.6.3 or designed in accordance with accepted engineering practices.

For SI: 1 inch = 25.4 mm.

FIGURE R804.2.6.1
ROOF FRAMING MEMBER WEB HOLES

R804.2.6.2 Web hole reinforcing.
Reinforcement of web holes in ceiling joists not conforming to the requirements of Section R804.2.6.1 shall be permitted if the hole is located fully within the center 40 percent of the span and the depth and length of the hole do not exceed 65 percent of the flat width of the web. The reinforcing shall be a steel plate or C-shaped section with a hole that does not exceed the web hole size limitations of Section R804.2.6.1 for the member being reinforced. The steel reinforcing shall be the same thickness as the receiving member and shall extend not less than 1 inch (25 mm) beyond all edges of the hole. The steel reinforcing shall be fastened to the web of the receiving member with No. 8 screws spaced not greater than 1 inch (25 mm) center-to-center along the edges of the patch with minimum edge distance of \( \frac{1}{2} \) inch (12.7 mm).

R804.2.6.3 Hole patching.
Patching of web holes in roof framing members not conforming to the requirements in Section R804.2.6.1 shall be permitted in accordance with either of the following methods:

1. Framing members shall be replaced or designed in accordance with accepted engineering practices where web holes exceed either of the following size limits:
   
   1.1. The depth of the hole, measured across the web, exceeds 70 percent of the flat width of the web.
   
   1.2. The length of the hole measured along the web, exceeds 10 inches (254 mm) or the depth of the web, whichever is greater.

2. Web holes not exceeding the dimensional requirements in Section R804.2.6.3, Item 1, shall be patched with a solid steel plate, stud section or track section in accordance with Figure R804.2.6.3. The steel patch shall, as a minimum, be the same thickness as the receiving member and shall extend not less than 1 inch (25 mm) beyond all edges of the hole. The steel patch shall be fastened to the web of the receiving member with No. 8 screws spaced not greater than 1 inch (25 mm) center-to-center along the edges of the patch with minimum edge distance of \( \frac{1}{2} \) inch (12.7 mm).
FIGURE R804.2.6.3
ROOF FRAMING MEMBER WEB HOLE PATCH

R804.3 Roof construction.
Cold-formed steel roof systems constructed in accordance with the provisions of this section shall consist of both ceiling joists and rafters in accordance with Figure R804.3 and fastened in accordance with Table R804.3.
FIGURE R804.3
COLD-FORMED STEEL ROOF CONSTRUCTION

TABLE R804.3
ROOF FRAMING FASTENING SCHEDULE

<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND SIZE OF FASTENERS</th>
<th>SPACING OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof sheathing (oriented strand board or plywood) to rafter</td>
<td>No. 8 screws</td>
<td>6” o.c. on edges and 12” o.c. at interior supports. 6” o.c. at gable end truss</td>
</tr>
<tr>
<td>Gable end truss to end wall top track</td>
<td>No. 10 screws</td>
<td>12” o.c.</td>
</tr>
<tr>
<td>Rafter to ceiling joist</td>
<td>Minimum No. 10 screws, in accordance with Table R804.3.1.1(3)</td>
<td>Evenly spaced, not less than ( \frac{1}{8} )&quot; from all edges.</td>
</tr>
<tr>
<td>Ceiling joist or roof truss to top track of bearing wall</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
R804.3.1 Ceiling joists.
Cold-formed steel ceiling joists shall be in accordance with this section.

R804.3.1.1 Minimum ceiling joist size.
Ceiling joist size and thickness shall be determined in accordance with the limits set forth in Tables R804.3.1.1(1) and R804.3.1.1(2). When determining the size of ceiling joists, the lateral support of the top flange shall be classified as unbraced, braced at midspan or braced at third points in accordance with Section R804.3.1.4. Where sheathing material is attached to the top flange of ceiling joists or where the bracing is spaced closer than third point of the joists, the “third point” values from Tables R804.3.1.1(1) and R804.3.1.1(2) shall be used.

Ceiling joists shall have a bearing support length of not less than $1 \frac{1}{2}$ inches (38 mm) and shall be connected to roof rafters (heel joint) with No. 10 screws in accordance with Figure R804.3.1.1 and Table 804.3.1.1(3).

Where continuous joists are framed across interior bearing supports, the interior bearing supports shall be located within 24 inches (610 mm) of midspan of the ceiling joist, and the individual spans shall not exceed the applicable spans in Tables R804.3.1.1(1) and R804.3.1.1(2).

Where the attic is to be used as an occupied space, the ceiling joists shall be designed in accordance with Section R505.

TABLE R804.3.1.1(1)
CEILING JOIST SPANS
10 PSF LIVE LOAD (NO ATTIC STORAGE) a,b,c

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>ALLOWABLE SPAN (feet–inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lateral Support of Top (Compression) Flange</td>
</tr>
<tr>
<td></td>
<td>Unbraced</td>
</tr>
<tr>
<td></td>
<td>Ceiling Joist Spacing (inches)</td>
</tr>
<tr>
<td>350S162-33</td>
<td>9'-5&quot;</td>
</tr>
</tbody>
</table>

For SI:
- 1 inch = 25.4 mm
- 1 foot = 304.8 mm
- 1 pound per square foot = 0.0479 kPa
- 1 mil = 0.0254 mm.

a. Screws are a minimum No. 10 unless noted otherwise.
b. Indicated number of screws shall be applied through the flanges of the truss or ceiling joist or through each leg of a 54 mil clip angle. See Section R804.3.8 for additional requirements to resist uplift forces.
Ceiling dead load = 5 psf.

Deflection criterion: L/240 for total loads.

Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 64 and 68 mil thicknesses.

### TABLE R804.3.1.1(2)

**CEILING JOIST SPANS**

20 PSF LIVE LOAD (LIMITED ATTIC STORAGE)

<table>
<thead>
<tr>
<th>MEMBER DESIGNATION</th>
<th>ALLOWABLE SPAN (feet - inches)</th>
<th>Lateral Support of Top (Compression) Flange</th>
<th>Ceiling Joist Spacing (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unbraced</td>
<td>Midspan-Bracing</td>
<td>Third-point Bracing</td>
</tr>
<tr>
<td>350S162-33</td>
<td>10'-3&quot;</td>
<td>9'-12&quot;</td>
<td>13'-2&quot;</td>
</tr>
<tr>
<td>350S162-54</td>
<td>11'-1&quot;</td>
<td>9'-11&quot;</td>
<td>13'-9&quot;</td>
</tr>
<tr>
<td>350S162-68</td>
<td>12'-4&quot;</td>
<td>10'-9&quot;</td>
<td>14'-8&quot;</td>
</tr>
<tr>
<td>550S162-33</td>
<td>10'-7&quot;</td>
<td>9'-6&quot;</td>
<td>14'-10&quot;</td>
</tr>
<tr>
<td>550S162-54</td>
<td>12'-6&quot;</td>
<td>11'-2&quot;</td>
<td>17'-7&quot;</td>
</tr>
<tr>
<td>550S162-68</td>
<td>13'-6&quot;</td>
<td>12'-1&quot;</td>
<td>19'-2&quot;</td>
</tr>
<tr>
<td>800S162-33</td>
<td>13'-0&quot;</td>
<td>11'-9&quot;</td>
<td>18'-10&quot;</td>
</tr>
<tr>
<td>800S162-54</td>
<td>13'-10&quot;</td>
<td>12'-5&quot;</td>
<td>20'-0&quot;</td>
</tr>
<tr>
<td>800S162-68</td>
<td>14'-11&quot;</td>
<td>13'-4&quot;</td>
<td>21'-3&quot;</td>
</tr>
<tr>
<td>1000S162-34</td>
<td>14'-9&quot;</td>
<td>13'-3&quot;</td>
<td>21'-4&quot;</td>
</tr>
<tr>
<td>1000S162-54</td>
<td>15'-10&quot;</td>
<td>14'-2&quot;</td>
<td>22'-8&quot;</td>
</tr>
<tr>
<td>1200S162-68</td>
<td>16'-8&quot;</td>
<td>14'-11&quot;</td>
<td>23'-11&quot;</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mil = 0.0254 mm, 1 pound per square foot = 0.0479 kPa.

a. Deflection criterion: L/240 for total loads.
b. Ceiling dead load = 5 psf.
c. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 64 and 68 mil thicknesses.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Deflection criterion: L/240 for total loads.
b. Ceiling drift load = 5 psf.
c. Minimum Grade 33 ksi steel shall be used for 33 mil and 43 mil thicknesses. Minimum Grade 50 ksi steel shall be used for 54 and 68 mil thicknesses.

<table>
<thead>
<tr>
<th>TABLE R804.3.1.1(3)</th>
<th>NUMBER OF SCREWS REQUIRED FOR CEILING JOIST TO ROOF RAFTER CONNECTION&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROOF SLOPE</td>
<td>NUMBER OF SCREWS</td>
</tr>
<tr>
<td>Ground snow load (psf)</td>
<td>24</td>
</tr>
<tr>
<td>3/12</td>
<td>5</td>
</tr>
<tr>
<td>4/12</td>
<td>4</td>
</tr>
<tr>
<td>5/12</td>
<td>3</td>
</tr>
<tr>
<td>6/12</td>
<td>3</td>
</tr>
<tr>
<td>7/12</td>
<td>3</td>
</tr>
<tr>
<td>8/12</td>
<td>2</td>
</tr>
<tr>
<td>9/12</td>
<td>2</td>
</tr>
<tr>
<td>10/12</td>
<td>2</td>
</tr>
<tr>
<td>11/12</td>
<td>2</td>
</tr>
<tr>
<td>12/12</td>
<td>2</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Screws shall be No. 10.
R804.3.1.1 Ceiling joist bottom flange bracing.
The bottom flanges of ceiling joists shall be laterally braced by the application of gypsum board or continuous steel straps installed perpendicular to the joist run in accordance with one of the following:

1. Gypsum board shall be fastened with No. 6 screws in accordance with Section R702.

2. Steel straps with a minimum size of \(1 \frac{1}{2}\) inches by 33 mils (38 mm by 0.84 mm) shall be installed at a maximum spacing of 4 feet (1219 mm). Straps shall be fastened to the bottom flange at each joist with one No. 8 screw and shall be fastened to blocking with two No. 8 screws. Blocking shall be installed between joists at a maximum spacing of 12 feet (3658 mm) measured along a line of continuous strapping (perpendicular to the joist run). Blocking shall also be located at the termination of all straps.
R804.3.1.3 Ceiling joist top flange bracing.
The top flanges of ceiling joists shall be laterally braced as required by Tables R804.3.1.1(1) and R804.3.1.1(2), in accordance with one of the following:

1. Minimum 33 mil (0.84 mm) C-shaped member in accordance with Figure R804.3.1.3(1).

2. Minimum 33 mil (0.84 mm) track section in accordance with Figure R804.3.1.3(1).

3. Minimum 33 mil (0.84 mm) hat section in accordance with Figure R804.3.1.3(1).

4. Minimum 54 mil (1.37 mm) 1\frac{1}{2} -inch (38 mm) cold-rolled channel section in accordance with Figure R804.3.1.3(1).

5. Minimum 1\frac{1}{2} -inch by 33 mil (38 mm by 0.84 mm) continuous steel strap in accordance with Figure R804.3.1.3(2).

Lateral bracing shall be installed perpendicular to the ceiling joists and shall be fastened to the top flange of each joist with one No. 8 screw. Blocking shall be installed between joists in line with bracing at a maximum spacing of 12 feet (3658 mm) measured perpendicular to the joists. Ends of lateral bracing shall be attached to blocking or anchored to a stable building component with two No. 8 screws.

FIGURE R804.3.1.3(1)
CEILING JOIST TOP FLANGE BRACING WITH C-SHAPED, TRACK OR COLD-ROLLED CHANNEL
FIGURE R804.3.1.3(2)
CEILING JOIST TOP FLANGE BRACING WITH CONTINUOUS STEEL STRAP AND BLOCKING

R804.3.1.4 Ceiling joist splicing.
Splices in ceiling joists shall be permitted, if ceiling joist splices are supported at interior bearing points and are constructed in accordance with Figure R804.3.1.4. The number of screws on each side of the splice shall be the same as required for the heel joint connection in Table R804.3.1.1(3).
R804.3.2 Roof rafters.
Cold-formed steel roof rafters shall be in accordance with this section.

R804.3.2.1 Minimum roof rafter sizes.
Roof rafter size and thickness shall be determined in accordance with the limits set forth in Table R804.3.2.1(1) based on the horizontal projection of the roof rafter span. For determination of roof rafter sizes, reduction of roof spans shall be permitted where a roof rafter support brace is installed in accordance with Section R804.3.2.2. The reduced roof rafter span shall be taken as the larger of the distances from the roof rafter support brace to the ridge or to the heel measured horizontally.

For the purpose of determining roof rafter sizes in Table R804.3.2.1(1), ultimate design wind speeds shall be converted to equivalent ground snow loads in accordance with Table R804.3.2.1(2). Roof rafter sizes shall be based on the higher of the ground snow load or the equivalent snow load converted from the ultimate design wind speed.

TABLE R804.3.2.1(1)
ROOF RAFTER SPANS

For SI: 1 inch = 25.4 mm.

FIGURE R804.3.1.4
SPliced ceiling Joists
### Table R804.3.2.1(2)

**Ultimate Design Wind Speed to Equivalent Snow Load Conversion**

<table>
<thead>
<tr>
<th>Basic Wind Speed and Exposure</th>
<th>Equivalent Ground Snow Load (psf)</th>
<th>Roof slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp. B 85 mph</td>
<td>12:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td>Exp. C 100 mph</td>
<td>12:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td>110 mph</td>
<td>12:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>11:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>10:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>9:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>8:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>7:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>6:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>5:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>4:12</td>
<td>20 20 30 50</td>
</tr>
<tr>
<td></td>
<td>3:12</td>
<td>20 20 30 50</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

**R804.3.2.1.1 Eave overhang.**

Eave overhangs shall not exceed 24 inches (610 mm) measured horizontally.

**R804.3.2.1.2 Rake overhangs.**

Rake overhangs shall not exceed 12 inches (305 mm) measured horizontally.

Outlookers at gable endwalls shall be installed in accordance with Figure R804.3.2.1.2.
FIGURE R804.3.2.2
GABLE ENDWALL OVERHANG DETAILS

R804.3.2.2 Roof rafter support brace.
When used to reduce roof rafter spans in determining roof rafter sizes, a roof rafter support brace shall meet all of the following conditions:

1. Minimum 350S162-33 C-shaped brace member with maximum length of 8 feet (2438 mm).

2. Minimum brace member slope of 45 degrees (0.785 rad) to the horizontal.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
3. Minimum connection of brace to a roof rafter and ceiling joist with four No.10 screws at each end.

4. Maximum 6 inches (152 mm) between brace/ceiling joist connection and load-bearing wall below.

5. Each roof rafter support brace greater than 4 feet (1219 mm) in length, shall be braced with a supplemental brace having a minimum size of 350S162-33 or 350T162-33 such that the maximum unsupported length of the roof rafter support brace is 4 feet (1219 mm). The supplemental brace shall be continuous and shall be connected to each roof rafter support brace using two No. 8 screws.

R804.3.2.3 Roof rafter splice.
Roof rafters shall not be spliced.

R804.3.2.4 Roof rafter to ceiling joist and ridge member connection.
Roof rafters shall be connected to a parallel ceiling joist to form a continuous tie between exterior walls in accordance with Figure R804.3.1.1 and Table R804.3.1.1(3). Ceiling joists shall be connected to the top track of the load-bearing wall in accordance with Table R804.3, either with the required number of No. 10 screws applied through the flange of the ceiling joist or by using a 54 mil (1.37 mm) clip angle with the required number of No.10 screws in each leg. Roof rafters shall be connected to a ridge member with a minimum 2-inch by 2-inch (51 mm by 51 mm) clip angle fastened with No. 10 screws to the ridge member in accordance with Figure R804.3.2.4 and Table R804.3.2.4. The clip angle shall have a steel thickness equivalent to or greater than the roof rafter thickness and shall extend the depth of the roof rafter member to the extent possible. The ridge member shall be fabricated from a C-shaped member and a track section that shall have a minimum size and steel thickness equivalent to or greater than that of adjacent roof rafters and shall be installed in accordance with Figure R804.3.2.4. The ridge member shall extend the full depth of the sloped roof rafter cut.
For SI: 1 inch = 25.4 mm.

**FIGURE R804.3.2.4**
RIDGE MEMBER CONNECTION

**TABLE R804.3.2.4**
SCREWS REQUIRED AT EACH LEG OF CLIP ANGLE FOR ROOF RAFTER TO RIDGE MEMBER CONNECTION

<table>
<thead>
<tr>
<th>BUILDING WIDTH (feet)</th>
<th>NUMBER OF SCREWS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ground snow load (psf)</td>
</tr>
<tr>
<td></td>
<td>0 to 20</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>36</td>
<td>3</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a—Screws shall be No. 10 minimum.

**R804.3.2.5 Roof rafter bottom flange bracing.**
The bottom flanges of roof rafters shall be continuously braced, at a maximum spacing of 8 feet (2440 mm) as measured parallel to the roof rafters, with one of the following members:

1. Minimum 33-mil (0.84 mm) C-shaped member.

2. Minimum 33-mil (0.84 mm) track section.

3. Minimum 1 \(\frac{1}{2}\) -inch by 33-mil (38 mm by 0.84 mm) steel strap.

The bracing element shall be fastened to the bottom flange of each roof rafter with one No. 8 screw and shall be fastened to blocking with two No. 8 screws. Blocking shall be installed between roof rafters in line with the continuous bracing at a maximum spacing of 12 feet (3658 mm) measured perpendicular to the roof rafters. The ends of continuous bracing shall be fastened to blocking or anchored to a stable building component with two No. 8 screws.

**R804.3.3 Cutting and notching.**
Flanges and lips of load-bearing, cold-formed steel roof framing members shall not be cut or notched.

**R804.3.4 Headers.**
Roof-ceiling framing above wall openings shall be supported on headers. The allowable spans for headers in load-bearing walls shall not exceed the values set forth in Section R603.6 and Tables R603.6(1) through R603.6(6).
**R804.3.5 Framing of openings in roofs and ceilings.**
Openings in roofs and ceilings shall be framed with header and trimmer joists. Header joist spans shall not exceed 4 feet (1219 mm) in length. Header and trimmer joists shall be fabricated from joist and track members having a minimum size and thickness equivalent to the adjacent ceiling joists or roof rafters and shall be installed in accordance with Figures R804.3.5(1) and R804.3.5(2). Each header joist shall be connected to trimmer joists with not less than four 2-inch by 2-inch (51 by 51 mm) clip angles. Each clip angle shall be fastened to both the header and trimmer joists with four No. 8 screws, evenly spaced, through each leg of the clip angle. The steel thickness of the clip angles shall be not less than that of the ceiling joist or roof rafter. Each track section for a built-up header or trimmer joist shall extend the full length of the joist (continuous).
FIGURE R804.3.5(2)
HEADER TO TRIMMER CONNECTION

R804.3.6 Roof trusses.
Cold-formed steel trusses shall be designed and installed in accordance with AISI S100, Section D4. In the absence of specific bracing requirements, trusses shall be braced in accordance with accepted industry practices, such as the SBCA Cold-Formed Steel Building Component Safety Information (CFSBCSI) Guide to Good Practice for Handling, Installing & Bracing of Cold-Formed Steel Trusses. Trusses shall be connected to the top track of the load-bearing wall in accordance with Table R804.3, either with two No. 10 screws applied through the flange of the truss or by using a 54-mil (1.37 mm) clip angle with two No. 10 screws in each leg.

R804.3.7 Ceiling and roof diaphragms.
Ceiling and roof diaphragms shall be in accordance with this section.
R804.3.7.1 Ceiling diaphragms.

At gable endwalls a ceiling diaphragm shall be provided by attaching a minimum \( \frac{1}{2} \) -inch (12.7 mm) gypsum board or a minimum \( \frac{3}{8} \) -inch (9.5 mm) wood structural panel sheathing, that complies with Section R803, to the bottom of ceiling joists or roof trusses and connected to wall framing in accordance with Figures R804.3.7.1(1) and R804.3.7.1(2), unless stude are designed as full height without bracing at the ceiling. Flat blocking shall consist of C-shaped or track section with a minimum thickness of 33 mils (0.84 mm). For a gypsum board sheathed ceiling, the diaphragm length shall be in accordance with Table R804.3.7.1. For a wood structural panel sheathed ceiling, the diaphragm length shall be not less than 12 feet (3658 mm) for building widths less than
36 feet (10,973 mm), or not less than 14 feet (4267 mm) for building widths greater than or equal to 36 feet (10,973 mm).

The ceiling diaphragm shall be secured with screws spaced at a maximum 6 inches (152 mm) o.c. at panel edges and a maximum 12 inches (305 mm) o.c. in the field. The required lengths in Table R804.3.7.1 for gypsum board sheathed ceiling diaphragms shall be permitted to be multiplied by 0.35 if all panel edges are blocked. Multiplying the required lengths in Table R804.3.7.1 for gypsum board sheathed ceiling diaphragms by 0.9 shall be permitted if all panel edges are secured with screws spaced at 4 inches (102 mm) o.c.

**TABLE R804.3.7.1**
**REQUIRED LENGTHS FOR CEILING DIAPHRAGMS AT GABLE ENDWALLS**
**GYPSUM BOARD SHEATHED, CEILING HEIGHT = 8 FEET**

<table>
<thead>
<tr>
<th>EXPOSURE CATEGORY</th>
<th>ULTIMATE DESIGN WIND SPEED (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>126</td>
</tr>
<tr>
<td>C</td>
<td>110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roof pitch</th>
<th>Building endwall width (feet)</th>
<th>Minimum diaphragm length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:12 to 6:12</td>
<td>24–28</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>&gt;28–32</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>&gt;32–36</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>&gt;36–40</td>
<td>30</td>
</tr>
<tr>
<td>6:12 to 9:12</td>
<td>&gt;24–28</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>&gt;28–32</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>&gt;32–36</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>&gt;36–40</td>
<td>36</td>
</tr>
<tr>
<td>9:12 to 12:12</td>
<td>&gt;24–28</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>&gt;28–32</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>&gt;32–36</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>&gt;36–40</td>
<td>42</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 mile per hour = 0.447 m/s, 1 foot = 304.8 mm, 1 mil = 0.0254 mm.

a. Ceiling diaphragm is composed of 1/8-inch gypsum board (min. thickness) secured with screws spaced at 6 inches o.c. at panel edges and 12 inches o.c. infield. Use No. 8 screws (min.) where framing members have a designation thickness of 54 mils or less and No. 10 screws (min.) where framing members have a designation thickness greater than 54 mils.

b. Maximum aspect ratio (length/width) of diaphragms is 2:1.

c. Building width is in the direction of horizontal framing members supported by the wall studs.

d. Required diaphragm lengths are to be provided at each end of the structure.

e. Multiplying required diaphragm lengths by 0.35 is permitted if all panel edges are blocked.

f. Multiplying required diaphragm lengths by 0.9 is permitted if all panel edges are secured with screws spaced at 4 inches o.c.

g. To determine the minimum diaphragm length for buildings with ceiling heights of 9 feet or 10 feet values in the table above shall be multiplied by 1.15.
For SI: 1 inch = 25.4 mm.

**FIGURE R804.3.7.1(1)**

CEILING DIAPHRAGM TO GABLE ENDBALL DETAIL

For SI: 1 inch = 25.4 mm.

**FIGURE R804.3.7.1(2)**

CEILING DIAPHRAGM TO SIDEWALL DETAIL
**R804.3.7.2 Roof diaphragm.**
A roof diaphragm shall be provided by attaching a minimum of \( \frac{3}{8} \) -inch (9.5 mm) wood structural panel which complies with Section R803 to roof rafters or truss top chords in accordance with Table R804.3. Buildings with 3:1 or larger plan aspect ratio and with roof rafter slope (pitch) of 9:12 or larger shall have the roof rafters and ceiling joists blocked in accordance with Figure R804.3.7(2).

**R804.3.8 Roof tie-down.**
Roof assemblies shall be connected to walls below in accordance with Table R804.3. A continuous load path shall be provided to transfer uplift loads to the foundation.

**SECTION R805**
**CEILING FINISHES**

**R805.1 Ceiling installation.**
Ceilings shall be installed in accordance with the requirements for interior wall finishes as provided in Section R702.

**SECTION R806**
**ROOF VENTILATION**

**R806.1 Ventilation required.**
Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain or snow. Ventilation openings shall have a least dimension of \( \frac{1}{16} \) inch (1.6 mm) minimum and \( \frac{1}{4} \) inch (6.4 mm) maximum. Ventilation openings having a least dimension larger than \( \frac{1}{4} \) inch (6.4 mm) shall be provided with corrosion-resistant wire cloth screening, hardware cloth or similar material with openings having a least dimension of \( \frac{1}{16} \) inch (1.6 mm) minimum and \( \frac{1}{4} \) inch (6.4 mm) maximum. Openings in roof framing members shall conform to the requirements of Section R802.7. Required ventilation openings shall open directly to the outside air.

**R806.2 Minimum vent area.**
The minimum net free ventilating area shall be \( \frac{1}{150} \) of the area of the vented space.

**Exception:** The minimum net free ventilation area shall be \( \frac{1}{200} \) of the vented space provided one or more of the following conditions are met:

1. In Climate Zones 6, 7 and 8, a Class I or II vapor retarder is installed on the warm, winter side of the ceiling.

2. Not less than 40 percent and not more than 50 percent of the required ventilating area is provided by ventilators located in the upper portion of the attic or rafter space. Upper ventilators shall be located not more than 3 feet (914 mm) below the ridge or

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highest point of the space, measured vertically, with the balance of the required ventilation provided by eave or cornice vents. Where the location of wall or roof framing members conflicts with the installation of upper ventilators, installation more than 3 feet (914 mm) below the ridge or highest point of the space shall be permitted.

The total net free ventilating area shall not be less than 1/150 of the area of the space ventilated except that reduction of the total area to 1/300 is permitted provided that at least 50 percent and not more than 80 percent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet (914 mm) above the eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents. As an alternative, the net free cross-ventilation area may be reduced to 1/300 when a Class I or II vapor retarder is installed on the warm-in-winter side of the ceiling.

**Exceptions:**

1. Enclosed attic/rafter spaces requiring less than 1 square foot (0.0929 m²) of ventilation may be vented with continuous soffit ventilation only.

2. Enclosed attic/rafter spaces over unconditioned space may be vented with continuous soffit vent only.

**R806.3 Vent and insulation clearance.**
Where eave or cornice vents are installed, insulation shall not block the free flow of air. Not less than a 1-inch (25 mm) space shall be provided between the insulation and the roof sheathing and at the location of the vent.

**R806.4 Installation and weather protection.** Deleted.
Ventilators shall be installed in accordance with manufacturer’s instructions. Installation of ventilators in roof systems shall be in accordance with the requirements of Section R903. Installation of ventilators in wall systems shall be in accordance with the requirements of Section R703.1.

**R806.5 Unvented attic and unvented enclosed rafter assemblies.**
Unvented attics and unvented enclosed roof framing assemblies created by ceilings that are applied directly to the underside of the roof framing members and structural roof sheathing applied directly to the top of the roof framing members/rafters, shall be permitted where all the following conditions are met:

1. The unvented attic space is completely within the building thermal envelope.
2. No interior Class I vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly or on the ceiling side of the unvented enclosed roof framing assembly.
3. Where wood shingles or shakes are used, a minimum \( \frac{1}{4} \)-inch (6.4 mm) vented airspace separates the shingles or shakes and the roofing underlayment above the structural sheathing.
4. In Climate Zones 5, 6, 7 and 8, any air-impermeable insulation shall be a Class II vapor retarder, or shall have a Class II vapor retarder coating or covering in direct contact with the underside of the insulation. Deleted.

5. Insulation shall be located in accordance with the following:

5.1. Item 5.1.1, 5.1.2, 5.1.3 or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.

5.1.1. Where only air-impermeable insulation is provided, it shall be applied in direct contact with the underside of the structural roof sheathing.

5.1.2. Where air-permeable insulation is provided inside the building thermal envelope, it shall be installed in accordance with Section 5.1. In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing in accordance with the R-values in Table R806.5 for condensation control.

5.1.3. Where both air-impermeable and air-permeable insulation are provided, the air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing in accordance with Item 5.1.1 and shall be in accordance with the R-values in Table R806.5 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

5.2. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

<table>
<thead>
<tr>
<th>TABLE R806.5</th>
<th>INSULATION FOR CONDENSATION CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLIMATE ZONE</td>
<td>MINIMUM RIGID BOARD ON AIR-IMPERMEABLE INSULATION R-VALUE&lt;sup&gt;a, b&lt;/sup&gt;</td>
</tr>
<tr>
<td>2B and 3B tile roof only</td>
<td>0 (none required)</td>
</tr>
<tr>
<td>1, 2A, 2B, 3A, 3B, 3C</td>
<td>R-5</td>
</tr>
<tr>
<td>4C</td>
<td>R-10</td>
</tr>
<tr>
<td>4A, 4B</td>
<td>R-15</td>
</tr>
<tr>
<td>5</td>
<td>R-20</td>
</tr>
<tr>
<td>6</td>
<td>R-25</td>
</tr>
</tbody>
</table>
R807.1 Attic access.
Buildings with combustible ceiling or roof construction shall have an attic access opening to attic areas that have a vertical height of 30 inches (762 mm) or greater over an area of not less than 30 square feet (2.8 m²). The vertical height shall be measured from the top of the ceiling framing members to the underside of the roof framing members.

The rough-framed opening shall be not less than 22 inches by 30 inches (559 mm by 762 mm) and shall be located in a hallway or other readily accessible location. Where located in a wall, the opening shall be not less than 22 inches wide by 30 inches high (559 mm wide by 762 mm high). Where the access is located in a ceiling, minimum unobstructed headroom in the attic space shall be 30 inches (762 mm) at some point above the access measured vertically from the bottom of ceiling framing members. See Section M1305.1.3 for access requirements where mechanical equipment is located in attics.

An attic access opening shall be provided to attic areas that exceed 400 square feet (37.16 m²) and have a vertical height of 60 inches (1524 mm) or greater. The net clear opening shall not be less than 20 inches by 30 inches (508 mm by 762 mm) and shall be located in a hallway or other readily accessible location. A 30-inch (762 mm) minimum unobstructed headroom in the attic space shall be provided at some point above the access opening. See Section M1305.1.3 for access requirements where mechanical equipment is located in attics.

Exceptions:

1. Concealed areas not located over the main structure including porches, areas behind knee walls, dormers, bay windows, etc. are not required to have access.

2. Pull down stair treads, stringers, handrails, and hardware may protrude into the net clear opening.
CHAPTER 9
ROOF ASSEMBLIES

SECTION R901
GENERAL

R901.1 Scope.
The provisions of this chapter shall govern the design, materials, construction and quality of roof assemblies.

SECTION R902
FIRE CLASSIFICATION

R902.1 Roofing covering materials.
Roofs shall be covered with materials as set forth in Sections R904 and R905. Class A, B or C roofing shall be installed in jurisdictions designated by law as requiring their use or where the edge of the roof is less than 3 feet (914 mm) from a lot line. Class A, B and C roofing required by this section to be listed shall be tested in accordance with UL 790 or ASTM E 108.

Exceptions:

1. Class A roof assemblies include those with coverings of brick, masonry and exposed concrete roof deck.

2. Class A roof assemblies include ferrous or copper shingles or sheets, metal sheets and shingles, clay or concrete roof tile, or slate installed on noncombustible decks.

3. Class A roof assemblies include minimum 16 ounces per square foot copper sheets installed over combustible decks.

4. Class A roof assemblies include slate installed over underlayment over combustible decks.

R902.2 Fire-retardant-treated shingles and shakes.
Fire-retardant-treated wood shakes and shingles shall be treated by impregnation with chemicals by the full-cell vacuum-pressure process, in accordance with AWPA C1. Each bundle shall be marked to identify the manufactured unit and the manufacturer, and shall be labeled to identify the classification of the material in accordance with the testing required in Section R902.1, the treating company and the quality control agency.

R902.3 Building-integrated photovoltaic product.
Building-integrated photovoltaic products installed as the roof covering shall be tested, listed and labeled for fire classification in accordance with Section R902.1.

R902.4 Rooftop-mounted photovoltaic panels and modules.
Rooftop-mounted photovoltaic panels and modules installed on or above the roof covering shall be tested, listed and identified with a fire classification in accordance with UL 1703. Class A, B
or C photovoltaic panels and modules shall be installed in jurisdictions designated by law as requiring their use or where the edge of the roof is less than 3 feet (914 mm) from a lot line.

SECTION R903
WEATHER PROTECTION

R903.1 General.
Roof decks shall be covered with approved roof coverings secured to the building or structure in accordance with the provisions of this chapter. Roof assemblies shall be designed and installed in accordance with this code and the approved manufacturer’s instructions such that the roof assembly shall serve to protect the building or structure.

R903.2 Flashing.
Flashings shall be installed in a manner that prevents moisture from entering the wall and roof through joints in copings, through moisture permeable materials and at intersections with parapet walls and other penetrations through the roof plane.

   R903.2.1 Locations.
   Flashings shall be installed at wall and roof intersections, wherever there is a change in roof slope or direction and around roof openings. A flashing shall be installed to divert the water away from where the eave of a sloped roof intersects a vertical sidewall. Where flashing is of metal, the metal shall be corrosion resistant with a thickness of not less than 0.019 inch (0.5 mm) (No. 26 galvanized sheet).

   R903.2.2 Crickets and saddles.
   A cricket or saddle shall be installed on the ridge side of any chimney or penetration more than 30 inches (762 mm) wide as measured perpendicular to the slope. Cricket or saddle coverings shall be sheet metal or of the same material as the roof covering.

      Exception: Unit skylights installed in accordance with Section R308.6 and flashed in accordance with the manufacturer’s instructions shall be permitted to be installed without a cricket or saddle.

R903.3 Coping.
Parapet walls shall be properly coped with noncombustible, weatherproof materials of a width not less than the thickness of the parapet wall. Parapet coping shall extend 2 inches (51 mm) minimum down the faces of the parapet.

R903.4 Roof drainage.
Unless roofs are sloped to drain over roof edges, roof drains shall be installed at each low point of the roof.

   R903.4.1 Secondary (emergency overflow) drains or scuppers.
   Where roof drains are required, secondary emergency overflow roof drains or scuppers shall be provided where the roof perimeter construction extends above the roof in such a manner that water will be entrapped if the primary drains allow buildup for any reason. Overflow drains having the same size as the roof drains shall be installed with the inlet flow line located 2 inches (51 mm) above the low point of the roof, or overflow scuppers having three times the size of the roof drains and having a minimum opening height of 4 inches (102 mm).
shall be installed in the adjacent parapet walls with the inlet flow located 2 inches (51 mm) above the low point of the roof served. The installation and sizing of overflow drains, leaders and conductors shall comply with Sections 1106 and 1108 of the International Plumbing Code, as applicable.

Overflow drains shall discharge to an approved location and shall not be connected to roof drain lines.

SECTION R904
MATERIALS

R904.1 Scope.
The requirements set forth in this section shall apply to the application of roof covering materials specified herein. Roof assemblies shall be applied in accordance with this chapter and the manufacturer’s installation instructions. Installation of roof assemblies shall comply with the applicable provisions of Section R905.

R904.2 Compatibility of materials.
Roof assemblies shall be of materials that are compatible with each other and with the building or structure to which the materials are applied.

R904.3 Material specifications and physical characteristics.
Roof covering materials shall conform to the applicable standards listed in this chapter.

R904.4 Product identification.
Roof covering materials shall be delivered in packages bearing the manufacturer’s identifying marks and approved testing agency labels when required. Bulk shipments of materials shall be accompanied by the same information issued in the form of a certificate or on a bill of lading by the manufacturer.

SECTION R905
REQUIREMENTS FOR ROOF COVERINGS

R905.1 Roof covering application.
Roof coverings shall be applied in accordance with the applicable provisions of this section and the manufacturer’s installation instructions. Unless otherwise specified in this section, roof coverings shall be installed to resist the component and cladding loads specified in Table R301.2(2), adjusted for height and exposure in accordance with Table R301.2(3).

R905.1.1 Underlayment.
Underlayment for asphalt shingles, clay and concrete tile, metal roof shingles, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles, wood shakes and metal roof panels shall conform to the applicable standards listed in this chapter. Underlayment materials required to comply with ASTM D 226, D 1970, D 4869 and D 6757 shall bear a label indicating compliance to the standard designation and, if applicable, type classification indicated in Table R905.1.1(1). Underlayment shall be applied in accordance with Table R905.1.1(2). Underlayment shall be attached in accordance with Table R905.1.1(3).
Exceptions:

1. As an alternative, self-adhering polymer-modified bitumen underlayment complying with ASTM D 1970 installed in accordance with both the underlayment manufacturer’s and roof covering manufacturer’s instructions for the deck material, roof ventilation configuration and climate exposure for the roof covering to be installed, shall be permitted.

2. As an alternative, a minimum 4-inch-wide (102 mm) strip of self-adhering polymer-modified bitumen membrane complying with ASTM D 1970, installed in accordance with the manufacturer’s instructions for the deck material, shall be applied over all joints in the roof decking. An approved underlayment for the applicable roof covering for maximum ultimate design wind speeds, \(V_{ult}\), less than 140 miles per hour shall be applied over the entire roof over the 4-inch-wide (102 mm) membrane strips.

<table>
<thead>
<tr>
<th>TABLE R905.1.1(1) UNDERLAYMENT TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROOF COVERING</td>
</tr>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Asphalt shingles</td>
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<tr>
<td></td>
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<td></td>
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<tr>
<td>Clay and concrete tile</td>
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<td></td>
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<tr>
<td>Metal roof shingles</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Mineral-surfaced roll roofing</td>
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<tr>
<td></td>
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<tr>
<td>Slate and slate-type shingles</td>
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<tr>
<td></td>
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<tr>
<td>Wood shingles</td>
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<tr>
<td></td>
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<tr>
<td>Wood shakes</td>
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<td></td>
</tr>
<tr>
<td>Metal panels</td>
</tr>
</tbody>
</table>

| TABLE R905.1.1(2)                   |

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## UNDERLAYMENT APPLICATION

<table>
<thead>
<tr>
<th>ROOF COVERING</th>
<th>SECTION</th>
<th>MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{\text{ult}} &lt; 140$ MPH</th>
<th>MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{\text{ult}} \geq 140$ MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt shingles</td>
<td>R905.2</td>
<td>For roof slopes from two units vertical in 12 units horizontal (2:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied in the following manner: underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet.</td>
<td>Same as Maximum Ultimate Design Wind Speed, $V_{\text{ult}} &lt; 140$ mph except all laps shall be not less than 4 inches.</td>
</tr>
<tr>
<td>Clay and concrete tile</td>
<td>R905.3</td>
<td>For roof slopes from two and one-half units vertical in 12 units horizontal (2½:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be a minimum of two layers applied as follows: starting at the eave, apply a 19-inch strip of underlayment felt, parallel with the eave. Starting at the eave, apply 36-inch-wide strips of underlayment felt, overlapping successive sheets 19 inches. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be a minimum of one layer of underlayment felt applied shingle fashion, parallel to and starting from the eaves and lapped 2 inches. End laps shall be 4 inches and shall be offset by 6 feet.</td>
<td>Same as Maximum Ultimate Design Wind Speed, $V_{\text{ult}} &lt; 140$ mph except all laps shall be not less than 4 inches.</td>
</tr>
<tr>
<td>Metal roof shingles</td>
<td>R905.4</td>
<td>For roof slopes from two and one-half units vertical in 12 units horizontal (2½:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be a minimum of two layers applied as follows: starting at the eave, apply a 19-inch strip of underlayment felt, parallel with the eave. Starting at the eave, apply 36-inch-wide strips of underlayment felt, overlapping successive sheets 19 inches. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be a minimum of one layer of underlayment felt applied shingle fashion, parallel to and starting from the eaves and lapped 2 inches. End laps shall be 4 inches and shall be offset by 6 feet.</td>
<td>Same as Maximum Ultimate Design Wind Speed, $V_{\text{ult}} &lt; 140$ mph except all laps shall be not less than 4 inches.</td>
</tr>
</tbody>
</table>
### TABLE R905.1.1(3) UNDERLAYMENT ATTACHMENT

<table>
<thead>
<tr>
<th>ROOF COVERING</th>
<th>SECTION</th>
<th>MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{\text{ult}} &lt; 140$ MPH</th>
<th>MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{\text{ult}} \geq 140$ MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt shingles</td>
<td>R905.2</td>
<td>Fastened sufficiently to hold in place</td>
<td>The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 12 inches between side laps with a 6-inch spacing at the side laps. Underlayment shall be attached using metal or plastic cap nails or cap staples with a</td>
</tr>
<tr>
<td>Slate and slate-type shingles</td>
<td>R905.6</td>
<td>Apply in accordance with the manufacturer's installation instructions.</td>
<td>For roof slopes from two units vertical in 12 units horizontal (2:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches, and fastened sufficiently to hold in place. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied in the following manner: underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 4 inches. End laps shall be 4 inches and shall be offset by 6 feet.</td>
</tr>
<tr>
<td>Wood shakes</td>
<td>R905.8</td>
<td>Apply in accordance with the manufacturer's installation instructions.</td>
<td>For roof slopes from two units vertical in 12 units horizontal (2:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches, and fastened sufficiently to hold in place. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied in the following manner: underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 4 inches. End laps shall be 4 inches and shall be offset by 6 feet.</td>
</tr>
<tr>
<td>Metal panels</td>
<td>R905.10</td>
<td>Apply in accordance with the manufacturer's installation instructions.</td>
<td>For roof slopes from two units vertical in 12 units horizontal (2:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied in the following manner: apply a 19-inch strip of underlayment felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches, and fastened sufficiently to hold in place. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied in the following manner: underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 4 inches. End laps shall be 4 inches and shall be offset by 6 feet.</td>
</tr>
<tr>
<td>Material Type</td>
<td>Code Section</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>--------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>Clay and concrete tile</td>
<td>R905.3</td>
<td>Nominal cap diameter of not less than 1 inch. Metal caps shall have a thickness of not less than 32-gage sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch for ring shank cap nails and 0.091 inch for smooth shank cap nails. Staples shall be not less than 21 gage. Cap nail shank and cap staple legs shall have a length sufficient to penetrate through the roof sheathing or not less than 3/4 inch into the roof sheathing.</td>
<td></td>
</tr>
<tr>
<td>Metal roof shingles</td>
<td>R905.4</td>
<td>The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 12 inches between side laps with a 6-inch spacing at the side laps. Underlayment shall be attached using metal or plastic cap nails or cap staples with a nominal cap diameter of not less than 1 inch. Metal caps shall have a thickness of at least 32-gage sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch for ring shank cap nails and 0.091 inch for smooth shank cap nails. Staples shall be not less than 21 gage. Cap nail shank and cap staple legs shall have a length sufficient to penetrate through the roof sheathing or not less than 3/4 inch into the roof sheathing.</td>
<td></td>
</tr>
<tr>
<td>Mineral-surfaced roll roofing</td>
<td>R905.5</td>
<td>Manufacturer's installation instructions.</td>
<td></td>
</tr>
<tr>
<td>Slate and slate-type shingles</td>
<td>R905.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Material</th>
<th>Code</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood shingles</td>
<td>R905.7</td>
<td>not less than (\frac{3}{4}) inch into the roof sheathing.</td>
</tr>
<tr>
<td>Wood shakes</td>
<td>R905.8</td>
<td></td>
</tr>
<tr>
<td>Metal panels</td>
<td>R905.10</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

**R905.1.2 Ice barriers.**
In areas where there has been a history of ice forming along the eaves causing a backup of water as designated in Table R301.2(1) the average daily temperature in January is 25° F (-4° C) or less or when Table R301.2(1) criteria so designates, an ice barrier shall be installed for asphalt shingles, metal roof shingles, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles and wood shakes. The ice barrier shall consist of not fewer than two layers of underlayment cemented together, or a self-adhering polymer-modified bitumen sheet shall be used in place of normal underlayment and extend from the lowest edges of all roof surfaces to a point not less than 24 inches (610 mm) inside the exterior wall line of the building. On roofs with slope equal to or greater than 8 units vertical in 12 units horizontal, the ice barrier shall also be applied not less than 36 inches (914 mm) measured along the roof slope from the eave edge of the building.

**Exception:** Detached accessory structures not containing conditioned floor area.

**R905.2 Asphalt shingles.**
The installation of asphalt shingles shall comply with the provisions of this section.

**R905.2.1 Sheathing requirements.**
Asphalt shingles shall be fastened to solidly sheathed decks.
R905.2.2 Slope.
Asphalt shingles shall be used only on roof slopes of two units vertical in 12 units horizontal (2:12) or greater. For roof slopes from two units vertical in 12 units horizontal (2:12) up to four units vertical in 12 units horizontal (4:12), double underlayment application is required in accordance with Section R905.1.1.

R905.2.3 Underlayment.
Underlayment shall comply with Section R905.1.1.

R905.2.4 Asphalt shingles.
Asphalt shingles shall comply with ASTM D 3462.

R905.2.4.1 Wind resistance of asphalt shingles.
Asphalt shingles shall be tested in accordance with ASTM D 7158. Asphalt shingles shall meet the classification requirements of Table R905.2.4.1 for the appropriate ultimate design wind speed. Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D 7158 and the required classification in Table R905.2.4.1.

**Exception:** Asphalt shingles not included in the scope of ASTM D 7158 shall be tested and labeled to indicate compliance with ASTM D 3161 and the required classification in Table R905.2.4.1.

**TABLE R905.2.4.1**
CLASSIFICATION OF ASPHALT ROOF SHINGLES

<table>
<thead>
<tr>
<th>MAXIMUM ULTIMATE DESIGN WIND SPEED, $V_{ult}$ FROM FIGURE R301.2(4)A (mph)</th>
<th>MAXIMUM BASIC WIND SPEED, FROM TABLE R301.2.1.3 (mph)</th>
<th>ASTM D 7158 SHINGLE CLASSIFICATION</th>
<th>ASTM D 3161 SHINGLE CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>85</td>
<td>D, G or H</td>
<td>A, D or F</td>
</tr>
<tr>
<td>116</td>
<td>90</td>
<td>D, G or H</td>
<td>A, D or F</td>
</tr>
<tr>
<td>129</td>
<td>100</td>
<td>G or H</td>
<td>A, D or F</td>
</tr>
<tr>
<td>142</td>
<td>110</td>
<td>G or H</td>
<td>F</td>
</tr>
<tr>
<td>155</td>
<td>120</td>
<td>G or H</td>
<td>F</td>
</tr>
<tr>
<td>168</td>
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<td>H</td>
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<td>181</td>
<td>140</td>
<td>H</td>
<td>F</td>
</tr>
<tr>
<td>194</td>
<td>150</td>
<td>H</td>
<td>F</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm; 1 mph = 0.447 m/s.
a. The standard calculations contained in ASTM D 7158 assume Exposure Category B or C and building height of 60 feet or less. Additional calculations are required for conditions outside of these assumptions.

R905.2.5 Fasteners.
Fasteners for asphalt shingles shall be galvanized steel, stainless steel, aluminum or copper roofing nails, minimum 12-gage [0.105 inch (3 mm)] shank with a minimum $\frac{3}{8}$-inch-diameter (9.5 mm) head, complying with ASTM F 1667, of a length to penetrate through the roofing materials and not less than $\frac{3}{4}$ inch (19.1 mm) into the roof sheathing. Where the roof
sheathing is less than \(\frac{3}{4}\) inch (19.1 mm) thick, the fasteners shall penetrate through the sheathing.

**R905.2.6 Attachment.**
Asphalt shingles shall have the minimum number of fasteners required by the manufacturer, but not less than four fasteners per strip shingle or two fasteners per individual shingle. Where the roof slope exceeds 21 units vertical in 12 units horizontal (21:12, 175-percent slope), shingles shall be installed as required by the manufacturer.

**Exception:** Asphalt strip shingles shall have a minimum of six fasteners per shingle where the roof is in one of the following categories:

1. The ultimate wind speed in accordance with Table R301.2(4) is 130 miles per hour (58 m/s) or greater and the eave is 20 feet (6096 mm) or higher above grade.
2. The ultimate wind speed in accordance with Table R301.2(4) is 140 miles per hour (63 m/s) or greater.
3. Special mountain regions in accordance with Table R301.2(5) that meet items 1 or 2 above.

**R905.2.7 Ice barrier.**
Where required, ice barriers shall comply with Section R905.1.2.

**R905.2.8 Flashing.**
Flashing for asphalt shingles shall comply with this section.

**R905.2.8.1 Base and cap flashing.**
Base and cap flashing shall be installed in accordance with manufacturer's instructions. Base flashing shall be of either corrosion-resistant metal of minimum nominal 0.019-inch (0.5 mm) thickness or mineral-surfaced roll roofing weighing not less than 77 pounds per 100 square feet (4 kg/m\(^2\)). Cap flashing shall be corrosion-resistant metal of minimum nominal 0.019-inch (0.5 mm) thickness.

**R905.2.8.2 Valleys.**
Valley linings shall be installed in accordance with the manufacturer's instructions before applying shingles. Valley linings of the following types shall be permitted:

1. For open valleys (valley lining exposed) lined with metal, the valley lining shall be not less than 24 inches (610 mm) wide and of any of the corrosion-resistant metals in Table R905.2.8.2.
2. For open valleys, valley lining of two plies of mineral-surfaced roll roofing, complying with ASTM D 3909 or ASTM D 6380 Class M, shall be permitted. The bottom layer shall be 18 inches (457 mm) and the top layer not less than 36 inches (914 mm) wide.
3. For closed valleys (valley covered with shingles), valley lining of one ply of smooth roll roofing complying with ASTM D 6380 and not less than 36 inches wide (914 mm) or valley lining as described in Item 1 or 2 shall be permitted. Self-adhering polymer modified bitumen underlayment complying with ASTM D 1970 shall be permitted in lieu of the lining material.

### TABLE R905.2.8.2 VALLEY LINING MATERIAL

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>MINIMUM THICKNESS (inches)</th>
<th>GAGE</th>
<th>WEIGHT (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold-rolled copper</td>
<td>0.0216 nominal</td>
<td>—</td>
<td>ASTM B 370, 16 oz. per square foot</td>
</tr>
<tr>
<td>Lead-coated copper</td>
<td>0.0216 nominal</td>
<td>—</td>
<td>ASTM B 101, 16 oz. per square foot</td>
</tr>
<tr>
<td>High-yield copper</td>
<td>0.0162 nominal</td>
<td>—</td>
<td>ASTM B 370, 12 oz. per square foot</td>
</tr>
<tr>
<td>Lead-coated high-yield copper</td>
<td>0.0162 nominal</td>
<td>—</td>
<td>ASTM B 101, 12 oz. per square foot</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.024</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>—</td>
<td>28</td>
<td>—</td>
</tr>
<tr>
<td>Galvanized steel</td>
<td>0.0179 26 (zinc coated G90)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Zinc alloy</td>
<td>0.027</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Lead</td>
<td>—</td>
<td>—</td>
<td>$2^{1/2}$</td>
</tr>
<tr>
<td>Painted terne</td>
<td>—</td>
<td>—</td>
<td>20</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg.

**R905.2.8.3 Sidewall flashing.**
Base flashing against a vertical sidewall shall be continuous at horizontal surfaces or step flashing at sloped surfaces and shall be not less than 4 inches (102 mm) in height and 4 inches (102 mm) in width and shall direct water away from the vertical sidewall onto the roof or into the gutter. Where siding is provided on the vertical sidewall, the vertical leg of the flashing shall be continuous under the siding. Where anchored masonry veneer is provided on the vertical sidewall, the base flashing shall be provided in accordance with this section and counterflashing shall be provided in accordance with Section R703.7.2.2.8.5. Where exterior plaster or adhered masonry veneer is provided on the vertical sidewall, the base flashing shall be provided in accordance with this section and Section R703.6.3.

**R905.2.8.4 Other flashing.**
Flashing against a vertical front wall, as well as soil stack, vent pipe and chimney flashing, shall be applied in accordance with the asphalt shingle manufacturer’s printed instructions.

**R905.2.8.5 Drip edge. Deleted.**
A drip edge shall be provided at eaves and rake edges of shingle roofs. Adjacent segments of drip edge shall be overlapped not less than 2 inches (51 mm). Drip edges shall extend not less than $\frac{1}{4}$ inch (6.4 mm) below the roof sheathing and extend up back.
onto the roof deck not less than 2 inches (51 mm). Drip edges shall be mechanically fastened to the roof deck at not more than 12 inches (305 mm) o.c. with fasteners as specified in Section R905.2.5. Underlayment shall be installed over the drip edge along eaves and under the underlayment along rake edges.

R905.3 Clay and concrete tile.
The installation of clay and concrete tile shall comply with the provisions of this section.

R905.3.1 Deck requirements.
Concrete and clay tile shall be installed only over solid sheathing or spaced structural sheathing boards.

R905.3.2 Deck slope.
Clay and concrete roof tile shall be installed on roof slopes of two and one-half units vertical in 12 units horizontal (2:12) or greater. For roof slopes from two and one-half units vertical in 12 units horizontal (2:12) to four units vertical in 12 units horizontal (4:12), double underlayment application is required in accordance with Section R905.3.3.

R905.3.3 Underlayment.
Underlayment shall comply with Section R905.1.1.

R905.3.4 Clay tile.
Clay roof tile shall comply with ASTM C 1167.

R905.3.5 Concrete tile.
Concrete roof tile shall comply with ASTM C 1492.

R905.3.6 Fasteners.
Nails shall be corrosion resistant and not less than 11 gage, 5/16-inch (11 mm) head, and of sufficient length to penetrate the deck not less than 3/4 inch (19 mm) or through the thickness of the deck, whichever is less. Attaching wire for clay or concrete tile shall not be smaller than 0.083 inch (2 mm). Perimeter fastening areas include three tile courses but not less than 36 inches (914 mm) from either side of hips or ridges and edges of eaves and gable rakes.

R905.3.7 Application.
Tile shall be applied in accordance with this chapter and the manufacturer’s installation instructions, based on the following:

1. Climatic conditions.
2. Roof slope.
3. Underlayment system.
4. Type of tile being installed.
Clay and concrete roof tiles shall be fastened in accordance with this section and the manufacturer’s installation instructions. Perimeter tiles shall be fastened with not less than one fastener per tile. Tiles with installed weight less than 9 pounds per square foot (0.4 kg/m$^2$) require not less than one fastener per tile regardless of roof slope. Clay and concrete roof tile attachment shall be in accordance with the manufacturer’s installation instructions where applied in areas where the ultimate design wind speed exceeds 130 miles per hour (58 m/s) and on buildings where the roof is located more than 40 feet (12 192 mm) above grade. In areas subject to snow, not less than two fasteners per tile are required. In other areas, clay and concrete roof tiles shall be attached in accordance with Table R905.3.7.

**TABLE R905.3.7**

<table>
<thead>
<tr>
<th>SHEATHING</th>
<th>ROOF SLOPE</th>
<th>NUMBER OF FASTENERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid without battens</td>
<td>All</td>
<td>One per tile</td>
</tr>
<tr>
<td>Spaced or solid with battens and slope $&lt; 5:12$</td>
<td>Fasteners not required</td>
<td>—</td>
</tr>
<tr>
<td>Spaced sheathing without battens</td>
<td>$5:12 \leq$ slope $&lt; 12:12$</td>
<td>One per tile/every other row</td>
</tr>
<tr>
<td></td>
<td>$12:12 \leq$ slope $&lt; 24:12$</td>
<td>One per tile</td>
</tr>
</tbody>
</table>

**R905.3.8 Flashing.**

At the juncture of roof vertical surfaces, flashing and counterflashing shall be provided in accordance with this chapter and the manufacturer’s installation instructions and, where of metal, shall be not less than 0.019 inch (0.5 mm) (No. 26 galvanized sheet gage) corrosion-resistant metal. The valley flashing shall extend not less than 11 inches (279 mm) from the centerline each way and have a splash diverter rib not less than 1 inch (25 mm) in height at the flow line formed as part of the flashing. Sections of flashing shall have an end lap of not less than 4 inches (102 mm). For roof slopes of three units vertical in 12 units horizontal (25-percent slope) and greater, valley flashing shall have a 36-inch-wide (914 mm) underlayment of one layer of Type I underlayment running the full length of the valley, in addition to other required underlayment. In areas where the average daily temperature in January is 25°F (-4°C) or less, metal valley flashing underlayment shall be solid-cemented to the roofing underlayment for slopes less than seven units vertical in 12 units horizontal (58-percent slope) or be of self-adhering polymer modified bitumen sheet.

**R905.4 Metal roof shingles.**

The installation of metal roof shingles shall comply with the provisions of this section.

**R905.4.1 Deck requirements.**

Metal roof shingles shall be applied to a solid or closely fitted deck, except where the roof covering is specifically designed to be applied to spaced sheathing.

**R905.4.2 Deck slope.**

Metal roof shingles shall not be installed on roof slopes below three units vertical in 12 units horizontal (25-percent slope).
R905.4.3 Underlayment.
Underlayment shall comply with Section R905.1.1.

R905.4.3.1 Ice barrier.
Where required, ice barriers shall comply with Section R905.1.2.

R905.4.4 Material standards.
Metal roof shingle roof coverings shall comply with Table R905.10.3(1). The materials used for metal roof shingle roof coverings shall be naturally corrosion resistant or be made corrosion resistant in accordance with the standards and minimum thicknesses listed in Table R905.10.3(2).

R905.4.5 Application.
Metal roof shingles shall be secured to the roof in accordance with this chapter and the approved manufacturer’s installation instructions.

R905.4.6 Flashing.
Roof valley flashing shall be of corrosion-resistant metal of the same material as the roof covering or shall comply with the standards in Table R905.10.3(1). The valley flashing shall extend not less than 8 inches (203 mm) from the centerline each way and shall have a splash diverter rib not less than \( \frac{3}{4} \) inch (19 mm) in height at the flow line formed as part of the flashing. Sections of flashing shall have an end lap of not less than 4 inches (102 mm). The metal valley flashing shall have a 36-inch-wide (914 mm) underlayment directly under it consisting of one layer of underlayment running the full length of the valley, in addition to underlayment required for metal roof shingles. In areas where the average daily temperature in January is 25°F (-4°C) or less, the metal valley flashing underlayment shall be solid cemented to the roofing underlayment for roof slopes under seven units vertical in 12 units horizontal (58-percent slope) or self-adhering polymer modified bitumen sheet.

R905.5 Mineral-surfaced roll roofing.
The installation of mineral-surfaced roll roofing shall comply with this section.

R905.5.1 Deck requirements.
Mineral-surfaced roll roofing shall be fastened to solidly sheathed roofs.

R905.5.2 Deck slope.
Mineral-surfaced roll roofing shall not be applied on roof slopes below one unit vertical in 12 units horizontal (8-percent slope).

R905.5.3 Underlayment.
Underlayment shall comply with Section R905.1.1.

R905.5.3.1 Ice barrier.
Where required, ice barriers shall comply with Section R905.1.2.

R905.5.4 Material standards.
Mineral-surfaced roll roofing shall conform to ASTM D 3909 or ASTM D 6380, Class M.
R905.5.5 Application.
Mineral-surfaced roll roofing shall be installed in accordance with this chapter and the manufacturer’s instructions.

R905.6 Slate shingles.
The installation of slate shingles shall comply with the provisions of this section.

R905.6.1 Deck requirements.
Slate shingles shall be fastened to solidly sheathed roofs.

R905.6.2 Deck slope.
Slate shingles shall be used only on slopes of four units vertical in 12 units horizontal (33-percent slope) or greater.

R905.6.3 Underlayment.
Underlayment shall comply with Section R905.1.1.

R905.6.3.1 Ice barrier.
Where required, ice barriers shall comply with Section R905.1.2.

R905.6.4 Material standards.
Slate shingles shall comply with ASTM C 406.

R905.6.5 Application.
Minimum headlap for slate shingles shall be in accordance with Table R905.6.5. Slate shingles shall be secured to the roof with two fasteners per slate. Slate shingles shall be installed in accordance with this chapter and the manufacturer’s instructions.

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>HEADLAP (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:12 ≤ slope &lt; 8:12</td>
<td>4</td>
</tr>
<tr>
<td>8:12 ≤ slope &lt; 20:12</td>
<td>3</td>
</tr>
<tr>
<td>Slope ≤ 20:12</td>
<td>2</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

R905.6.6 Flashing.
Flash ing and counter flashing shall be made with sheet metal. Valley flashing shall be not less than 15 inches (381 mm) wide. Valley and flashing metal shall be a minimum uncoated thickness of 0.0179-inch (0.5 mm) zinc coated G90. Chimneys, stucco or brick walls shall have not less than two plies of felt for a cap flashing consisting of a 4-inch-wide (102 mm) strip of felt set in plastic cement and extending 1 inch (25 mm) above the first felt and a top coating of plastic cement. The felt shall extend over the base flashing 2 inches (51 mm).

R905.7 Wood shingles.
The installation of wood shingles shall comply with the provisions of this section.

R905.7.1 Deck requirements.
Wood shingles shall be installed on solid or spaced sheathing. Where spaced sheathing is
used, sheathing boards shall be not less than 1-inch by 4-inch (25 mm by 102 mm) nominal dimensions and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners.

**R905.7.1 Solid sheathing required.**
In areas where the average daily temperature in January is 25°F (-4°C) or less, solid sheathing is required on that portion of the roof requiring the application of an ice barrier.

**R905.7.2 Deck slope.**
Wood shingles shall be installed on slopes of three units vertical in 12 units horizontal (25-percent slope) or greater.

**R905.7.3 Underlayment.**
Underlayment shall comply with Section R905.1.1.

**R905.7.3.1 Ice barrier.**
Where required, ice barriers shall comply with Section R905.1.2.

**R905.7.4 Material standards.**
Wood shingles shall be of naturally durable wood and comply with the requirements of Table R905.7.4.

| TABLE R905.7.4  
WOOD SHINGLE MATERIAL REQUIREMENTS |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>MINIMUM GRADES</td>
<td>APPLICABLE GRADING RULES</td>
</tr>
<tr>
<td>Wood shingles of naturally durable wood</td>
<td>1, 2 or 3</td>
<td>Cedar Shake and Shingle Bureau</td>
</tr>
</tbody>
</table>

**R905.7.5 Application.**
Wood shingles shall be installed in accordance with this chapter and the manufacturer’s instructions. Wood shingles shall be laid with a side lap not less than \( \frac{1}{2} \) inches (38 mm) between joints in courses, and two joints shall not be in direct alignment in any three adjacent courses. Spacing between shingles shall be not less than \( \frac{1}{4} \) inch to \( \frac{3}{8} \) inch (6.4 mm to 9.5 mm). Weather exposure for wood shingles shall not exceed those set in Table R905.7.5(1). Fasteners for untreated (naturally durable) wood shingles shall be box nails in accordance with Table R905.7.5(2). Nails shall be stainless steel Type 304 or 316 or hot-dipped galvanized with a coating weight of ASTM A 153 Class D (1.0 oz/ft\(^2\)). Alternatively, two 16-gage stainless steel Type 304 or 316 staples with crown widths \( \frac{7}{16} \) inch (11.1 mm) minimum, \( \frac{3}{4} \) inch (19.1 mm) maximum, shall be used. Fasteners installed within 15 miles (24 km) of salt water coastal areas shall be stainless steel Type 316. Fasteners for fire-retardant-treated shingles in accordance with Section R902 or pressure-impregnated-preservative-treated shingles of naturally durable wood in accordance with AWPA U1 shall be stainless steel Type 316. All fasteners shall have a minimum penetration into the
sheathing of \(\frac{3}{4}\) inch (19.1 mm). For sheathing less than \(\frac{3}{4}\) inch in (19.1 mm) thickness, each fastener shall penetrate through the sheathing. Wood shingles shall be attached to the roof with two fasteners per shingle, positioned in accordance with the manufacturer’s installation instructions. Fastener packaging shall bear a label indicating the appropriate grade material or coating weight.

### TABLE R905.7.5(1)
**WOOD SHINGLE WEATHER EXPOSURE AND ROOF SLOPE**

<table>
<thead>
<tr>
<th>ROOFING MATERIAL</th>
<th>LENGTH (inches)</th>
<th>GRADE</th>
<th>EXPOSURE (inches)</th>
<th>3:12 pitch to &lt; 4:12</th>
<th>4:12 pitch or steeper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingles of naturally durable wood</td>
<td>16</td>
<td>No. 1</td>
<td>(\frac{3}{4})</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 2</td>
<td>(\frac{1}{2})</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 3</td>
<td>3</td>
<td>(\frac{1}{2})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>No. 1</td>
<td>(4\frac{1}{4})</td>
<td>(\frac{1}{2})</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 2</td>
<td>4</td>
<td>(\frac{1}{2})</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 3</td>
<td>(\frac{1}{2})</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>No. 1</td>
<td>(5\frac{3}{4})</td>
<td>(\frac{1}{2})</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 2</td>
<td>(\frac{1}{2})</td>
<td>(\frac{1}{2})</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 3</td>
<td>5</td>
<td>(\frac{1}{2})</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

### TABLE R905.7.5(2)
**NAIL REQUIREMENTS FOR WOOD SHAKES AND WOOD SHINGLES**

<table>
<thead>
<tr>
<th>SHAKES</th>
<th>NAIL TYPE AND MINIMUM LENGTH</th>
<th>MINIMUM HEAD SIZE</th>
<th>MINIMUM SHANK DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>18” straight-split</td>
<td>5d box 1(\frac{3}{4})”</td>
<td>0.19”</td>
<td>.080”</td>
</tr>
<tr>
<td>18” and 24” handsplit and resawn</td>
<td>6d box 2”</td>
<td>0.19”</td>
<td>.0915”</td>
</tr>
<tr>
<td>24” taper-split</td>
<td>5d box 1(\frac{3}{4})”</td>
<td>0.19”</td>
<td>.080”</td>
</tr>
<tr>
<td>18” and 24” tapersawn</td>
<td>6d box 2”</td>
<td>0.19”</td>
<td>.0915”</td>
</tr>
<tr>
<td>Shingles</td>
<td>Nail Type and Minimum Length</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
R905.7.6 Valley flashing.
Roof flashing shall be not less than No. 26 gage [0.019 inches (0.5 mm)] corrosion-resistant sheet metal and shall extend 10 inches (254 mm) from the centerline each way for roofs having slopes less than 12 units vertical in 12 units horizontal (100-percent slope), and 7 inches (178 mm) from the centerline each way for slopes of 12 units vertical in 12 units horizontal and greater. Sections of flashing shall have an end lap of not less than 4 inches (102 mm).

R905.7.7 Label required.
Each bundle of shingles shall be identified by a label of an approved grading or inspection bureau or agency.

R905.8 Wood shakes.
The installation of wood shakes shall comply with the provisions of this section.

R905.8.1 Deck requirements.
Wood shakes shall be used only on solid or spaced sheathing. Where spaced sheathing is used, sheathing boards shall be not less than 1-inch by 4-inch (25 mm by 102 mm) nominal dimensions and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners. Where 1-inch by 4-inch (25 mm by 102 mm) spaced sheathing is installed at 10 inches (254 mm) on center, additional 1-inch by 4-inch (25 mm by 102 mm) boards shall be installed between the sheathing boards.

R905.8.1.1 Solid sheathing required.
In areas where the average daily temperature in January is 25°F (-4°C) or less, solid sheathing is required on that portion of the roof requiring an ice barrier.

R905.8.2 Deck slope.
Wood shakes shall only be used on slopes of three units vertical in 12 units horizontal (25-percent slope) or greater.

R905.8.3 Underlayment.
Underlayment shall comply with Section R905.1.1.

R905.8.3.1 Ice barrier.
Where required, ice barriers shall comply with Section R905.1.2.

R905.8.4 Interlayment.
Interlayment shall comply with ASTM D 226, Type I.

R905.8.5 Material standards.
Wood shakes shall comply with the requirements of Table R905.8.5.

<table>
<thead>
<tr>
<th>16” and 18”</th>
<th>3d box 1 1/4”</th>
<th>0.19”</th>
<th>.080”</th>
</tr>
</thead>
<tbody>
<tr>
<td>24”</td>
<td>4d box 1 1/2”</td>
<td>0.19”</td>
<td>.080”</td>
</tr>
</tbody>
</table>

**TABLE R905.8.5**
WOOD SHAKE MATERIAL REQUIREMENTS
R905.8.6 Application.
Wood shakes shall be installed in accordance with this chapter and the manufacturer’s installation instructions. Wood shakes shall be laid with a side lap not less than $1 \frac{1}{2}$ inches (38 mm) between joints in adjacent courses. Spacing between shakes in the same course shall be $\frac{3}{8}$ inch to $\frac{5}{8}$ inch (9.5 mm to 15.9 mm) including tapersawn shakes. Weather exposures for wood shakes shall not exceed those set in Table R905.8.6. Fasteners for untreated (naturally durable) wood shakes shall be box nails in accordance with Table R905.7.5(2). Nails shall be stainless steel Type 304, or Type 316 or hot-dipped with a coating weight of ASTM A 153 Class D (1 oz/ft$^2$). Alternatively, two 16-gage Type 304 or Type 316 stainless steel staples, with crown widths $\frac{7}{16}$ inch (11.1 mm) minimum, $\frac{3}{4}$ inch (19.1 mm) maximum, shall be used. Fasteners installed within 15 miles (24 km) of salt water coastal areas shall be stainless steel Type 316. Wood shakes shall be attached to the roof with two fasteners per shake positioned in accordance with the manufacturer’s installation instructions. Fasteners for fire-retardant-treated (as defined in Section R902) shakes or pressure-impregnated-preservative-treated shakes of naturally durable wood in accordance with AWPA U1 shall be stainless steel Type 316. All fasteners shall have a minimum penetration into the sheathing of $\frac{3}{4}$ inch (19.1 mm). Where the sheathing is less than $\frac{3}{4}$ inch (19.1 mm) thick, each fastener shall penetrate through the sheathing. Fastener packaging shall bear a label indicating the appropriate grade material or coating weight.

### TABLE R905.8.6
WOOD SHAKE WEATHER EXPOSURE AND ROOF SLOPE

<table>
<thead>
<tr>
<th>ROOFING MATERIAL</th>
<th>LENGTH (inches)</th>
<th>GRADE</th>
<th>EXPOSURE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shakes of naturally durable wood</td>
<td>18</td>
<td>No. 1</td>
<td>$7 \frac{1}{2}$</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>No. 1</td>
<td>$10^{a}$</td>
</tr>
</tbody>
</table>
R905.8.7 Shake placement.
The starter course at the eaves shall be doubled and the bottom layer shall be either 15-inch (381 mm), 18-inch (457 mm) or 24-inch (610 mm) wood shakes or wood shingles. Fifteen-inch (381 mm) or 18-inch (457 mm) wood shakes shall be permitted to be used for the final course at the ridge. Shakes shall be interlaid with 18-inch-wide (457 mm) strips of not less than No. 30 felt shingled between each course in such a manner that no felt is exposed to the weather by positioning the lower edge of each felt strip above the butt end of the shake it covers a distance equal to twice the weather exposure.

R905.8.8 Valley flashing.
Roof valley flashing shall be not less than No. 26 gage [0.019 inch (0.5 mm)] corrosion-resistant sheet metal and shall extend not less than 11 inches (279 mm) from the centerline each way. Sections of flashing shall have an end lap of not less than 4 inches (102 mm).

R905.8.9 Label required.
Each bundle of shakes shall be identified by a label of an approved grading or inspection bureau or agency.

R905.9 Built-up roofs.
The installation of built-up roofs shall comply with the provisions of this section.

R905.9.1 Slope.
Built-up roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage, except for coal-tar built-up roofs, which shall have a design slope of a minimum one-eighth unit vertical in 12 units horizontal (1-percent slope).

R905.9.2 Material standards.
Built-up roof covering materials shall comply with the standards in Table R905.9.2 or UL 55A.

<table>
<thead>
<tr>
<th>Preservative-treated tapersawn shakes of Southern Yellow Pine</th>
<th>18</th>
<th>No. 1</th>
<th>7/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>No. 1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>No. 2</td>
<td>5/2</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>No. 2</td>
<td>7/2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taper-sawn shakes of naturally durable wood</th>
<th>18</th>
<th>No. 1</th>
<th>7/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>No. 1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>No. 2</td>
<td>5/2</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>No. 2</td>
<td>7/2</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
a. For 24-inch by 3/8-inch handsplit shakes, the maximum exposure is 7/2 inches.
BUILT-UP ROOFING MATERIAL STANDARDS

<table>
<thead>
<tr>
<th>MATERIAL STANDARD</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic coatings used in roofing</td>
<td>ASTM D 6083</td>
</tr>
<tr>
<td>Aggregate surfacing</td>
<td>ASTM D 1863</td>
</tr>
<tr>
<td>Asphalt adhesive used in roofing</td>
<td>ASTM D 3747</td>
</tr>
<tr>
<td>Asphalt cements used in roofing</td>
<td>ASTM D 2822; D 3019; D 4586</td>
</tr>
<tr>
<td>Asphalt-coated glass fiber base sheet</td>
<td>ASTM D 4601</td>
</tr>
<tr>
<td>Asphalt coatings used in roofing</td>
<td>ASTM D 1227; D 2823; D 2824; D 4479</td>
</tr>
<tr>
<td>Asphalt glass felt</td>
<td>ASTM D 2178</td>
</tr>
<tr>
<td>Asphalt primer used in roofing</td>
<td>ASTM D 41</td>
</tr>
<tr>
<td>Asphalt-saturated and asphalt-coated organic felt base sheet</td>
<td>ASTM D 2626</td>
</tr>
<tr>
<td>Asphalt-saturated organic felt (perforated)</td>
<td>ASTM D 226</td>
</tr>
<tr>
<td>Asphalt used in roofing</td>
<td>ASTM D 312</td>
</tr>
<tr>
<td>Coal-tar cements used in roofing</td>
<td>ASTM D 4022; D 5643</td>
</tr>
<tr>
<td>Coal-tar primer used in roofing, dampproofing and waterproofing</td>
<td>ASTM D 43</td>
</tr>
<tr>
<td>Coal-tar saturated organic felt</td>
<td>ASTM D 227</td>
</tr>
<tr>
<td>Coal-tar used in roofing</td>
<td>ASTM D 450, Type I or II</td>
</tr>
<tr>
<td>Glass mat, coal tar</td>
<td>ASTM D 4990</td>
</tr>
<tr>
<td>Glass mat, venting type</td>
<td>ASTM D 4897</td>
</tr>
<tr>
<td>Mineral-surfaced inorganic cap sheet</td>
<td>ASTM D 3909</td>
</tr>
<tr>
<td>Thermoplastic fabrics used in roofing</td>
<td>ASTM D 5665; D 5726</td>
</tr>
</tbody>
</table>

**R905.9.3 Application.**
Built-up roofs shall be installed in accordance with this chapter and the manufacturer’s instructions.

**R905.10 Metal roof panels.**
The installation of metal roof panels shall comply with the provisions of this section.

**R905.10.1 Deck requirements.**
Metal roof panel roof coverings shall be applied to solid or spaced sheathing, except where the roof covering is specifically designed to be applied to spaced supports.

**R905.10.2 Slope.**
Minimum slopes for metal roof panels shall comply with the following:

1. The minimum slope for lapped, nonsoldered-seam metal roofs without applied lap sealant shall be three units vertical in 12 units horizontal (25-percent slope).

2. The minimum slope for lapped, nonsoldered-seam metal roofs with applied lap sealant shall be one-half unit vertical in 12 units horizontal (4-percent slope). Lap sealants shall be applied in accordance with the approved manufacturer’s installation instructions.

3. The minimum slope for standing-seam roof systems shall be one-quarter unit vertical in 12 units horizontal (2-percent slope).
R905.10.3 Material standards.
Metal-sheet roof covering systems that incorporate supporting structural members shall be designed in accordance with the International Building Code. Metal-sheet roof coverings installed over structural decking shall comply with Table R905.10.3(1). The materials used for metal-sheet roof coverings shall be naturally corrosion resistant or provided with corrosion resistance in accordance with the standards and minimum thicknesses shown in Table R905.10.3(2).

**TABLE R905.10.3(1)**
METAL ROOF COVERING STANDARDS

<table>
<thead>
<tr>
<th>ROOF COVERING TYPE</th>
<th>STANDARD APPLICATION RATE/THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvanized steel</td>
<td>ASTM A 653 G90 Zinc coated</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>ASTM A 240, 300 Series alloys</td>
</tr>
<tr>
<td>Steel</td>
<td>ASTM A 924</td>
</tr>
<tr>
<td>Lead-coated copper</td>
<td>ASTM B 101</td>
</tr>
<tr>
<td>Cold-rolled copper</td>
<td>ASTM B 370 minimum 16 oz/sq ft and 12 oz/sq ft high-yield copper for metal-sheet roof-covering systems; 12 oz/sq ft for preformed metal shingle systems.</td>
</tr>
<tr>
<td>Hard lead</td>
<td>2 lb/sq ft</td>
</tr>
<tr>
<td>Soft lead</td>
<td>3 lb/sq ft</td>
</tr>
<tr>
<td>Aluminum</td>
<td>ASTM B 209, 0.024 minimum thickness for roll-formed panels and 0.019-inch minimum thickness for pressformed shingles.</td>
</tr>
<tr>
<td>Terne (tin) and terne-coated stainless</td>
<td>Terne coating of 40 lb per double base box, field painted where applicable in accordance with manufacturer’s installation instructions.</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.027 inch minimum thickness: 99.995% electrolytic high-grade zinc with alloy additives of copper (0.08 - 0.20%), titanium (0.07% - 0.12%) and aluminum (0.015%).</td>
</tr>
</tbody>
</table>

For SI: 1 ounce per square foot = 0.305 kg/m\(^2\), 1 pound per square foot = 4.214 kg/m\(^2\), 1 inch = 25.4 mm, 1 pound = 0.454 kg.

**TABLE R905.10.3(2)**
MINIMUM CORROSION RESISTANCE

<table>
<thead>
<tr>
<th>MINIMUM CORROSION RESISTANCE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>55% aluminum-zinc alloy coated steel</td>
<td>ASTM A 792 AZ 50</td>
</tr>
<tr>
<td>5% aluminum alloy-coated steel</td>
<td>ASTM A 875 GF60</td>
</tr>
<tr>
<td>Aluminum-coated steel</td>
<td>ASTM A 463 T2 65</td>
</tr>
<tr>
<td>Galvanized steel</td>
<td>ASTM A 653 G-90</td>
</tr>
<tr>
<td>Prepainted steel</td>
<td>ASTM A 755(^a)</td>
</tr>
</tbody>
</table>

\(^a\) Paint systems in accordance with ASTM A 755 shall be applied over steel products with corrosion-resistant coatings complying with ASTM A 792, ASTM A 875, ASTM A 463, or ASTM A 653.

R905.10.4 Attachment.
Metal roof panels shall be secured to the supports in accordance with this chapter and the manufacturer’s installation instructions. In the absence of manufacturer’s installation instructions, the following fasteners shall be used:

1. Galvanized fasteners shall be used for steel roofs.
2. Copper, brass, bronze, copper alloy and 300-series stainless steel fasteners shall be used for copper roofs.

3. Stainless steel fasteners are acceptable for metal roofs.

**R905.10.5 Underlayment.**
Underlayment shall comply with Section R905.1.1.

**R905.11 Modified bitumen roofing.**
The installation of modified bitumen roofing shall comply with the provisions of this section.

**R905.11.1 Slope.**
Modified bitumen membrane roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage.

**R905.11.2 Material standards.**
Modified bitumen roof coverings shall comply with the standards in Table R905.11.2.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic coating</td>
<td>ASTM D 6083</td>
</tr>
<tr>
<td>Asphalt adhesive</td>
<td>ASTM D 3747</td>
</tr>
<tr>
<td>Asphalt cement</td>
<td>ASTM D 3019</td>
</tr>
<tr>
<td>Asphalt coating</td>
<td>ASTM D 1227; D 2824</td>
</tr>
<tr>
<td>Asphalt primer</td>
<td>ASTM D 41</td>
</tr>
<tr>
<td>Modified bitumen roof membrane</td>
<td>ASTM D 6162; D 6163; D 6164; D 6222; D 6223; D 6298; CGSB 37-GP-56M</td>
</tr>
</tbody>
</table>

**R905.11.3 Application.**
Modified bitumen roofs shall be installed in accordance with this chapter and the manufacturer’s instructions.

**R905.12 Thermoset single-ply roofing.**
The installation of thermoset single-ply roofing shall comply with the provisions of this section.

**R905.12.1 Slope.**
Thermoset single-ply membrane roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage.

**R905.12.2 Material standards.**
Thermoset single-ply roof coverings shall comply with ASTM D 4637, ASTM D 5019 or CGSB 37-GP-52M.

**R905.12.3 Application.**
Thermoset single-ply roofs shall be installed in accordance with this chapter and the manufacturer’s instructions.
R905.13 Thermoplastic single-ply roofing.
The installation of thermoplastic single-ply roofing shall comply with the provisions of this section.

R905.13.1 Slope.
Thermoplastic single-ply membrane roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope).

R905.13.2 Material standards.
Thermoplastic single-ply roof coverings shall comply with ASTM D 4434, ASTM D 6754, ASTM D 6878 or CGSB CAN/CGSB 37.54.

R905.13.3 Application.
Thermoplastic single-ply roofs shall be installed in accordance with this chapter and the manufacturer’s instructions.

R905.14 Sprayed polyurethane foam roofing.
The installation of sprayed polyurethane foam roofing shall comply with the provisions of this section.

R905.14.1 Slope.
Sprayed polyurethane foam roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage.

R905.14.2 Material standards.
Spray-applied polyurethane foam insulation shall comply with ASTM C 1029, Type III or IV or ASTM D 7425.

R905.14.3 Application.
Foamed-in-place roof insulation shall be installed in accordance with this chapter and the manufacturer’s instructions. A liquid-applied protective coating that complies with Table R905.14.3 shall be applied not less than 2 hours nor more than 72 hours following the application of the foam.

TABLE R905.14.3
PROTECTIVE COATING MATERIAL STANDARDS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic coating</td>
<td>ASTM D 6083</td>
</tr>
<tr>
<td>Silicone coating</td>
<td>ASTM D 6694</td>
</tr>
<tr>
<td>Moisture-cured polyurethane coating</td>
<td>ASTM D 6947</td>
</tr>
</tbody>
</table>

R905.14.4 Foam plastics.
Foam plastic materials and installation shall comply with Section R316.

R905.15 Liquid-applied roofing.
The installation of liquid-applied roofing shall comply with the provisions of this section.
R905.15.1 Slope.
Liquid-applied roofing shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope).

R905.15.2 Material standards.
Liquid-applied roofing shall comply with ASTM C 836, C 957, D 1227, D 3468, D 6083, D 6694 or D 6947.

R905.15.3 Application.
Liquid-applied roofing shall be installed in accordance with this chapter and the manufacturer’s instructions.

R905.16 Photovoltaic shingles. Deleted.
The installation of photovoltaic shingles shall comply with the provisions of this section, Section R324 and NFPA 70.

R905.16.1 Deck requirements.
Photovoltaic shingles shall be applied to a solid or closely-fitted deck, except where the roof covering is specifically designed to be applied over spaced sheathing.

R905.16.2 Deck slope.
Photovoltaic shingles shall be used only on roof slopes of two units vertical in 12 units horizontal (2:12) or greater.

R905.16.3 Underlayment.
Unless otherwise noted, required underlayment shall conform to ASTM D 4869 or ASTM D6757.

R905.16.4 Underlayment application.
Underlayment shall be applied shingle fashion, parallel to and starting from the eave, lapped 2 inches (51 mm) and fastened sufficiently to hold in place.

R905.16.4.1 Ice barrier.
In areas where there has been a history of ice forming along the eaves causing a backup of water, as designated in Table R301.2(1), an ice barrier that consists of not less than two layers of underlayment cemented together or of a self-adhering polymer modified bitumen sheet shall be used in lieu of normal underlayment and extend from the lowest edges of all roof surfaces to a point not less than 24 inches (610 mm) inside the exterior wall line of the building.

Exception: Detached accessory structures that contain no conditioned floor area.

R905.16.4.2 Underlayment and high winds.
Underlayment applied in areas subject to high winds [above 140 mph (63 m/s), in accordance with Figure R301.2(4)A] shall be applied with corrosion-resistant fasteners in accordance with the manufacturer’s installation instructions. Fasteners are to be applied along the overlap not farther apart than 36 inches (914 mm) on center.

Underlayment installed where the ultimate design wind speed equals or exceeds 150 mph (67 m/s) shall comply with ASTM D 4869 Type IV, or ASTM D 6757. The underlayment shall be attached in a grid pattern of 12 inches (305 mm) between side
laps with a 6-inch (152 mm) spacing at the side laps. Underlayment shall be applied as required for asphalt shingles in accordance with Table R905.1.1(2). Underlayment shall be attached using metal or plastic cap nails with a head diameter of not less than 1-inch (25 mm) with a thickness of not less than 32-gage sheet metal. The cap-nail shank shall be not less than 12-gage (0.105 inches) with a length to penetrate through the roof sheathing or not less than \( \frac{3}{4} \) inch (19 mm) into the roof sheathing.

**Exception:** As an alternative, adhered underlayment complying with ASTM D 1970 shall be permitted.

R905.16.5 Material standards. Photovoltaic shingles shall be listed and labeled in accordance with UL 1703.

R905.16.6 Attachment. Photovoltaic shingles shall be attached in accordance with the manufacturer’s installation instructions.

R905.16.7 Wind resistance. Photovoltaic shingles shall be tested in accordance with procedures and acceptance criteria in ASTM D 3161. Photovoltaic shingles shall comply with the classification requirements of Table R905.2.4.1 for the appropriate maximum basic wind speed. Photovoltaic shingle packaging shall bear a label to indicate compliance with the procedures in ASTM D 3161 and the required classification from Table R905.2.4.1.

SECTION R906 ROOF INSULATION

R906.1 General. The use of above-deck thermal insulation shall be permitted provided such insulation is covered with an approved roof covering and complies with FM 4450 or UL 1256.

R906.2 Material standards. Above-deck thermal insulation board shall comply with the standards in Table R906.2.

**TABLE R906.2 MATERIAL STANDARDS FOR ROOF INSULATION**

<table>
<thead>
<tr>
<th>Material</th>
<th>ASTM Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular glass board</td>
<td>ASTM C 552</td>
</tr>
<tr>
<td>Composite boards</td>
<td>ASTM C 1289, Type III, IV, V or VI</td>
</tr>
<tr>
<td>Expanded polystyrene</td>
<td>ASTM C 578</td>
</tr>
<tr>
<td>Extruded polystyrene board</td>
<td>ASTM C 578</td>
</tr>
<tr>
<td>Perlite board</td>
<td>ASTM C 728</td>
</tr>
<tr>
<td>Polyisocyanurate board</td>
<td>ASTM C 1289, Type I or II</td>
</tr>
<tr>
<td>Wood fiberboard</td>
<td>ASTM C 208</td>
</tr>
<tr>
<td>Fiber-reinforced gypsum board</td>
<td>ASTM C 1278</td>
</tr>
<tr>
<td>Glass-faced gypsum board</td>
<td>ASTM C 1177</td>
</tr>
</tbody>
</table>
SECTION R907
ROOFTOP-MOUNTED PHOTOVOLTAIC SYSTEMS

Deleted

R907.1 Rooftop-mounted photovoltaic systems.
Rooftop-mounted photovoltaic panels or modules shall be installed in accordance with this section, Section R324 and NFPA 70.

R907.2 Wind resistance.
Rooftop-mounted photovoltaic panel or modules systems shall be installed to resist the component and cladding loads specified in Table R301.2(2), adjusted for height and exposure in accordance with Table R301.2(3).

R907.3 Fire classification.
Rooftop-mounted photovoltaic panels or modules shall have the same fire classification as the roof assembly required in Section R902.

R907.4 Installation.
Rooftop-mounted photovoltaic panels or modules shall be installed in accordance with the manufacturer’s instructions.

R907.5 Photovoltaic panels and modules.
Rooftop-mounted photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703 and shall be installed in accordance with the manufacturer’s printed instructions.

SECTION R908
REROOFING

R908.1 General.
Materials and methods of application used for re-covering or replacing an existing roof covering shall comply with the requirements of Chapter 9.

Exceptions:

1. Reroofing shall not be required to meet the minimum design slope requirement of one-quarter unit vertical in 12 units horizontal (2-percent slope) in Section R905 for roofs that provide positive roof drainage.

2. For roofs that provide positive drainage, re-covering or replacing an existing roof covering shall not require the secondary (emergency overflow) drains or scuppers of Section R903.4.1 to be added to an existing roof.

R908.2 Structural and construction loads.
The structural roof components shall be capable of supporting the roof covering system and the material and equipment loads that will be encountered during installation of the roof covering system.
R908.3 Roof replacement.
Roof replacement shall include the removal of existing layers of roof coverings down to the roof deck.

Exception: Where the existing roof assembly includes an ice barrier membrane that is adhered to the roof deck, the existing ice barrier membrane shall be permitted to remain in place and covered with an additional layer of ice barrier membrane in accordance with Section R905.

R908.3.1 Roof re-cover.
The installation of a new roof covering over an existing roof covering shall be permitted where any of the following conditions occur:

1. Where the new roof covering is installed in accordance with the roof covering manufacturer’s approved instructions

2. Complete and separate roofing systems, such as standing-seam metal roof systems, that are designed to transmit the roof loads directly to the building’s structural system and do not rely on existing roofs and roof coverings for support, shall not require the removal of existing roof coverings.

3. Metal panel, metal shingle and concrete and clay tile roof coverings shall be permitted to be installed over existing wood shake roofs where applied in accordance with Section R908.4.

4. The application of a new protective coating over an existing spray polyurethane foam roofing system shall be permitted without tear-off of existing roof coverings.

R908.3.1.1 A roof re-cover shall not be permitted where any of the following conditions occur:

1. Where the existing roof or roof covering is water soaked or has deteriorated to the point that the existing roof or roof covering is not adequate as a base for additional roofing.

2. Where the existing roof covering is slate, clay, cement or asbestos-cement tile.

3. Where the existing roof has two or more applications of any type of roof covering.

R908.4 Roof re-covering.
Where the application of a new roof covering over wood shingle or shake roofs creates a combustible concealed space, the entire existing surface shall be covered with gypsum board, mineral fiber, glass fiber or other approved materials securely fastened in place.

R908.5 Reinstallation of materials.
Existing slate, clay or cement tile shall be permitted for reinstallation, except that damaged, cracked or broken slate or tile shall not be reinstalled. Any existing flashings, edgings, outlets, vents or similar devices that are a part of the assembly shall be replaced where rusted, damaged or deteriorated. Aggregate surfacing materials shall not be reinstalled.
R908.6 Flashings.
Flashings shall be reconstructed in accordance with approved manufacturer’s installation instructions. Metal flashing to which bituminous materials are to be adhered shall be primed prior to installation.

SECTION R909
ROOFTOP-MOUNTED PHOTOVOLTAIC PANEL SYSTEMS

R909.1 General.
The installation of photovoltaic panel systems that are mounted on or above the roof covering shall comply with this section, Section R324 and NFPA 70.

R909.2 Structural requirements.
Rooftop-mounted photovoltaic panel systems shall be designed to structurally support the system and withstand applicable gravity loads in accordance with Chapter 3. The roof upon which these systems are installed shall be designed and constructed to support the loads imposed by such systems in accordance with Chapter 8.

R909.3 Installation.
Rooftop-mounted photovoltaic systems shall be installed in accordance with the manufacturer’s instructions. Roof penetrations shall be flashed and sealed in accordance with this chapter.
CHAPTER 10
CHIMNEYS AND FIREPLACES

SECTION R1001
MASSORY FIREPLACES

R1001.1 General.
Masonry fireplaces shall be constructed in accordance with this section and the applicable provisions of Chapters 3 and 4.

TABLE R1001.1
SUMMARY OF REQUIREMENTS FOR MASONRY FIREPLACES AND CHIMNEYS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>LETTER</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearth slab thickness</td>
<td>A</td>
<td>4”</td>
</tr>
<tr>
<td>Hearth extension (each side of opening)</td>
<td>B</td>
<td>8” fireplace opening &lt; 6 square foot. 12” fireplace opening ≥ 6 square foot.</td>
</tr>
<tr>
<td>Hearth extension (front of opening)</td>
<td>C</td>
<td>16” fireplace opening &lt; 6 square foot. 20” fireplace opening ≥ 6 square foot.</td>
</tr>
<tr>
<td>Hearth slab reinforcing</td>
<td>D</td>
<td>Reinforced to carry its own weight and all imposed loads.</td>
</tr>
<tr>
<td>Thickness of wall of firebox</td>
<td>E</td>
<td>10” solid brick or 8” where a firebrick lining is used. Joints in firebrick 1/4” maximum.</td>
</tr>
<tr>
<td>Distance from top of opening to throat</td>
<td>F</td>
<td>8”</td>
</tr>
<tr>
<td>Smoke chamber wall thickness Unlined walls</td>
<td>G</td>
<td>6” 8”</td>
</tr>
<tr>
<td>Chimney Vertical reinforcing</td>
<td>H</td>
<td>Four No. 4 full-length bars for chimney up to 40² wide. Add two No. 4 bars for each additional 40² or fraction of width or each additional flue.</td>
</tr>
<tr>
<td>Horizontal reinforcing</td>
<td>J</td>
<td>1/4” ties at 18” and two ties at each bend in vertical steel.</td>
</tr>
<tr>
<td>Bond beams</td>
<td>K</td>
<td>No specified requirements.</td>
</tr>
<tr>
<td>Fireplace lintel</td>
<td>L</td>
<td>Noncombustible material.</td>
</tr>
<tr>
<td>Chimney walls with flue lining</td>
<td>M</td>
<td>Solid masonry units or hollow masonry units grouted solid with not less than 4-inch nominal thickness.</td>
</tr>
<tr>
<td>Distances between adjacent flues</td>
<td>—</td>
<td>See Section R1003.13.</td>
</tr>
<tr>
<td>Effective flue area (based on area of fireplace opening)</td>
<td>P</td>
<td>See Section R1003.15.</td>
</tr>
<tr>
<td>Clearances</td>
<td>R</td>
<td>See Sections R1001.11 and R1003.18. See Section R1001.11, Exception 4. 3 at roofline and 2’ at 10’.</td>
</tr>
</tbody>
</table>
| Anchorage | S | 3/16” × 1”  
| --- | --- | --- | 
| Strap Number |  | Two  
| Embedment into chimney Fasten to Bolts |  | 12” hooked around outer bar with 6” extension.  
|  |  | 4 joists  
|  |  | Three 1/2” diameter.  

| Footing Thickness Width | T | 12” min.  
| --- | --- |  
|  |  | 6” each side of fireplace wall.  

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square foot = 0.0929 m².

**Note:** This table provides a summary of major requirements for the construction of masonry chimneys and fireplaces. Letter references are to Figure R1001.1, which shows examples of typical construction. This table does not cover all requirements, nor does it cover all aspects of the indicated requirements. For the actual mandatory requirements of the code, see the indicated section of text.

- a. The letters refer to Figure R1001.1.
- b. Not required in Seismic Design Category A, B or C.
R1001.2 Footings and foundations.
Footings for masonry fireplaces and their chimneys shall be constructed of concrete or solid masonry not less than 12 inches (305 mm) thick and shall extend not less than 6 1/2 inches (152 mm) beyond the face of the fireplace or foundation wall on all sides. Footings shall be founded on natural, undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be not less than 12 inches (305 mm) below finished grade.
R1001.2.1 Ash dump cleanout.
Cleanout openings located within foundation walls below fireboxes, when provided, shall be equipped with ferrous metal or masonry doors and frames constructed to remain tightly closed except when in use. Cleanouts shall be accessible and located so that ash removal will not create a hazard to combustible materials.

R1001.3 Seismic reinforcing. Deleted.
Masonry or concrete chimneys in Seismic Design Category D₀, D₁, or D₂ shall be reinforced.
Reinforcing shall conform to the requirements set forth in Table R1001.1 and Section R606.

R1001.3.1 Vertical reinforcing.
For chimneys up to 40 inches (1016 mm) wide, four No. 4 continuous vertical bars shall be placed between wythes of solid masonry or within the cells of hollow unit masonry and grouted in accordance with Section R606. Grout shall be prevented from bonding with the flue liner so that the flue liner is free to move with thermal expansion. For chimneys more than 40 inches (1016 mm) wide, two additional No. 4 vertical bars shall be provided for each additional flue incorporated into the chimney or for each additional 40 inches (1016 mm) in width or fraction thereof.

R1001.3.2 Horizontal reinforcing.
Vertical reinforcement shall be placed within \( \frac{1}{4} \) inch (6.4 mm) ties, or other reinforcing of equivalent net cross-sectional area, placed in the bed joints in accordance with Section R606 at not less than every 18 inches (457 mm) of vertical height. Two such ties shall be installed at each bend in the vertical bars.

R1001.4 Seismic anchorage. Deleted.
Masonry or concrete chimneys in Seismic Design Category D₀, D₁, or D₂ shall be anchored at each floor, ceiling or roof line more than 6 feet (1829 mm) above grade, except where constructed completely within the exterior walls. Anchorage shall conform to the requirements of Section R1001.4.1.

R1001.4.1 Anchorage.
Two \( \frac{3}{16} \) inch by 1-inch (5 mm by 25 mm) straps shall be embedded not less than 12 inches (305 mm) into the chimney. Straps shall be hooked around the outer bars and extend 6 inches (152 mm) beyond the bend. Each strap shall be fastened to not less than four floor ceiling or floor joists or rafters with two \( \frac{1}{2} \) -inch (12.7 mm) bolts.

R1001.4.1.1 Cold-formed steel framing.
Where cold-formed steel framing is used, the location where the \( \frac{1}{2} \) -inch (12.7 mm) bolts are used to attach the straps to the framing shall be reinforced with not less than a 3-inch \( \times \) 3-inch \( \times \) 0.229-inch (76 mm \( \times \) 76 mm \( \times \) 5.8 mm) steel plate on top of the strap that is screwed to the framing with not fewer than seven No. 6 screws for each bolt.

R1001.5 Firebox walls.
Masonry fireboxes shall be constructed of solid masonry units, hollow masonry units grouted
solid, stone or concrete. Where a lining of firebrick not less than 2 inches (51 mm) thick or other approved lining is provided, the minimum thickness of back and sidewalls shall each be 8 inches (203 mm) of solid masonry, including the lining. The width of joints between firebricks shall not be greater than \( \frac{1}{4} \) inch (6.4 mm). Where a lining is not provided, the total minimum thickness of back and side walls shall be 10 inches (254 mm) of solid masonry. Firebrick shall conform to ASTM C 27 or C 1261 and shall be laid with medium duty refractory mortar conforming to ASTM C 199.

R1001.5.1 Steel fireplace units.
Installation of steel fireplace units with solid masonry to form a masonry fireplace is permitted when installed either in accordance with the requirements of their listing or the requirements of this section. Steel fireplace units incorporating a steel firebox lining shall be constructed with steel not less than \( \frac{1}{4} \) inch (6.4 mm) thick, and an air-circulating chamber that is ducted to the interior of the building. The firebox lining shall be encased with solid masonry to provide a total thickness at the back and sides of not less than 8 inches (203 mm), of which not less than 4 inches (102 mm) shall be of solid masonry or concrete. Circulating air ducts used with steel fireplace units shall be constructed of metal or masonry.

R1001.6 Firebox dimensions.
The firebox of a concrete or masonry fireplace shall have a minimum depth of 20 inches (508 mm). The throat shall not be less than 8 inches (203 mm) above the fireplace opening. The throat opening shall not be less than 4 inches (102 mm) deep. The cross-sectional area of the passageway above the firebox, including the throat, damper and smoke chamber, shall not be less than the cross-sectional area of the flue.

Exception: Rumford fireplaces shall be permitted provided that the depth of the fireplace is not less than 12 inches (305 mm) and not less than one-third of the width of the fireplace opening, that the throat is not less than 12 inches (305 mm) above the lintel and is not less than \( \frac{1}{20} \) the cross-sectional area of the fireplace opening.

R1001.7 Lintel and throat.
Masonry over a fireplace opening shall be supported by a lintel of noncombustible material. The minimum required bearing length on each end of the fireplace opening shall be 4 inches (102 mm). The fireplace throat or damper shall be located not less than 8 inches (203 mm) above the lintel.

R1001.7.1 Damper.
Masonry fireplaces shall be equipped with a ferrous metal damper located not less than 8 inches (203 mm) above the top of the fireplace opening. Dampers shall be installed in the fireplace or the chimney venting the fireplace, and shall be operable from the room containing the fireplace.

R1001.8 Smoke chamber.
Smoke chamber walls shall be constructed of solid masonry units, hollow masonry units grouted solid, stone or concrete. The total minimum thickness of front, back and side walls shall be 8 inches (203 mm) of solid masonry. The inside surface shall be parged smooth with refractory mortar conforming to ASTM C 199. Where a lining of firebrick not less than 2 inches (51 mm)
thick, or a lining of vitrified clay not less than \( \frac{5}{8} \) inch (16 mm) thick, is provided, the total
minimum thickness of front, back and side walls shall be 6 inches (152 mm) of solid masonry,
including the lining. Firebrick shall conform to ASTM C 1261 and shall be laid with medium duty
refractory mortar conforming to ASTM C 199. Vitrified clay linings shall conform to ASTM C 315.

R1001.8.1 Smoke chamber dimensions.
The inside height of the smoke chamber from the fireplace throat to the beginning of the flue
shall not be greater than the inside width of the fireplace opening. The inside surface of the
smoke chamber shall not be inclined more than 45 degrees (0.79 rad) from vertical where
prefabricated smoke chamber linings are used or where the smoke chamber walls are rolled
or sloped rather than corbeled. Where the inside surface of the smoke chamber is formed by
corbeled masonry, the walls shall not be corbeled more than 30 degrees (0.52 rad) from
vertical.

R1001.9 Hearth and hearth extension.
Masonry fireplace hearths and hearth extensions shall be constructed of concrete or masonry,
supported by noncombustible materials, and reinforced to carry their own weight and all
imposed loads. Combustible material shall not remain against the underside of hearths and
hearth extensions after construction.

R1001.9.1 Hearth thickness.
The minimum thickness of fireplace hearths shall be 4 inches (102 mm).

R1001.9.2 Hearth extension thickness.
The minimum thickness of hearth extensions shall be 2 inches (51 mm).

Exception: Where the bottom of the firebox opening is raised not less than 8 inches
(203 mm) above the top of the hearth extension, a hearth extension of not less than \( \frac{3}{8} \) -
inch-thick (10 mm) brick, concrete, stone, tile or other approved noncombustible material
is permitted.

R1001.10 Hearth extension dimensions.
Hearth extensions shall extend not less than 16 inches (406 mm) in front of and not less than 8
inches (203 mm) beyond each side of the fireplace opening. Where the fireplace opening is 6
square feet (0.6 m\(^2\)) or larger, the hearth extension shall extend not less than 20 inches (508
mm) in front of and not less than 12 inches (305 mm) beyond each side of the fireplace opening.

R1001.11 Fireplace clearance.
Wood beams, joists, studs and other combustible material shall have a clearance of not less
than 2 inches (51 mm) from the front faces and sides of masonry fireplaces and not less than 4
inches (102 mm) from the back faces of masonry fireplaces. The airspace shall not be filled,
except to provide fireblocking in accordance with Section R1001.12.

Exceptions:

1. Masonry fireplaces listed and labeled for use in contact with combustibles in
   accordance with UL 127 and installed in accordance with the manufacturer’s
instructions are permitted to have combustible material in contact with their exterior surfaces.

2. Where masonry fireplaces are part of masonry or concrete walls, combustible materials shall not be in contact with the masonry or concrete walls less than 12 inches (306 mm) from the inside surface of the nearest firebox lining.

3. Exposed combustible trim and the edges of sheathing materials such as wood siding, flooring and gypsum board shall be permitted to abut the masonry fireplace sidewalls and hearth extension in accordance with Figure R1001.11, provided such combustible trim or sheathing is not less than 12 inches (305 mm) from the inside surface of the nearest firebox lining.

4. Exposed combustible mantels or trim may be placed directly on the masonry fireplace front surrounding the fireplace opening providing such combustible materials are not placed within 6 inches (152 mm) of a fireplace opening. Combustible material within 12 inches (306 mm) of the fireplace opening shall not project more than \( \frac{1}{8} \) inch (3 mm) for each 1-inch (25 mm) distance from such an opening.

For SI: 1 inch = 25.4 mm.

**FIGURE R1001.11 CLEARANCE FROM COMBUSTIBLES**

**R1001.12 Fireplace fireblocking.**
Fireplace fireblocking shall comply with the provisions of Section R602.8.

**SECTION R1002**
MASONRY HEATERS
**R1002.1 Definition.**
A masonry heater is a heating appliance constructed of concrete or solid masonry, hereinafter referred to as masonry, that is designed to absorb and store heat from a solid-fuel fire built in the firebox by routing the exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox includes flow in a horizontal or downward direction before entering the chimney and that delivers heat by radiation from the masonry surface of the heater.

**R1002.2 Installation.**
Masonry heaters shall be installed in accordance with this section and comply with one of the following:

1. Masonry heaters shall comply with the requirements of ASTM E 1602.

2. Masonry heaters shall be listed and labeled in accordance with UL 1482 or CEN 15250 and installed in accordance with the manufacturer’s instructions.

**R1002.3 Footings and foundation.**
The firebox floor of a masonry heater shall be a minimum thickness of 4 inches (102 mm) of noncombustible material and be supported on a noncombustible footing and foundation in accordance with Section R1003.2.

**R1002.4 Seismic reinforcing.** Deleted.
In Seismic Design Categories D_0, D_1, and D_2, masonry heaters shall be anchored to the masonry foundation in accordance with Section R1003.3. Seismic reinforcing shall not be required within the body of a masonry heater whose height is equal to or less than 3.5 times its body width and where the masonry chimney serving the heater is not supported by the body of the heater. Where the masonry chimney shares a common wall with the facing of the masonry heater, the chimney portion of the structure shall be reinforced in accordance with Section R1003.

**R1002.5 Masonry heater clearance.**
Combustible materials shall not be placed within 36 inches (914 mm) of the outside surface of a masonry heater in accordance with NFPA 211 Section 8-7 (clearances for solid-fuel-burning appliances), and the required space between the heater and combustible material shall be fully vented to permit the free flow of air around all heater surfaces.

**Exceptions:**

1. Where the masonry heater wall is not less than 8 inches (203 mm) thick of solid masonry and the wall of the heat exchange channels is not less than 5 inches (127 mm) thick of solid masonry, combustible materials shall not be placed within 4 inches (102 mm) of the outside surface of a masonry heater. A clearance of not less than 8 inches (203 mm) shall be provided between the gas-tight capping slab of the heater and a combustible ceiling.

2. Masonry heaters listed and labeled in accordance with UL 1482 or CEN 15250 shall be installed in accordance with the listing specifications and the manufacturer’s written instructions.

SECTION R1003
MASONRY CHIMNEYS

R1003.1 Definition.
A masonry chimney is a chimney constructed of *solid masonry* units, hollow masonry units grouted solid, stone or concrete, hereinafter referred to as masonry. Masonry chimneys shall be constructed, anchored, supported and reinforced as required in this chapter.

R1003.2 Footings and foundations.
Footings for masonry chimneys shall be constructed of concrete or *solid masonry* not less than 12 inches (305 mm) thick and shall extend not less than 6 12 inches (152 305 mm) beyond the face of the foundation or support wall on all sides. Footings shall be founded on natural undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be not less than 12 inches (305 mm) below finished grade.

R1003.3 Seismic reinforcing. Deleted.
Masonry or concrete chimneys shall be constructed, anchored, supported and reinforced as required in this chapter. In Seismic Design Category D₀, D₁ or D₂, masonry and concrete chimneys shall be reinforced and anchored as detailed in Sections R1003.3.1, R1003.3.2 and R1003.4. In Seismic Design Category A, B or C, reinforcement and seismic anchorage are not required.

R1003.3.1 Vertical reinforcing.
For chimneys up to 40 inches (1016 mm) wide, four No. 4 continuous vertical bars, anchored in the foundation, shall be placed in the concrete, or between wythes of *solid masonry*, or within the cells of hollow unit masonry, and grouted in accordance with Section R609.1.1. Grout shall be prevented from bonding with the flue liner so that the flue liner is free to move with thermal expansion. For chimneys more than 40 inches (1016 mm) wide, two additional No. 4 vertical bars shall be installed for each additional 40 inches (1016 mm) in width or fraction thereof.

R1003.3.2 Horizontal reinforcing.
Vertical reinforcement shall be placed enclosed within 1/4-inch (6.4 mm) ties, or other reinforcing of equivalent net cross-sectional area, spaced not to exceed 18 inches (457 mm) on center in concrete, or placed in the bed joints of unit masonry, at not less than every 18 inches (457 mm) of vertical height. Two such ties shall be installed at each bend in the vertical bars.

R1003.4 Seismic anchorage. Deleted.
Masonry and concrete chimneys and foundations in Seismic Design Category D₀, D₁ or D₂ shall be anchored at each floor, ceiling or roof line more than 6 feet (1829 mm) above grade, except where constructed completely within the exterior walls. Anchorage shall conform to the requirements in Section R1003.4.1.

R1003.4.1 Anchorage.
Two 3/16-inch by 1-inch (5 mm by 25 mm) straps shall be embedded not less than 12 inches (305 mm) into the chimney. Straps shall be hooked around the outer bars and extend 6
inches (152 mm) beyond the bend. Each strap shall be fastened to not less than four floor joists with two \( \frac{1}{2} \) -inch (12.7 mm) bolts.

**R1003.4.1.1 Cold-formed steel framing.**

Where cold-formed steel framing is used, the location where the \( \frac{1}{2} \) -inch (12.7 mm) bolts are used to attach the straps to the framing shall be reinforced with not less than a 3-inch \( \times \) 3-inch \( \times \) 0.229-inch (76 mm \( \times \) 76 mm \( \times \) 5.8 mm) steel plate on top of a strap that is screwed to the framing with not fewer than seven No. 6 screws for each bolt.

**R1003.5 Corbeling.**

Masonry chimneys shall not be corbeled more than one-half of the chimney's wall thickness from a wall or foundation, nor shall a chimney be corbeled from a wall or foundation that is less than 12 inches (305 mm) thick unless it projects equally on each side of the wall, except that on the second story of a two-story dwelling, corbeling of chimneys on the exterior of the enclosing walls may equal the wall thickness. The projection of a single course shall not exceed one-half the unit height or one-third of the unit bed depth, whichever is less.

**R1003.6 Changes in dimension.**

The chimney wall or chimney flue lining shall not change in size or shape within 6 inches (152 mm) above or below where the chimney passes through floor components, ceiling components or roof components.

**R1003.7 Offsets.**

Where a masonry chimney is constructed with a fireclay flue liner surrounded by one wythe of masonry, the maximum offset shall be such that the centerline of the flue above the offset does not extend beyond the center of the chimney wall below the offset. Where the chimney offset is supported by masonry below the offset in an approved manner, the maximum offset limitations shall not apply. Each individual corbeled masonry course of the offset shall not exceed the projection limitations specified in Section R1003.5.

**R1003.8 Additional load.**

Chimneys shall not support loads other than their own weight unless they are designed and constructed to support the additional load. Construction of masonry chimneys as part of the masonry walls or reinforced concrete walls of the building shall be permitted.

**R1003.9 Termination.**

Chimneys shall extend not less than 2 feet (610 mm) higher than any portion of a building within 10 feet (3048 mm), but shall be not less than 3 feet (914 mm) above the highest point where the chimney passes through the roof.

**R1003.9.1 Chimney caps.**

Masonry chimneys shall have a concrete, metal or stone cap, a drip edge and a caulked bond break around any flue liners in accordance with ASTM C 1283. The concrete, metal or stone cap shall be sloped to shed water.

**R1003.9.2 Spark arrestors.**

Where a spark arrestor is installed on a masonry chimney, the spark arrestor shall meet all of the following requirements:
1. The net free area of the arrestor shall be not less than four times the net free area of the outlet of the chimney flue it serves.

2. The arrestor screen shall have heat and corrosion resistance equivalent to 19-gage galvanized steel or 24-gage stainless steel.

3. Openings shall not permit the passage of spheres having a diameter greater than \( \frac{1}{2} \) inch (12.7 mm) nor block the passage of spheres having a diameter less than \( \frac{3}{8} \) inch (9.5 mm).

4. The spark arrestor shall be accessible for cleaning and the screen or chimney cap shall be removable to allow for cleaning of the chimney flue.

R1003.9.3 Rain caps.
Where a masonry or metal rain cap is installed on a masonry chimney, the net free area under the cap shall be not less than four times the net free area of the outlet of the chimney flue it serves.

R1003.10 Wall thickness.
Masonry chimney walls shall be constructed of solid masonry units or hollow masonry units grouted solid with not less than a 4-inch (102 mm) nominal thickness.

R1003.10.1 Masonry veneer chimneys.
Where masonry is used to veneer a frame chimney, through-flashing and weep holes shall be installed as required by Section R703.

R1003.11 Flue lining (material).
Masonry chimneys shall be lined. The lining material shall be appropriate for the type of appliance connected, in accordance with the terms of the appliance listing and manufacturer's instructions.

R1003.11.1 Residential-type appliances (general).
Flue lining systems shall comply with one of the following:

1. Clay flue lining complying with the requirements of ASTM C 315.

2. Listed and labeled chimney lining systems complying with UL 1777.

3. Factory-built chimneys or chimney units listed for installation within masonry chimneys.

4. Other approved materials that will resist corrosion, erosion, softening or cracking from flue gases and condensate at temperatures up to 1,800°F (982°C).

R1003.11.2 Flue linings for specific appliances.
Flue linings other than those covered in Section R1003.11.1, intended for use with specific types of appliances, shall comply with Sections R1003.11.3 through R1003.11.6.
R1003.11.3 Gas appliances.
Flue lining systems for gas *appliances* shall be in accordance with Chapter 24.

R1003.11.4 Pellet fuel-burning appliances.
Flue lining and vent systems for use in masonry chimneys with pellet fuel-burning *appliances* shall be limited to the following:

1. Flue lining systems complying with Section R1003.11.1.

2. Pellet vents listed for installation within masonry chimneys (see Section R1003.11.6 for marking).

R1003.11.5 Oil-fired appliances approved for use with Type L vent.
Flue lining and vent systems for use in masonry chimneys with oil-fired *appliances* approved for use with Type L vent shall be limited to the following:

1. Flue lining systems complying with Section R1003.11.1.

2. Listed chimney liners complying with UL 641 (see Section R1003.11.6 for marking).

R1003.11.6 Notice of usage.
When a flue is relined with a material not complying with Section R1003.11.1, the chimney shall be plainly and permanently identified by a *label* attached to a wall, ceiling or other conspicuous location adjacent to where the connector enters the chimney. The *label* shall include the following message or equivalent language:

```
THIS CHIMNEY FLUE IS FOR USE ONLY WITH [TYPE OR CATEGORY OF APPLIANCE] APPLIANCES THAT BURN [TYPE OF FUEL]. DO NOT CONNECT OTHER TYPES OF APPLIANCES.
```

R1003.12 Clay flue lining (installation).
Clay flue liners shall be installed in accordance with ASTM C 1283 and extend from a point not less than 8 inches (203 mm) below the lowest inlet or, in the case of fireplaces, from the top of the smoke chamber to a point above the enclosing walls. The lining shall be carried up vertically, with a maximum slope not greater than 30 degrees (0.52 rad) from the vertical.

Clay flue liners shall be laid in medium-duty water insoluble refractory mortar conforming to ASTM C 199 *(Types M and S)* with tight mortar joints left smooth on the inside and installed to maintain an airspace or insulation not to exceed the thickness of the flue liner separating the flue liners from the interior face of the chimney masonry walls. Flue liners shall be supported on all sides. Only enough mortar shall be placed to make the joint and hold the liners in position.

R1003.12.1 Listed materials.
*Listed* materials used as flue linings shall be installed in accordance with the terms of their listings and manufacturer’s instructions.

R1003.12.2 Space around lining.
The space surrounding a chimney lining system or vent installed within a masonry chimney shall not be used to vent any other *appliance*. 
Exception: This shall not prevent the installation of a separate flue lining in accordance with the manufacturer’s instructions.

R1003.13 Multiple flues.
Where two or more flues are located in the same chimney, masonry wythes shall be built between adjacent flue linings. The masonry wythes shall be not less than 4 inches (102 mm) thick and bonded into the walls of the chimney.

Exception: Where venting only one appliance, two flues shall be permitted to adjoin each other in the same chimney with only the flue lining separation between them. The joints of the adjacent flue linings shall be staggered not less than 4 inches (102 mm).

R1003.14 Flue area (appliance).
Chimney flues shall not be smaller in area than that of the area of the connector from the appliance [see Tables R1003.14(1) and R1003.14(2)]. The sizing of a chimney flue to which multiple appliance venting systems are connected shall be in accordance with Section M1805.3.

**TABLE R1003.14(1)**
NET CROSS-SECTIONAL AREA OF ROUND FLUE SIZES

<table>
<thead>
<tr>
<th>FLUE SIZE, INSIDE DIAMETER (inches)</th>
<th>CROSS-SECTIONAL AREA (square inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>28</td>
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<tr>
<td>7</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>78</td>
</tr>
<tr>
<td>10 3/4</td>
<td>90</td>
</tr>
<tr>
<td>12</td>
<td>113</td>
</tr>
<tr>
<td>15</td>
<td>176</td>
</tr>
<tr>
<td>18</td>
<td>254</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm

a. Flue sizes are based on ASTM C 315.

**TABLE R1003.14(2)**
NET CROSS-SECTIONAL AREA OF SQUARE AND RECTANGULAR FLUE SIZES

<table>
<thead>
<tr>
<th>FLUE SIZE, OUTSIDE NOMINAL DIMENSIONS (inches)</th>
<th>CROSS-SECTIONAL AREA (square inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 × 8.5</td>
<td>23</td>
</tr>
<tr>
<td>4.5 × 13</td>
<td>34</td>
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<tr>
<td>8 × 8</td>
<td>42</td>
</tr>
<tr>
<td>8.5 × 8.5</td>
<td>49</td>
</tr>
<tr>
<td>8 × 12</td>
<td>67</td>
</tr>
<tr>
<td>8.5 × 13</td>
<td>76</td>
</tr>
<tr>
<td>Flue Size</td>
<td>R Value</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>12 x 12</td>
<td>102</td>
</tr>
<tr>
<td>8.5 x 18</td>
<td>101</td>
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<tr>
<td>20 x 24</td>
<td>335</td>
</tr>
<tr>
<td>24 x 24</td>
<td>431</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm$^2$

**R1003.15 Flue area (masonry fireplace).**

Flue sizing for chimneys serving fireplaces shall be in accordance with Section R1003.15.1 or R1003.15.2.

**R1003.15.1 Option 1.**

Round chimney flues shall have a minimum net cross-sectional area of not less than $\frac{1}{12}$ of the fireplace opening. Square chimney flues shall have a minimum net cross-sectional area of $\frac{1}{10}$ of the fireplace opening. Rectangular chimney flues with an aspect ratio less than 2 to 1 shall have a minimum net cross-sectional area of $\frac{1}{8}$ of the fireplace opening. Rectangular chimney flues with an aspect ratio of 2 to 1 or more shall have a minimum net cross-sectional area of $\frac{1}{10}$ of the fireplace opening. Cross-sectional areas of clay flue linings are shown in Tables R1003.14(1) and R1003.14(2) or as provided by the manufacturer or as measured in the field.

**R1003.15.2 Option 2.**

The minimum net cross-sectional area of the chimney flue shall be determined in accordance with Figure R1003.15.2. A flue size providing not less than the equivalent net cross-sectional area shall be used. Cross-sectional areas of clay flue linings are shown in Tables R1003.14(1) and R1003.14(2) or as provided by the manufacturer or as measured in the field. The height of the chimney shall be measured from the firebox floor to the top of the chimney flue.
FIGURE R1003.15.2
FLUE SIZES FOR MASONRY CHIMNEYS

R1003.16 Inlet.
Inlets to masonry chimneys shall enter from the side. Inlets shall have a thimble of fireclay, rigid refractory material or metal that will prevent the connector from pulling out of the inlet or from extending beyond the wall of the liner.

R1003.17 Masonry chimney cleanout openings.
Cleanout openings shall be provided within 6 inches (152 mm) of the base of each flue within every masonry chimney. The upper edge of the cleanout shall be located not less than 6 inches (152 mm) below the lowest chimney inlet opening. The height of the opening shall be not less than 6 inches (152 mm). The cleanout shall be provided with a noncombustible cover.
Exception: Chimney flues serving masonry fireplaces where cleaning is possible through the fireplace opening.

R1003.18 Chimney clearances.
Any portion of a masonry chimney located in the interior of the building or within the exterior wall of the building shall have a minimum airspace clearance to combustibles of 2 inches (51 mm). Chimneys located entirely outside the exterior walls of the building, including chimneys that pass through the soffit or cornice, shall have a minimum airspace clearance of 1 inch (25 mm). The airspace shall not be filled, except to provide fire blocking in accordance with Section R1003.19.

Exceptions:

1. Masonry chimneys equipped with a chimney lining system listed and labeled for use in chimneys in contact with combustibles in accordance with UL 1777 and installed in accordance with the manufacturer’s instructions are permitted to have combustible material in contact with their exterior surfaces.

2. Where masonry chimneys are constructed as part of masonry or concrete walls, combustible materials shall not be in contact with the masonry or concrete wall less than 12 inches (305 mm) from the inside surface of the nearest flue lining.

3. Exposed combustible trim and the edges of sheathing materials, such as wood siding and flooring, shall be permitted to abut the masonry chimney side walls, in accordance with Figure R1003.18, provided such combustible trim or sheathing is not less than 8 inches (203 mm) from the inside surface of the nearest flue lining.

For SI: 1 inch = 25.4 mm.

FIGURE R1003.18
CLEARANCE FROM COMBUSTIBLES

R1003.19 Chimney fireblocking.
Spaces between chimneys and floors and ceilings through which chimneys pass shall be fireblocked with noncombustible material securely fastened in place. The fireblocking of spaces between chimneys and wood joists, beams or headers shall be self-supporting or be placed on
strips of metal or metal lath laid across the spaces between combustible material and the chimney.

**R1003.20 Chimney crickets.**
Chimneys shall be provided with crickets where the dimension parallel to the ridgeline is greater than 30 inches (762 mm) and does not intersect the ridgeline. The intersection of the cricket and the chimney shall be flashed and counterflashed in the same manner as normal roof-chimney intersections. Crickets shall be constructed in compliance with Figure R1003.20 and Table R1003.20.

<table>
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<tr>
<th>ROOF SLOPE</th>
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</tr>
<tr>
<td>3 - 12</td>
<td>( \frac{1}{8} ) of W</td>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm.

**FIGURE R1003.20**
CHIMNEY CRICKET

SECTION R1004
FACTORY-BUILT FIREPLACES
R1004.1 General.
Factory-built fireplaces shall be listed and labeled and shall be installed in accordance with the conditions of the listing. Factory-built fireplaces shall be tested in accordance with UL 127.

R1004.2 Hearth extensions.
Hearth extensions of approved factory-built fireplaces shall be installed in accordance with the listing of the fireplace. The hearth extension shall be readily distinguishable from the surrounding floor area. Listed and labeled hearth extensions shall comply with UL 1618.

R1004.3 Decorative shrouds.
Decorative shrouds shall not be installed at the termination of chimneys for factory-built fireplaces except where the shrouds are listed and labeled for use with the specific factory-built fireplace system and installed in accordance with the manufacturer's instructions.

R1004.4 Unvented gas log heaters.
An unvented gas log heater shall not be installed in a factory-built fireplace unless the fireplace system has been specifically tested, listed and labeled for such use in accordance with UL 127.

R1004.5 Gasketed fireplace doors.
A gasketed fireplace door shall not be installed on a factory-built fireplace except where the fireplace system has been specifically tested, listed and labeled for such use in accordance with UL 127.

SECTION R1005
FACTORY-BUILT CHIMNEYS

R1005.1 Listing.
Factory-built chimneys shall be listed and labeled and shall be installed and terminated in accordance with the manufacturer's instructions.

R1005.2 Decorative shrouds.
Decorative shrouds shall not be installed at the termination of factory-built chimneys except where the shrouds are listed and labeled for use with the specific factory-built chimney system and installed in accordance with the manufacturer's instructions.

R1005.3 Solid-fuel appliances.
Factory-built chimneys installed in dwelling units with solid-fuel-burning appliances shall comply with the Type HT requirements of UL 103 and shall be marked “Type HT and “Residential Type and Building Heating Appliance Chimney.”

Exception: Chimneys for use with open combustion chamber fireplaces shall comply with the requirements of UL 103 and shall be marked “Residential Type and Building Heating Appliance Chimney.”

Chimneys for use with open combustion chamber appliances installed in buildings other than dwelling units shall comply with the requirements of UL 103 and shall be marked “Building Heating Appliance Chimney” or “Residential Type and Building Heating Appliance Chimney.”
R1005.4 Factory-built fireplaces.
Chimneys for use with factory-built fireplaces shall comply with the requirements of UL 127.

R1005.5 Support.
Where factory-built chimneys are supported by structural members, such as joists and rafters, those members shall be designed to support the additional load.

R1005.6 Medium-heat appliances.
Factory-built chimneys for medium-heat appliances producing flue gases having a temperature above 1,000°F (538°C), measured at the entrance to the chimney, shall comply with UL 959.

R1005.7 Factory-built chimney offsets.
Where a factory-built chimney assembly incorporates offsets, no part of the chimney shall be at an angle of more than 30 degrees (0.52 rad) from vertical at any point in the assembly and the chimney assembly shall not include more than four elbows.

SECTION R1006
EXTERIOR AIR SUPPLY

R1006.1 Exterior air.
Factory-built or masonry fireplaces covered in this chapter shall be equipped with an exterior air supply to ensure proper fuel combustion unless the room is mechanically ventilated and controlled so that the indoor pressure is neutral or positive.

R1006.1.1 Factory-built fireplaces.
Exterior combustion air ducts for factory-built fireplaces shall be a listed component of the fireplace and shall be installed in accordance with the fireplace manufacturer’s instructions.

R1006.1.2 Masonry fireplaces.
Listed combustion air ducts for masonry fireplaces shall be installed in accordance with the terms of their listing and the manufacturer’s instructions.

R1006.2 Exterior air intake.
The exterior air intake shall be capable of supplying all combustion air from the exterior of the dwelling or from spaces within the dwelling ventilated with outdoor air such as nonmechanically ventilated crawl or attic spaces. The exterior air intake shall not be located within the garage or basement of the dwelling. The exterior air intake, for other than listed factory-built fireplaces, shall not be located at an elevation higher than the firebox. The exterior air intake shall be covered with a corrosion-resistant screen of 1/4-inch (6.4 mm) mesh.

R1006.3 Clearance.
Unlisted combustion air ducts shall be installed with a minimum 1-inch (25 mm) clearance to combustibles for all parts of the duct within 5 feet (1524 mm) of the duct outlet.

R1006.4 Passageway.
The combustion air passageway shall be not less than 6 square inches (3870 mm²) and not more than 55 square inches (0.035 m²), except that combustion air systems for listed fireplaces shall be constructed in accordance with the fireplace manufacturer’s instructions.
R1006.5 Outlet.
The exterior air outlet shall be located in the back or side of the firebox chamber or shall be located outside of the firebox, at the level of the hearth and not greater than 24 inches (610 mm) from the firebox opening. The outlet shall be closable and designed to prevent burning material from dropping into concealed combustible spaces.
Part IV—Energy Conservation

CHAPTER 11 [RE]
ENERGY EFFICIENCY

SECTION N1101
GENERAL

N1101.1 Scope.
This chapter regulates the energy efficiency for the design and construction of buildings regulated by this code.

Note: The text of the following Sections N1101.2 through N1105 is extracted from the 2012 2018 edition of the International North Carolina Energy Conservation Code—Residential Provisions and has been editorially revised to conform to the scope and application of this code. The section numbers appearing in parenthesis after each section number are the section numbers of the corresponding text in the International North Carolina Energy Conservation Code—Residential Provisions.

N1101.2 (R101.3) Intent.
This chapter shall regulate the design and construction of buildings for the effective use and conservation of energy over the useful life of each building. This chapter is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this objective. This chapter is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

N1101.3 (R101.5.1) Compliance materials.
The building official shall be permitted to approve specific computer software, worksheets, compliance manuals and other similar materials that meet the intent of this code.

N1101.4 (R102.1.1) Above code programs. Deleted.
The building official or other authority having jurisdiction shall be permitted to deem a national, state or local energy-efficiency program to exceed the energy-efficiency required by this code. Buildings approved in writing by such an energy-efficiency program shall be considered in compliance with this code. The requirements identified as “mandatory” in this chapter, as applicable, shall be met.

N1101.5 (R103.2) Information on construction documents. Deleted.
Construction documents shall be drawn to scale upon suitable material. Electronic media documents are permitted to be submitted when approved by the building official. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, as applicable:

1. Insulation materials and their R-values.
2. Fenestration $U$-factors and SHGCs.

3. Area-weighted $U$-factor and SHGC calculations.

4. Mechanical system design criteria.

5. Mechanical and service water heating system and equipment types, sizes and efficiencies.

6. Equipment and system controls.

7. Duct sealing, duct and pipe insulation and location.

8. Air sealing details.

**N1101.5.1 (R103.2.1) Thermal envelope depiction.** Deleted.  
The building’s thermal envelope shall be represented on the construction drawings.

**N1101.6 (R202) Defined terms.** Deleted. See Chapter 2.  
The following words and terms shall, for the purposes of this chapter, have the meanings shown herein:

**ABOVE-GRADE WALL.** A wall more than 50 percent above grade and enclosing conditioned space. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

**ACCESSIBLE.** Admitting close approach as a result of not being guarded by locked doors, elevation or other effective means (see “Readily accessible”).

**ADDITION.** An extension or increase in the conditioned space floor area or height of a building or structure.

**AIR BARRIER.** Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.

**ALTERATION.** Any construction, retrofit or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a building, electrical, gas, mechanical or plumbing system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.

**AUTOMATIC.** Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature or mechanical configuration (see “Manual”).

**BASEMENT WALL.** A wall 50 percent or more below grade and enclosing conditioned space.
BUILDING. Any structure used or intended for supporting or sheltering any use or occupancy, including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building.

BUILDING SITE. A contiguous area of land that is under the ownership or control of one entity.

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floor, roof and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

C-FACTOR (THERMAL CONDUCTANCE). The coefficient of heat transmission (surface to surface) through a building component or assembly, equal to the time rate of heat flow per unit area and the unit temperature difference between the warm side and cold side surfaces (Btu/h·ft²·°F)[W/(m²·K)].

CIRCULATING HOT WATER SYSTEM. A specifically designed water distribution system where one or more pumps are operated in the service hot water piping to circulate heated water from the water-heating equipment to fixtures and back to the water-heating equipment.

CLIMATE ZONE. A geographical region based on climatic criteria as specified in this code.

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the conditioned space.

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and that is directly heated or cooled or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

CONTINUOUS AIR BARRIER. A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior, or is integral to any opaque surface, of the building envelope.

CRAWL SPACE WALL. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

CURTAIN WALL. Fenestration products used to create an external nonload-bearing wall that is designed to separate the exterior and interior environments.

DEMAND RECIRCULATION WATER SYSTEM. A water distribution system where pump(s) prime the service hot water piping with heated water upon demand for hot water.

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.
DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

ENERGY ANALYSIS. A method for estimating the annual energy use of the proposed design and standard reference design based on estimates of energy use.

ENERGY COST. The total estimated annual cost for purchased energy for the building functions regulated by this code, including applicable demand charges.

ENERGY SIMULATION TOOL. An approved software program or calculation-based methodology that projects the annual energy use of a building.

ERI REFERENCE DESIGN. A version of the rated design that meets the minimum requirements of the 2006 International Energy Conservation Code.

EXTERIOR WALL. Walls including both above-grade walls and basement walls.

FENESTRATION. Products classified as either vertical fenestration or skylights.

FENESTRATION PRODUCT, SITE-BUILT. A fenestration designed to be made up of field-glazed or field-assembled units using specific factory cut or otherwise factory-formed framing and glazing units. Examples of site-built fenestration include storefront systems, curtain walls, and atrium roof systems.

FENESTRATION, VERTICAL. Windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of at least 60 degrees (1.05 rad) from horizontal.

HEATED SLAB. Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab.

HIGH-EFFICACY LAMPS. Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

1. 60 lumens per watt for lamps over 40 watts;

2. 50 lumens per watt for lamps over 15 watts to 40 watts; and

3. 40 lumens per watt for lamps 15 watts or less.

HISTORIC BUILDING. Buildings that are listed in or eligible for listing in the National Register of Historic Places, or designated as historic under an appropriate state or local law.

INFILTRATION. The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INSULATED SIDING. A type of continuous insulation with manufacturer-installed insulating material as an integral part of the cladding product having a minimum R-value of R-2.
INSULATING SHEATHING. An insulating board with a core material having a minimum R-value of R-2.

LOW-VOLTAGE LIGHTING. Lighting equipment powered through a transformer such as a cable conductor, a rail conductor and track lighting.

MANUAL. Capable of being operated by personal intervention (see “Automatic”).

PROPOSED DESIGN. A description of the proposed building used to estimate annual energy use for determining compliance based on total building performance.

RATED DESIGN. A description of the proposed building used to determine the energy rating index.

READILY ACCESSIBLE. Capable of being reached quickly for operation, renewal or inspection without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders or access equipment (see “Accessible”).

REPAIR. The reconstruction or renewal of any part of an existing building for the purpose of its maintenance or to correct damage. For definitions applicable in Chapter 11, see Section N1.101.9.

REROOFING. The process of recovering or replacing an existing roof covering. See “Roof recover” and “Roof replacement.”

RESIDENTIAL BUILDING. For this chapter, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses) as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.

ROOF RECOVER. The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering.

ROOF REPAIR. Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance.

ROOF REPLACEMENT. The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering.

R-VALUE (THERMAL RESISTANCE). The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area \((h·\text{ft}^2·\text{°F}/\text{Btu})/\text{(m}^2\cdot\text{K})/\text{W}\).

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

SKYLIGHT. Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition.
**SOLAR HEAT GAIN COEFFICIENT (SHGC).** The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation that is then reradiated, conducted or convected into the space.

**STANDARD REFERENCE DESIGN.** A version of the proposed design that meets the minimum requirements of this code and is used to determine the maximum annual energy use requirement for compliance based on total building performance.

**SUNROOM.** A one-story structure attached to a dwelling with a glazing area in excess of 40 percent of the gross area of the structure’s exterior walls and roof.

**THERMAL ISOLATION.** Physical and space conditioning separation from conditioned space(s). The conditioned space(s) shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.

**THERMOSTAT.** An automatic control device used to maintain temperature at a fixed or adjustable set point.

**U-FACTOR (THERMAL TRANSMITTANCE).** The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films \((\text{Btu/h·ft}^2·\text{°F})[\text{W/(m}^2·\text{K})]\).

**VENTILATION AIR.** That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

**VISIBLE TRANSMITTANCE [VT].** The ratio of visible light entering the space through the fenestration product assembly to the incident visible light. Visible Transmittance, includes the effects of glazing material and frame and is expressed as a number between 0 and 1.

**WHOLE HOUSE MECHANICAL VENTILATION SYSTEM.** An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air with outdoor air when operating continuously or through a programmed intermittent schedule to satisfy the whole house ventilation rates.

**ZONE.** A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.

**N1101.7 (R301.1) Climate zones.** Climate zones from Figure N1101.7 or Table N1101.7 shall be used in determining the applicable requirements in Sections N1101 through N1111. Locations not in Table N1101.7 (outside the United States) shall be assigned a climate zone based on Section N101.10.2.
Warm and humid counties are below the dashed line.

FIGURE N1101.7 (R301.1) CLIMATE ZONES

TABLE N1101.7 (R301.1) CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID
DESIGNATIONS BY STATE, COUNTY AND TERRITORY

Key: A – Moist, B—Dry, C—Marine. Absence of moisture designation indicates moisture regime is irrelevant. Asterisk (*) indicates a warm-humid location.

US STATES BY COUNTY

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(continued)

**TABLE N1101.7 (R301.1)—continued**

**CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY**

<p>| 4C-Humboldt | 3B-Yuba | 5B-Morgan | 2A-Flagler* | 2A-Union* |
| 2B-Imperial | COLORADO | 4B-Otero | 2A-Franklin* | 2A-Volusia* |
| 4B-Inyo | 5B-Adams | 6B-Ouray | 2A-Gadsden* | 2A-Wakulla* |
| 3B-Kern | 6B-Alamosa | 5B-Phillips | 2A-Gilchrist* | 2A-Walton* |
| 3B-Kings | 5B-Arapahoe | 7-Pitkin | 2A-Glades* | 2A-Washington* |
| 4B-Lake | 5B-Archipela | 5B-Prowers | 2A-Gulf* | GEORGIA |
| 5B-Lassen | 6B-Archipela | 5B-Pueblo | 2A-Hamilton* | 2A-Appling* |
| 3B-Los-Angeles | 4B-Baca | 5B-Rio-Blanco | 2A-Hardee* | 2A-Hendry* |
| 3B-Madera | 5B-Bent | 5B-Rio-Grande | 2A-Hendry* | 2A-Atkinson* |
| 3C-Marin | 5B-Boulder | 7-Reutt | 2A-Hernando* | 2A-Bacon* |
| 4B-Mariposa | 5B-Broomfield | 5B-Hillsborough* | 2A-Highlands* | 2A-Baker* |
| 3C-Mendocino | 6B-Chaffee | 6B-Saguache | 2A-Hillsborough* | 3A-Baldwin |
| 3B-Merced | 5B-Cheyenne | 7-San-Juan | 2A-Holmes* | 4A-Banks |
| 5B-Mendoc | 7-Clear-Creek | 6B-San-Miguel | 2A-Indian River* | 3A-Barrow |
| 6B-Mono | 6B-Conejos | 5B-Sedgewick | 2A-Jackson* | 3A-Bartow |
| 3C-Monterey | 6B-Costilla | 7-Summit | 2A-Jefferson* | 3A-Ben-Hill* |
| 3C-Napa | 5B-Crowley | 5B-Teller | 2A-Lafayette* | 2A-Berrien* |
| 5B-Nevada | 6B-Custer | 5B-Washington | 2A-Lake* | 3A-Bibb |
| 3B-Orange | 5B-Delta | 5B-Weld | 2A-Lee* | 3A-Bleckley* |
| 3B-Placer | 5B-Denver | 5B-Yuma | 2A-Leon* | 2A-Brantley* |
| 5B-Plumas | 6B-Dolores | CONNECTICUT | 2A-Levy* | 2A-Brooks* |</p>
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<td>CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY</td>
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| 5A-Mclean | 5A-Boone | 5A-Miami | 5A-Appanoose | 5A-Jasper |

2018 North Carolina Residential Code
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**INDIANA**

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2018 North Carolina Residential Code
TABLE N1101.7 (R301.1)—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID
DESIGNATIONS BY STATE, COUNTY AND TERRITORY

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**MARYLAND**

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 TABLE N1101.7 (R301.1)—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID
DESIGNATIONS BY STATE, COUNTY AND TERRITORY

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**TABLE N1101.7 (R301.1)—continued**

CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY
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2018 North Carolina Residential Code
(continued)

TABLE N1101.7 (R301.1)—continued
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID
DESIGNATIONS BY STATE, COUNTY AND TERRITORY

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<th>Warm-Humid Designation</th>
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2018 North Carolina Residential Code
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TABLE N1101.7 (R301.1)—continued

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### Table N1101.7 (R301.1)—continued

CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY

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| 4A.Allemand* | 6A.Aurora | 5A.Mellette | 4A.Centennial | 4A.Fentress | 4A.Putnam |
| 3A.Amanda | 6A.Beadle | 6A.Miner | 4A.Franklin | 4A.Rhea |
| 3A.Burnet* | 3B.Campbell | 3B.Carroll | 3B.Cherokee | 3B.Chauteau |
| 3A.Henderson | 3A.Hidalgo | 3A.Lamar | 3A.Las Colinas | 3A.Las Vegas |
| 3A.Liberty | 3A.Maricopa | 3A.Maricopa | 3A.Marietta | 3A.Marietta |
| 3A.Mesa | 3A.Pima | 3A.Pima | 3A.Pima | 3A.Pima |
| 3A.Pinal | 3A.Pinal | 3A.Pinal | 3A.Pinal | 3A.Pinal |
| 3A.Russell | 3A.Santa Cruz | 3A.Santa Cruz | 3A.Santa Cruz | 3A.Santa Cruz |
| 3A.Tempe | 3A.Tempe | 3A.Tempe | 3A.Tempe | 3A.Tempe |
| 3A.Wickenburg | 3A.Wickenburg | 3A.Wickenburg | 3A.Wickenburg | 3A.Wickenburg |
| 3A.Yavapai | 3A.Yavapai | 3A.Yavapai | 3A.Yavapai | 3A.Yavapai |

#### Texas

| 2A.Colorado* | 3A.GRAYSON | 2A.Kleberg* | 3A.Panola* |
| 4A.Wilson | 3B.Collingsworth | 4B.Gray | 2B.Kinney | 3A.Palo Pinto* |
| 2A.California | 3A.Graceland | 2A.Kleberg* | 3A.Panola* |
| 4A.Wilson | 3B.Collingsworth | 4B.Gray | 2B.Kinney | 3A.Palo Pinto* |
| 2A.Colorado* | 3A.GRAYSON | 2A.Kleberg* | 3A.Panola* |
TABLE N1101.7 (R301.1)—continued

CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE, COUNTY AND TERRITORY

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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A-Wilson*</td>
<td></td>
<td>WASHINGTON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3B-Winkler</td>
<td>5B-Adams</td>
<td>4A-Calphoun</td>
<td>4A-Wirt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3A-Wise</td>
<td>5B-Aso tin</td>
<td>4B-Clay</td>
<td>4A-Wood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3A-Wood*</td>
<td>5B-Benton</td>
<td>5A-Doddridge</td>
<td>4A-Wyoming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4B-Yoakum</td>
<td>5B-Chelan</td>
<td>5A-Fayette</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continued)
N1101.7.1 (R301.2) Warm humid counties.
Warm humid counties are identified in Table N1101.7 by an asterisk.

N1101.7.2 (R301.3) International climate zones. Deleted.
The climate zone for any location outside the United States shall be determined by applying Table N1101.7.2(1) and then Table N1101.7.2(2).

**TABLE N1101.7.2(1)[R302.3(1)]
INTERNATIONAL CLIMATE ZONE DEFINITIONS**

<table>
<thead>
<tr>
<th>ZONE NUMBER</th>
<th>THERMAL CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IP Units</td>
</tr>
<tr>
<td></td>
<td>9000 &lt; CDD50°F</td>
</tr>
<tr>
<td>2</td>
<td>6300 &lt; CDD50°F ≤ 9000</td>
</tr>
<tr>
<td>3A and 3B</td>
<td>4500 &lt; CDD50°F ≤ 6300 AND HDD65°F ≤ 5400</td>
</tr>
<tr>
<td>4A and 4B</td>
<td>CDD50°F ≤ 4500 AND HDD65°F ≤ 5400</td>
</tr>
</tbody>
</table>

For SI:°C = [(°F) - 32] / 1.8, 1 inch = 2.54 cm.
### 2018 North Carolina Residential Code

#### N1101.8 (R301.4) Tropical climate zone. Deleted.
The tropical climate zone shall be defined as:

1. Hawaii, Puerto Rico, Guam, American Samoa, US Virgin Islands, Commonwealth of Northern Mariana Islands; and

2. Islands in the area between the Tropic of Cancer and the Tropic of Capricorn.

#### N1101.9 (R302.1) Interior design conditions.
The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

#### N1101.10 (R303.1) Identification.
Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

##### N1101.10.1 (R303.1.1) Building thermal envelope insulation.
An \( R \)-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and \( R \)-value of insulation installed in each element of the *building thermal envelope*. For blown or sprayed insulation (fiberglass and cellulose), the initial installed thickness, settled thickness, settled \( R \)-value, installed density, coverage area and number of bags installed shall be listed on the certification. For insulated siding, the \( R \)-value shall be labeled on the product’s package and shall be listed on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

##### N1101.10.1.1 (R303.1.1.1) Blown or sprayed roof/ceiling insulation.
The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed at least one for every 300 square feet (28 m\(^2\)) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers not less than 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed \( R \)-value shall be listed on certification provided by the insulation installer.

##### N1101.10.2 (R303.1.2) Insulation mark installation.
Insulating materials shall be installed such that the manufacturer’s \( R \)-value mark is readily observable upon inspection.

---

### Table: Degree Days

<table>
<thead>
<tr>
<th>HDD65°F</th>
<th>HDD18°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3600</td>
<td>&lt; 2000</td>
</tr>
<tr>
<td>3600 ≤ 5400</td>
<td>2000 ≤ 3000</td>
</tr>
<tr>
<td>5400 ≤ 7200</td>
<td>3000 ≤ 4000</td>
</tr>
<tr>
<td>7200 ≤ 9000</td>
<td>4000 ≤ 5000</td>
</tr>
<tr>
<td>9000 ≤ 12600</td>
<td>5000 ≤ 7000</td>
</tr>
<tr>
<td>12600 ≤ HDD65°F</td>
<td>HDD18°C ≤ 7000</td>
</tr>
</tbody>
</table>

For SI:°C = \[(°F) - 32\]/1.8.
N1101.10.3 (R303.1.3) Fenestration product rating.

*U*-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100.

**Exception:** Where required, garage door *U*-factors shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

*U*-factors shall be determined by an accredited, independent laboratory, and labeled and certified by the manufacturer.

Products lacking such a labeled *U*-factor shall be assigned a default *U*-factor from Table N1101.10.3(1) or N1101.10.3(2). The solar heat gain coefficient (SHGC) and visible transmittance (VT) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled SHGC or VT shall be assigned a default SHGC or VT from Table N1101.10.3(3).

*U*-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100. *U*-factors shall be determined by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled *U*-factor shall be assigned a default *U*-factor from Table N1101.10.3(1) or N1101.10.3(2). The solar heat gain coefficient (SHGC) and visible transmittance (VT) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled SHGC or VT shall be assigned a default SHGC or VT from Table N1101.10.3(3).

**Exception:** When a garage door is a part of the building thermal envelope garage door *U*-factors shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

### TABLE N1101.10.3(1)[R303.1.3(1)]

**DEFAULT GLAZED FENESTRATION U-FACTORS**

<table>
<thead>
<tr>
<th>FRAME TYPE</th>
<th>SINGLE PANES</th>
<th>DOUBLE PANES</th>
<th>SKYLIGHT Single</th>
<th>SKYLIGHT Double</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal</td>
<td>1.20</td>
<td>0.80</td>
<td>2.00</td>
<td>1.30</td>
</tr>
<tr>
<td>Metal with Thermal Break</td>
<td>1.10</td>
<td>0.65</td>
<td>1.90</td>
<td>1.10</td>
</tr>
<tr>
<td>Nonmetal or Metal Clad</td>
<td>0.95</td>
<td>0.55</td>
<td>1.75</td>
<td>1.05</td>
</tr>
<tr>
<td>Glazed Block</td>
<td></td>
<td></td>
<td>0.60</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE N1101.10.3(2)[R303.1.3(2)]

**DEFAULT DOOR U-FACTORS**

<table>
<thead>
<tr>
<th>DOOR TYPE</th>
<th>U-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninsulated Metal</td>
<td>1.20</td>
</tr>
<tr>
<td>Insulated Metal</td>
<td>0.60</td>
</tr>
<tr>
<td>Wood</td>
<td>0.50</td>
</tr>
<tr>
<td>Insulated, nonmetal edge, max 45% glazing, any glazing double pane</td>
<td>0.35</td>
</tr>
</tbody>
</table>

### TABLE N1101.10.3(3)[R303.1.3(3)]

**DEFAULT GLAZED FENESTRATION SHGC AND VT**
### Table: Insulation Product Rating

<table>
<thead>
<tr>
<th></th>
<th>SINGLE GLAZED</th>
<th></th>
<th>DOUBLE GLAZED</th>
<th></th>
<th>GLAZED BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clear</td>
<td>Tinted</td>
<td>Clear</td>
<td>Tinted</td>
<td></td>
</tr>
<tr>
<td>SHGC</td>
<td>0.8</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>VT</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
<td>0.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**N1101.10.4 (R303.1.4) Insulation product rating.**

The thermal resistance (R-value) of insulation shall be determined in accordance with the U.S. Federal Trade Commission R-value rule (CFR Title 16, Part 460) in units of h × ft² ×°F/Btu at a mean temperature of 75°F (24°C).

**N1101.10.4.1 (R303.1.4.1) Insulated siding.**

The thermal resistance (R-value) of insulated siding shall be determined in accordance with ASTM C 1363. Installation for testing shall be in accordance with the manufacturer’s installation instructions.

**N1101.11 (R303.2) Installation.**

All materials, systems and equipment shall be installed in accordance with the manufacturer’s instructions and this code.

**N1101.11.1 (R303.2.1) Protection of exposed foundation insulation.**

Insulation applied to the exterior of basement walls, crawlspace walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation’s thermal performance. The protective covering shall cover the exposed exterior insulation and extend not less than 6 inches (153 mm) below grade.

**N1101.12 (R303.3) Maintenance information.**

Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

**N1101.13 (R401.2) Compliance.**

Projects shall comply with one of the following:

1. Sections N1101.14 through N1104.

2. Section N1105 and the provisions of Sections N1101.14 through N1104 labeled “Mandatory.”

3. An energy rating index (ERI) approach in Section N1106.

4. North Carolina specific REScheck shall be permitted to demonstrate compliance with this code. Envelope requirements may not be traded off against the use of high efficiency heating or cooling equipment. No trade-off calculations are needed for required termite inspection and treatment gaps.
N1101.13.1 (R401.2.1) Tropical zone. Deleted.

Residential buildings in the tropical zone at elevations below 2,400 feet (731.5 m) above sea level shall be deemed to comply with this chapter where the following conditions are met:

1. Not more than one-half of the occupied space is air conditioned.
2. The occupied space is not heated.
3. Solar, wind or other renewable energy source supplies not less than 80 percent of the energy for service water heating.
4. Glazing in conditioned space has a solar heat gain coefficient of less than or equal to 0.40, or has an overhang with a projection factor equal to or greater than 0.30.
5. Permanently installed lighting is in accordance with Section N1104.
6. The exterior roof surface complies with one of the options in Table C402.2.1.1 of the International Energy Conservation Code, or the roof/ceiling has insulation with an R-value of R-15 or greater. If present, attics above the insulation are vented and attics below the insulation are unvented.
7. Roof surfaces have a minimum slope of $\frac{1}{4}$ inch (6.4 mm) per foot of run. The finished roof does not have water accumulation areas.
8. Operable fenestration provides ventilation area equal to not less than 14 percent of the floor area in each room. Alternatively, equivalent ventilation is provided by a ventilation fan.
9. Bedrooms with exterior walls facing two different directions have operable fenestration or exterior walls facing two directions.
10. Interior doors to bedrooms are capable of being secured in the open position.
11. A ceiling fan or ceiling fan rough-in is provided for bedrooms and the largest space that is not used as a bedroom.

N1101.14 (R401.3) Certificate (Mandatory).

A permanent certificate shall be completed by the builder or registered design professional and posted on a wall in the space where the furnace is located, a utility room or an approved location inside the building. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall list the predominant R-values of insulation installed in or on ceiling/roof, walls, foundation (slab, basement wall, crawl space wall and/or floor) and ducts outside conditioned spaces; U-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration, and the results from any required duct system and building envelope air leakage testing done on the building. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the types and efficiencies of heating, cooling and service water heating equipment. Where a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed in the
residence, the certificate shall list “gas-fired unvented room heater,” “electric furnace” or “baseboard electric heater,” as appropriate. An efficiency shall not be listed for gas-fired unvented room heaters, electric furnaces or electric baseboard heaters. A permanent certificate shall be posted on or in the electrical distribution panel, in the attic next to the attic insulation card, or inside a kitchen cabinet or other approved location. The certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The builder, permit holder, or registered design professional shall be responsible for completing the certificate. The certificate shall list the predominant R-values of insulation installed in or on ceiling/roof, walls, foundation (slab, basement wall, crawlspace wall and floor) and ducts outside conditioned spaces; U-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall indicate whether the building air leakage was visually inspected as required in Section N1102.4.2.1 or provide results of the air leakage testing required in Section N1102.4.2.2. The certificate shall provide results of duct leakage test required in Section N1103.3.3. Appendix E-1 contains a sample certificate.

N1101.15 (R401.4) Additional Voluntary Criteria for Increasing Residential Energy Efficiency. Appendix E-4 contains additional voluntary measures for increasing residential energy efficiency beyond code minimums. Implementation of the increased energy efficiency measures is strictly voluntary at the option of the permit holder. The sole purpose of the appendix is to provide guidance for achieving additional residential energy efficiency improvements that have been evaluated to be those that are most cost effective for achieving an additional 10-15 percent improvement in energy efficiency beyond code minimums.

SECTION N1102 (R402) BUILDING THERMAL ENVELOPE

N1102.1 (R402.1) General (Prescriptive). The building thermal envelope shall meet the requirements of Sections N1102.1.1 through N1102.1.45.

Exception: The following low energy buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with this section shall be exempt from the building thermal envelope provisions of Section N1102.

1. Those with a peak design rate of energy usage less than 3.4 Btu/h · ft² (10.7 W/m²) or 1.0 watt/ft² of floor area for space conditioning purposes.

2. Those that do not contain conditioned space.

N1102.1.1 (R402.1.1) Vapor retarder. Deleted. Wall assemblies in the building thermal envelope shall comply with the vapor retarder requirements of Section R702.7.
**N1102.1.2 (R402.1.2) Insulation and fenestration criteria.**
The building thermal envelope shall meet the requirements of Table N1102.1.2 based on the climate zone specified in Section N1101.7.

**TABLE N1102.1.2 (R402.1.2)**
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR</th>
<th>SKYLIGHT U-FACTOR</th>
<th>GLAZED FENESTRATION U-FACTOR</th>
<th>CEILING R-VALUE</th>
<th>WOOD FRAME WALL R-VALUE</th>
<th>MASS WALL R-VALUE</th>
<th>FLOOR R-VALUE</th>
<th>BASEMENT WALL R-VALUE</th>
<th>SLAB R-VALUE &amp; DEPTH</th>
<th>CRAWL SPACE R-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NR</td>
<td>0.75</td>
<td>0.25</td>
<td>30</td>
<td>13</td>
<td>3/4</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0.40</td>
<td>0.65</td>
<td>0.25</td>
<td>38</td>
<td>13</td>
<td>4/6</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0.35</td>
<td>0.55</td>
<td>0.25-0.30</td>
<td>38 or 30ci</td>
<td>20 15 or 13 + 2.55</td>
<td>85/13 or 5/10ci</td>
<td>19</td>
<td>5/13</td>
<td>0</td>
<td>5/13</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.35</td>
<td>0.55</td>
<td>0.40-0.30</td>
<td>49.38 or 30ci</td>
<td>20 15 or 13 + 2.55</td>
<td>85/13 or 5/10ci</td>
<td>19</td>
<td>10/13.15</td>
<td>10.2 ft</td>
<td>10/13.15</td>
</tr>
<tr>
<td>5 and Marine 4</td>
<td>0.32-0.35</td>
<td>0.55</td>
<td>NR</td>
<td>49 38 or 30ci</td>
<td>20 19 or 13 + 5 or 15+3h</td>
<td>13/17 or 13/12.5</td>
<td>30</td>
<td>15/19</td>
<td>10, 2 ft</td>
<td>150/19</td>
</tr>
<tr>
<td>6</td>
<td>0.32</td>
<td>0.55</td>
<td>NR</td>
<td>49</td>
<td>20 15 or 13 + 5 or 10</td>
<td>15/20</td>
<td>30</td>
<td>15/19</td>
<td>10, 4 ft</td>
<td>15/19</td>
</tr>
<tr>
<td>7 and 8</td>
<td>0.32</td>
<td>0.55</td>
<td>NR</td>
<td>49</td>
<td>20 15 or 13 + 5 or 10</td>
<td>19/21</td>
<td>30</td>
<td>15/19</td>
<td>10, 4 ft</td>
<td>15/19</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall not be less than the *R*-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration. **Exception:** Skylights may be excluded from glazed fenestration SHGC requirements in Climate Zones 1 through 3 where the SHGC for such skylights does not exceed 0.30.

c. “15/19” means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. “15/19” shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home. “10/13” means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall. “10/15” means R-10 continuous insulated sheathing.
on the interior or exterior of the home or R-15 cavity insulation at the interior of the basement wall or crawl space wall.

d. R-5 shall be added to the required slab edge R-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Zones 1 through 3 for heated slabs. For monolithic slabs, insulation shall be applied from the inspection gap downward to the bottom of the footing or a maximum of 24 inches below grade whichever is less. For floating slabs, insulation shall extend to the bottom of the foundation wall or 24 inches, whichever is less. (See Appendix O.)

e. There are no SHGC requirements in the Marine Zone. Deleted.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure N1101.10 and Table N1101.10.

g. Or insulation sufficient to fill the framing cavity, R-19 minimum.

h. The first value is cavity insulation, the second value is continuous insulation, so “13+5” means R-13 cavity insulation plus R-5 continuous insulation. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

i. The second R-value applies when more than half the insulation is on the interior of the mass wall.

j. In addition to the exemption in Section N1102.3.3, a maximum of two glazed fenestration product assemblies having a U-factor no greater than 0.55 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.

k. In addition to the exemption in Section N1102.3.3, a maximum of two glazed fenestration product assemblies having a SHGC no greater than 0.70 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.

l. R-30 shall be deemed to satisfy the ceiling insulation requirement wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Otherwise R-38 insulation is required where adequate clearance exists or insulation must extend to either the insulation baffle or within 1” of the attic roof deck.

m. Table value required except for roof edge where the space is limited by the pitch of the roof, there the insulation must fill the space up to the air baffle.

n. R-19 fiberglass batts compressed and installed in a nominal 2 × 6 framing cavity is deemed to comply.

Fiberglass batts rated R-19 or higher compressed and installed in a 2x4 wall is not deemed to comply.

o. Basement wall meeting the minimum mass wall specific heat content requirement may use the mass wall R-value as the minimum requirement.

### Table N1102.1.4 (R402.1.4)

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR</th>
<th>SKYLIGHT U-FACTOR</th>
<th>CEILING U-FACTOR</th>
<th>FRAME WALL U-FACTOR</th>
<th>MASS WALL U-FACTOR</th>
<th>FLOOR U-FACTOR</th>
<th>BASEMENT WALL U-FACTOR</th>
<th>CRAWL SPACE WALL U-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.50</td>
<td>0.75</td>
<td>0.035</td>
<td>0.084</td>
<td>0.197</td>
<td>0.064</td>
<td>0.360</td>
<td>0.477</td>
</tr>
<tr>
<td>2</td>
<td>0.40</td>
<td>0.65</td>
<td>0.030</td>
<td>0.084</td>
<td>0.165</td>
<td>0.064</td>
<td>0.360</td>
<td>0.477</td>
</tr>
<tr>
<td>3</td>
<td>0.35</td>
<td>0.55</td>
<td>0.030</td>
<td>0.060</td>
<td>0.098</td>
<td>0.141</td>
<td>0.047</td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 except Marine</td>
<td>0.35</td>
<td>0.55</td>
<td>0.026</td>
<td>0.030</td>
<td>0.060</td>
<td>0.098</td>
<td>0.141</td>
<td>0.047</td>
</tr>
<tr>
<td>5 and Marine 4</td>
<td>0.32 0.35</td>
<td>0.55</td>
<td>0.026</td>
<td>0.030</td>
<td>0.060</td>
<td>0.098</td>
<td>0.141</td>
<td>0.047</td>
</tr>
<tr>
<td>6</td>
<td>0.32</td>
<td>0.55</td>
<td>0.026</td>
<td>0.045</td>
<td>0.060</td>
<td>0.098</td>
<td>0.136</td>
<td>0.055</td>
</tr>
<tr>
<td>7 and 8</td>
<td>0.32</td>
<td>0.55</td>
<td>0.026</td>
<td>0.045</td>
<td>0.057</td>
<td>0.055</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Nonfenestration U-factors shall be obtained from measurement, calculation or an approved source.

b. When more than half the insulation is on the interior, the mass wall U-factors shall be a maximum of 0.17 in Zone 1, 0.14 in Zone 2, 0.12 in Zone 3, 0.087 in Zone 4 except Marine, and 0.065 in Zone 5 and Marine, and 0.057 in Zones 6 through 8.

c. Basement wall U-factor of 0.360 in warm-humid locations as defined by Figure N1101.10 (R301.1) and Table N1101.10 (R301.1).

d. A maximum of two glazed fenestration product assemblies having a U-factor no greater than 0.55 and a SHGC no greater than 0.70 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.
assemblies without penalty. When applying this note and using the REScheck “UA Trade-off” compliance method to allow continued use of the software, the applicable fenestration products shall be modeled as meeting the U-factor of 0.35 and the SHGC of 0.30, as applicable, but the fenestration products actual U-factor and actual SHGC shall be noted in the comments section of the software for documentation of application of this note to the applicable products. Compliance for these substitute products shall be verified compared to the allowed substituted maximum U-value requirement and maximum SHGC requirement, as applicable.

N1102.1.3 (R402.1.3) R-value computation.
Insulation material used in layers, such as framing cavity insulation, or continuous insulation shall be summed to compute the corresponding component R-value. The manufacturer’s settled R-value shall be used for blown insulation. Computed R-values shall not include an R-value for other building materials or air films. Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table N1102.1.2, the manufacturer’s labeled R-Value for insulated siding shall be reduced by R-0.6.

N1102.1.4 (R402.1.4) U-factor alternative.
An assembly with a U-factor equal to or less than that specified in Table N1102.1.4 shall be permitted as an alternative to the R-value in Table N1102.1.2.

N1102.1.5 (R402.1.5) Total UA alternative.
If the total building thermal envelope UA (sum of U-factor times assembly area) is less than or equal to the total UA resulting from using the U-factors in Table N1102.1.4 (multiplied by the same assembly area as in the proposed building), the building shall be considered in compliance with Table N1102.1.2. The UA calculation shall be done using a method consistent with the ASHRAE Handbook of Fundamentals and shall include the thermal bridging effects of framing materials. The SHGC requirements shall be met in addition to UA compliance.

N1102.2 (R402.2) Specific insulation requirements (Prescriptive).
In addition to the requirements of Section N1102.1, insulation shall meet the specific requirements of Sections N1102.2.1 through N1102.2.15.

N1102.2.1 (R402.2.1) Ceilings with attic spaces.
Where Section R1102.1.2 would require R-38 insulation in the ceiling, installing R-30 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-38 wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Similarly, where Section R1102.1.2 would require R-49 insulation in the ceiling, installing R-38 over 100 percent of the ceiling area requiring insulation shall be deemed to satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the U-factor alternative approach in Section R1102.1.4 and the total UA alternative in Section R1102.1.5.

Exceptions:

1. When insulation is installed in a fully enclosed attic floor system, as described in Appendix E-2.1, R-30 shall be deemed compliant.

2. In roof edge and other details such as bay windows, dormers, and similar areas where the space is limited, the insulation must fill the space up to the air baffle.
N1102.2.2 (R402.2.2) Ceilings without attic spaces.
Where Section N1102.1.2 would require R-38 insulation levels above R-30 and the design of the roof/ceiling assembly, including cathedral ceilings, bay windows and other similar areas, does not allow sufficient space for the required insulation, the minimum required insulation for such roof/ceiling assemblies shall be R-30. This reduction of insulation from the requirements of Section N1102.1.2 shall be limited to 500 square feet (46 m²) or 20 percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the U-factor alternative approach in Section N1102.1.4 and the total UA alternative in Section N1102.1.5.

N1102.2.3 (R402.2.3) Eave Soffit baffle.
For air-permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.

N1102.2.4 (R402.2.4) Access hatches and doors.
Horizontal access doors from conditioned spaces to unconditioned spaces such as attics and crawl spaces shall be weatherstripped and insulated to an R-10 minimum value and vertical doors to such spaces shall be weatherstripped and insulated to R-5 a level equivalent to the insulation on the surrounding surfaces. Access shall be provided to all equipment that prevents damaging or compressing the insulation. A wood-framed or equivalent baffle or retainer is required to be provided when loose-fill insulation is installed, the purpose of which is to prevent the loose-fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed R-value of the loose-fill insulation.

Exceptions:

1. Vertical doors that provide access from conditioned to unconditioned spaces shall be permitted to meet the fenestration requirements of Table RN1102.1.2 based on the applicable climate zone specified in Chapter 3 N1101.7.

2. Pull down stair systems shall be weatherstripped and insulated to a minimum R-5 insulation value such that the insulation does not interfere with proper operation of the stair. Non-rigid insulation materials are not allowed. Additional insulation systems that enclose the stair system from above are allowed. Exposed foam plastic must meet the provisions of Section R318.

N1102.2.5 (R402.2.5) Mass walls.
Mass walls for the purposes of this chapter shall be considered above-grade walls of concrete block, concrete, insulated concrete form (ICF), masonry cavity, brick (other than brick veneer), earth (adobe, compressed earth block, rammed earth) and solid timber/logs, or any other walls meeting the specification immediately following having a heat capacity greater than or equal to $6 \text{ Btu/ft}^2 \cdot \text{°F} = 123 \text{ kJ/m}^2 \cdot \text{°C}$. Masonry or concrete walls having a mass greater than or equal to 30 pounds per square foot (146 kg/m²). Solid wood walls having a mass greater than 20 pounds per square foot (98 kg/m²), and any walls having a heat capacity greater than or equal to $6 \text{ Btu/ft}^2 \cdot \text{°F}[266 \text{ J/(m}^2\text{°K})]$. 

2018 North Carolina Residential Code
N1102.2.6 (R402.2.6) Steel-frame ceilings, walls, and floors.
Steel-frame ceilings, walls, and floors shall meet the insulation requirements of Table N1102.2.6 or shall meet the \( U \)-factor requirements of Table N1102.1.4. The calculation of the \( U \)-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

**TABLE N1102.2.6 (R402.2.6)
STEEL-FRAME CEILING, WALL AND FLOOR INSULATION
(\( R \)-VALUE)**

<table>
<thead>
<tr>
<th>WOOD FRAME R-VALUE REQUIREMENT</th>
<th>COLD-FORMED STEEL EQUIVALENT R-VALUE</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel Truss Ceilings</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>R-30</td>
<td>R-38 or R-30 + 3 or R-26 + 5</td>
</tr>
<tr>
<td></td>
<td>R-38</td>
<td>R-49 or R-38 + 3</td>
</tr>
<tr>
<td></td>
<td>R-49</td>
<td>R-38 + 5</td>
</tr>
<tr>
<td></td>
<td>Steel Joist Ceilings</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>R-30</td>
<td>R-38 in 2 ( \times ) 4 or 2 ( \times ) 6 or 2 ( \times ) 8 R-49 in any framing</td>
</tr>
<tr>
<td></td>
<td>R-38</td>
<td>R-49 in 2 ( \times ) 4 or 2 ( \times ) 6 or 2 ( \times ) 8 or 2 ( \times ) 10</td>
</tr>
<tr>
<td></td>
<td>Steel-Framed Wall, 16” on center</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R-13</td>
<td>R-13 + 4.2 or R-19 + 2.1 or R-21 + 2.8 or R-0 + 9.3 or R-15 + 3.8 or R-21 + 3.1</td>
</tr>
<tr>
<td></td>
<td>R-13 + 3</td>
<td>R-0 + 11.2 or R-13 + 6.1 or R-15 + 5.7 or R-19 + 5.0 or R-21 + 4.7</td>
</tr>
<tr>
<td></td>
<td>R-20</td>
<td>R-0 + 14.0 or R-13 + 8.9 or R-15 + 8.5 or R-19 + 7.8 or R-19 + 6.2 or R-21 + 7.5</td>
</tr>
<tr>
<td></td>
<td>R-20 + 5</td>
<td>R-13 + 12.7 or R-15 + 12.3 or R-19 + 11.6 or R-21 + 11.3 or R-25 + 10.9</td>
</tr>
<tr>
<td></td>
<td>R-21</td>
<td>R-0 + 14.6 or R-13 + 9.5 or R-15 + 9.1 or R-19 + 8.4 or R-21 + 8.1 or R-25 + 7.7</td>
</tr>
<tr>
<td></td>
<td>Steel-Framed Wall, 24” on center</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R-13</td>
<td>R-0 + 9.3 or R-13 + 3.0 or R-15 + 2.4</td>
</tr>
<tr>
<td></td>
<td>R-13 + 3</td>
<td>R-0 + 11.2 or R-13 + 4.9 or R-15 + 4.3 or R-19 + 3.5 or R-21 + 3.1</td>
</tr>
<tr>
<td></td>
<td>R-20</td>
<td>R-0 + 14.0 or R-13 + 7.7 or R-15 + 7.1 or R-19 + 6.3 or R-21 + 5.9</td>
</tr>
<tr>
<td></td>
<td>R-20 + 5</td>
<td>R-13 + 11.5 or R-15 + 10.9 or R-19 + 10.1 or R-21 + 9.7 or R-25 + 9.1</td>
</tr>
<tr>
<td></td>
<td>R-21</td>
<td>R-0 + 14.6 or R-13 + 8.3 or R-15 + 7.7 or R-19 + 6.9 or R-21 + 6.5 or R-25 + 5.9</td>
</tr>
<tr>
<td></td>
<td>Steel Joist Floor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R-13</td>
<td>R-19 in 2 ( \times ) 6, or R-19 + 6 in 2 ( \times ) 8 or 2 ( \times ) 10</td>
</tr>
<tr>
<td></td>
<td>R-19</td>
<td>R-19 + 6 in 2 ( \times ) 6, or R-19 + 12 in 2 ( \times ) 8 or 2 ( \times ) 10</td>
</tr>
</tbody>
</table>

a. Cavity insulation \( R \)-value is listed first, followed by continuous insulation \( R \)-value.
b. Insulation exceeding the height of the framing shall cover the framing.

N1102.2.7 (R402.2.7) Walls with partial structural sheathing.
Where Section R1102.1.2 would require continuous insulation on exterior walls and structural
sheathing covers 40 percent or less of the gross area of all exterior walls, the continuous insulation $R$-value shall be permitted to be reduced by an amount necessary to result in a consistent total sheathing thickness, but not more than R-3, on areas of the walls covered by structural sheathing. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2. This reduction shall not apply to the $U$-factor alternative approach in Section RN1102.1.4 and the total UA alternative in Section RN1102.1.5.

N1102.2.8 (R402.2.8) Floors.
Floor framing-cavity insulation shall be installed to maintain permanent contact with the underside of the subfloor decking. The distance between tension support wires or other devices that hold the floor insulation in place against the subfloor shall be no more than 18 inches (457 mm). In addition, supports shall be located no further than 6 inches (152 mm) from each end of the insulation.

Exception: The floor framing-cavity insulation shall be permitted to be in contact with the topside of sheathing or continuous insulation installed on the bottom side of floor framing where combined with insulation that meets or exceeds the minimum wood frame wall $R$-value in Table 1102.1.2 and that extends from the bottom to the top of all perimeter floor framing members. Enclosed floor cavity such as garage ceilings, cantilevers or buildings on pilings with enclosed floor cavity with the insulation fully in contact with the lower air barrier. In this case, the band boards shall be insulated to maintain thermal envelope continuity.

N1102.2.9 (R402.2.9) Basement walls.
Walls associated with conditioned basements shall be insulated from the top of the basement wall down to 10 feet (3048 mm) below grade or to the basement floor, whichever is less. Walls associated with unconditioned basements shall meet this requirement unless the floor overhead is insulated in accordance with Sections N1102.1.2 and N1102.2.8. Foam plastic insulation applied to exterior of basement walls shall be provided with termite inspection and treatment gaps in accordance with Appendix O.

N1102.2.10 (R402.2.10) Slab-on-grade floors.
Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table N1102.1.2. The insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the distance provided in Table N1102.1.2 by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the building. Insulation extending away from the building shall be protected by pavement or by not less than 10 inches (254 mm) of soil. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Slab edge insulation is not required in jurisdictions designated by the building official as having a very heavy termite infestation. Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table N1102.1.2. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Slab edge insulation shall have 2 inch (51 mm) termite inspection gap consistent with Appendix O of this code.
N1102.2.11 (R402.2.11) Closed crawl space walls.  
As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24 inches (610 mm). Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with this code. All joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend not less than 6 inches (153 mm) up the stem wall and shall be attached to the stem wall. Where the floor above a closed crawl space is not insulated, the exterior crawlspace walls shall be insulated in accordance with Table N1102.1.2.

Wall insulation may be located in any combination of the outside and inside wall surfaces and within the structural cavities or materials of the wall system.

Wall insulation requires that the exterior wall band joist area of the floor frame be insulated. Wall insulation shall begin 3 inches (76 mm) below the top of the masonry foundation wall and shall extend down to 3 inches (76 mm) above the top of the footing or concrete floor, 3 inches (76 mm) above the interior ground surface or 24 inches (610 mm) below the outside finished ground level, whichever is less. (See Appendix E-2.2 details.)

Termite inspection, clearance, and wicking gaps are allowed in wall insulation systems. Insulation may be omitted in the gap area without energy penalty. The allowable insulation gap widths are listed in Table N1102.2.11. If gap width exceeds the allowances, one of the following energy compliance options shall be met:

1. Wall insulation is not allowed and the required insulation value shall be provided in the floor system.

2. Compliance shall be demonstrated with energy trade-off methods provided by a North Carolina-specific version of RESCHECK or the UA Alternative method or Section N1105.

**TABLE N1102.2.11 WALL INSULATION ALLOWANCES FOR TERMITE TREATMENT AND INSULATION GAPS**

<table>
<thead>
<tr>
<th>Gap Width (inches)</th>
<th>Insulation Location</th>
<th>Gap Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td>Above grade inspection between top of insulation and bottom of siding</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Outside</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>Outside</td>
</tr>
<tr>
<td>3a</td>
<td>4a</td>
<td>Inside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Below grade treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wall inspection between top of insulation and bottom of sill</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
N1102.2.12 (R402.2.12) Masonry veneer.
Insulation shall not be required on the horizontal portion of the foundation that supports a masonry veneer.

N1102.2.13 (R402.2.13) Sunroom insulation.
Sunrooms enclosing conditioned spaces shall meet the insulation requirements of this code.

Exception: For sunrooms with thermal isolation, and enclosing conditioned spaces, the following exceptions to the insulation requirements of this code shall apply:

1. The minimum ceiling insulation R-values shall be R-19 in Zones 1 through 3 and 4 and R-24 in Zones 5 through 8.

2. The minimum wall R-value shall be R-13 in all climate zones. New walls separating a sunroom with a thermal isolation from conditioned space shall meet the building thermal envelope requirements of this code.

N1102.2.14 (R402.2.14) Framed cavity walls.
The exterior thermal envelope wall insulation shall be installed in contact and continuous alignment with the building envelope air barrier. Insulation shall be free from installation gaps, voids, or compression. For framed walls, the cavity insulation shall be enclosed on all sides with solid rigid material or an air barrier material. Polyethylene shall not be allowed. Rim joists are not required to be enclosed on all sides. Wall insulation shall be enclosed at the following locations when installed on exterior walls prior to being covered by subsequent construction, consistent with Appendix E-2.3 of this code:

1. Tubs
2. Showers
3. Stairs
4. Fireplace units (Enclose with rigid material only)

N1102.2.15 (R402.2.15) Attic knee walls.
Enclosure of wall cavity insulation also applies to walls that adjoin attic spaces by placing a rigid material or air barrier material on the attic space side of the wall on the attic space side of the wall consistent with Appendix E-2.3 of this code. Joints shall be air sealed. Non-insulating class I vapor retarders, such as polyethylene, shall not be allowed.

N1102.3 (R402.3) Fenestration (Prescriptive).
In addition to the requirements of Section N1102, fenestration shall comply with Sections N1102.3.1 through N1102.4.5-N1102.3.5.
N1102.3.1 (R402.3.1) U-factor.  
An area-weighted average of fenestration products shall be permitted to satisfy the U-factor requirements.

N1102.3.2 (R402.3.2) Glazed fenestration SHGC.  
An area-weighted average of fenestration products more than 50-percent glazed shall be permitted to satisfy the SHGC requirements.

  *Dynamic glazing* shall be permitted to satisfy the SHGC requirements of Table R1102.1.2 provided the ratio of the higher to lower labeled SHGC is greater than or equal to 2.4, and the *dynamic glazing* is automatically controlled to modulate the amount of solar gain into the space in multiple steps. *Dynamic glazing* shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not dynamic glazing shall not be permitted.

**Exception:** *Dynamic glazing* is not required to comply with this section when both the lower and higher labeled SHGC already comply with the requirements of Table N1102.1.2.

N1102.3.3 (R402.3.3) Glazed fenestration exemption.  
Up to 15 Either two glazed fenestration assemblies or up to 24 square feet (1.4 2.2 m²) of glazed fenestration per dwelling unit shall be permitted to be exempt from U-factor and SHGC requirements in Section N1102.1.2. This exemption shall not apply to the U-factor alternative approach in Section N1102.1.4 and the total UA alternative in Section N1102.1.5.

N1102.3.4 (R402.3.4) Opaque door exemption.  
Opaque doors separating conditioned from unconditioned space shall have a maximum U-factor of 0.35.

**Exception:** One side-hinged opaque door assembly up to 24 square feet (2.22 m²) in area is exempted from the U-factor requirement in Section N1102.1.2. This exemption shall not apply to the U-factor alternative approach in Section N1102.1.4 and the total UA alternative in Section N1102.1.5.

N1102.3.5 (R402.3.5) Sunroom fenestration.  
Sunrooms enclosing conditioned space shall meet the fenestration requirements of this code.

**Exceptions:**

1. For sunrooms with *thermal isolation* and enclosing conditioned space in Climate Zones 2 3 through 8 5, the maximum fenestration U-factor shall be 0.45 and the maximum skylight U-factor shall be 0.70 - 0.75. Sunrooms with cooling systems shall have a maximum fenestration SHGC of 0.40 for all glazing.

2. A maximum of two glazed fenestration product assemblies having a U-factor no greater than 0.55 and, when cooling is provided, a SHGC no greater than 0.70 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.
New fenestration separating the sunroom with thermal isolation from conditioned space shall meet the building thermal envelope requirements of this code.

N1102.4 (R402.4) Air leakage control (Mandatory).
The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R1102.4.1 through R1102.4.46.

N1102.4.1 (R402.4.1) Building thermal envelope.
The building thermal envelope shall comply with Sections N1102.4.1.1 and N1102.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. The building thermal envelope shall be durably sealed to limit infiltration. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. For all homes, where present, the following shall be caulked, gasketed, weatherstripped or otherwise sealed with an air barrier material, or solid material consistent with Appendix E-2.4 of this code:

1. Blocking and sealing floor/ceiling systems and under knee walls open to unconditioned or exterior space.
2. Capping and sealing shafts or chases, including flue shafts.
3. Capping and sealing soffit or dropped ceiling areas.
4. Sealing HVAC register boots and return boxes to subfloor or drywall.
5. Seal exterior house wrap material joints and seams per manufacturer’s instructions or, if house wrap joints are not sealed, seal exterior sheathing and exposed band joist joints including perimeter joints and edges of these materials.

Exceptions:

1. Spray foam in building thermal envelope wall systems.
2. Wall sheathing joints where wall sheathing is fully glued to framing.

N1102.4.1.1 (R402.4.1.1) Installation.
The components of the building thermal envelope as listed in Table N1102.4.1.1 shall be installed in accordance with the manufacturer’s instructions and the criteria listed in Table N1102.4.1.1, as applicable to the method of construction. Where required by the building official, an approved third party shall inspect all components and verify compliance.

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>AIR BARRIER CRITERIA</th>
<th>INSULATION INSTALLATION CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>General requirements</td>
<td>A continuous air barrier shall be installed in the building envelope.</td>
<td>Air-permeable insulation shall not be used as a sealing material.</td>
</tr>
<tr>
<td>Section</td>
<td>Requirement</td>
<td>Example</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ceiling/attic</td>
<td>The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop-down stairs or knee wall doors to unconditioned attic spaces shall be sealed.</td>
<td>The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.</td>
</tr>
<tr>
<td>Walls</td>
<td>The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.</td>
<td>Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.</td>
</tr>
<tr>
<td>Windows, skylights and doors</td>
<td>The space between window/door jambe and framing, and skylights and framing shall be sealed.</td>
<td>Rim joists shall be insulated.</td>
</tr>
<tr>
<td>Rim joists</td>
<td>Rim joists shall include the air barrier.</td>
<td>Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing; and extends from the bottom to the top of all perimeter floor framing members.</td>
</tr>
<tr>
<td>Floors (including above garage and cantilevered floors)</td>
<td>The air barrier shall be installed at any exposed edge of insulation.</td>
<td></td>
</tr>
<tr>
<td>Crawl space walls</td>
<td>Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.</td>
<td>Where provided instead of floor insulation, insulation shall be permanently attached to the crawl space walls.</td>
</tr>
<tr>
<td>Shafts, penetrations</td>
<td>Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.</td>
<td></td>
</tr>
<tr>
<td>Narrow cavities</td>
<td>Batt insulation in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.</td>
<td></td>
</tr>
<tr>
<td>Garage separation</td>
<td>Air sealing shall be provided between the garage and conditioned spaces.</td>
<td></td>
</tr>
<tr>
<td>Recessed lighting</td>
<td>Recessed light fixtures installed in the building thermal envelope shall be sealed to the drywall.</td>
<td>Recessed light fixtures installed in the building thermal envelope shall be air tight and IC rated.</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Plumbing and wiring</td>
<td>Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.</td>
<td></td>
</tr>
<tr>
<td>Shower/tub on exterior wall</td>
<td>The air barrier installed at exterior walls adjacent to showers and tubs shall separate them from the showers and tubs.</td>
<td>Exterior walls adjacent to showers and tubs shall be insulated.</td>
</tr>
<tr>
<td>Electrical/phone box on exterior walls</td>
<td>The air barrier shall be installed behind electrical or communication boxes or air-sealed boxes shall be installed.</td>
<td></td>
</tr>
<tr>
<td>HVAC register boots</td>
<td>HVAC register boots that penetrate building thermal envelope shall be sealed to the subfloor or drywall.</td>
<td></td>
</tr>
<tr>
<td>Concealed sprinklers</td>
<td>When required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.</td>
<td></td>
</tr>
</tbody>
</table>

N1102.4.1.2 (R402.4.1.2) Testing.
The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding five air changes per hour in Climate Zones 1 and 2, and three air changes per hour in Climate Zones 3 through 8. Testing shall be conducted in accordance with ASTM E 779 or ASTM E 1827 and reported at a pressure of 0.2 inches w.g. (50 Pascals). Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weatherstripping or other infiltration control measures.

2. Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures.

3. Interior doors, if installed at the time of the test, shall be open.

a. In addition, inspection of log walls shall be in accordance with the provisions of ICC-400.
4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed.

5. Heating and cooling systems, if installed at the time of the test, shall be turned off.

6. Supply and return registers, if installed at the time of the test, shall be fully open.

N1102.4.2 Air sealing.
Building envelope air tightness shall be demonstrated by compliance with Sections N1102.4.2.1 or N1102.4.2.2. Appendix E-3 contains optional sample worksheets for visual inspection or testing for the permit holder’s use only.

N1102.4.2.1 Visual inspection option.
Building envelope tightness shall be considered acceptable when items providing insulation enclosure in Section N1102.2.14 and enclosure and air sealing in Section N1102.2.15 and air sealing in Section N1102.4.1 are addressed and when the items listed in Table N1102.4.2, applicable to the method of construction, are certified by the builder, permit holder or registered design professional via the certificate in Appendix E-1.

N1102.4.2.2 Testing option.
Building envelope tightness shall be considered acceptable when items providing insulation enclosure in Section N1102.2.14 and enclosure and air sealing in Section N1102.2.15 and air sealing in Section N1102.4.1 are addressed and when tested air leakage is less than or equal to one of the two following performance measurements:

1. 0.30 CFM50/Square Foot of Surface Area (SFSA) or

2. Five (5) air changes per hour (ACH50) when tested with a blower door fan assembly, at a pressure of 33.5 psf (50 Pa). A single point depressurization, not temperature corrected, test is sufficient to comply with this provision, provided that the blower door fan assembly has been certified by the manufacturer to be capable of conducting tests in accordance with ASTM E779 or ASTM E 1827. Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation and combustion appliances. Testing shall be reported by the permit holder, a North Carolina licensed general contractor, a North Carolina licensed HVAC contractor, a North Carolina licensed home inspector, a registered design professional, a certified BPI envelope professional or a certified HERS rater.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed;

2. Dampers shall be closed, but not sealed, including exhaust, backdraft, and flue dampers;

3. Interior doors shall be open;
4. Exterior openings for continuous ventilation systems, air intake ducted to the return side of the conditioning system, and energy or heat recovery ventilators shall be closed and sealed;

5. Heating and cooling system(s) shall be turned off; and

6. Supply and return registers shall not be sealed.

The air leakage information, building air leakage result, tester name, date, and contact information, shall be included on the certificate described in Section N1101.14.

For Test Criteria 1 above, the report shall be produced in the following manner: perform the blower door test and record the CFM50. Calculate the total square feet of surface area for the building thermal envelope (all floors, ceilings, and walls including windows and doors, bounding conditioned space) and record the area. Divide CFM50 by the total square feet and record the result. If the result is less than or equal to [0.30 CFM50/SFSA] the envelope tightness is acceptable; or

For Test Criteria 2 above, the report shall be produced in the following manner: Perform a blower door test and record the CFM50. Multiply the CFM50 by 60 minutes to create CFHour50 and record. Then calculate the total conditioned volume of the home and record. Divide the CFH50 by the total volume and record the result. If the result is less than or equal to 5 ACH50 the envelope tightness is acceptable.

**TABLE N1102.4.2**
**AIR BARRIER INSPECTION**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling/attic</td>
<td>Sealants or gaskets provide a continuous air barrier system joining the top plate of framed walls with either the ceiling drywall or the top edge of wall drywall to prevent air leakage. Top plate penetrations are sealed. For ceiling finishes that are not air barrier systems such as tongue-and-groove planks, air barrier systems (for example, taped house wrap), shall be used above the finish. Note: It is acceptable that sealants or gaskets applied as part of the application of the drywall will not be observable by the code official.</td>
</tr>
<tr>
<td>Walls</td>
<td>Sill plate is gasketed or sealed to subfloor or slab.</td>
</tr>
<tr>
<td>Windows and doors</td>
<td>Space between window and exterior door jambs and framing is sealed.</td>
</tr>
<tr>
<td>Floors (including above-garage and cantilevered floors)</td>
<td>Air barrier system is installed at any exposed edge of insulation.</td>
</tr>
</tbody>
</table>
Penetrations | Utility penetrations through the building thermal envelope, including those for plumbing, electrical wiring, ductwork, security and fire alarm wiring, and control wiring, shall be sealed.
---|---
Garage separation | Air sealing is provided between the garage and conditioned spaces. An air barrier system shall be installed between the ceiling system above the garage and the ceiling system of interior spaces.
Ceiling penetrations | Ceiling electrical box penetrations and ceiling mechanical box penetrations shall be caulked, gasketed, or sealed at the penetration of the ceiling finish. See Appendix E-2.4.
Exception: Ceiling electrical boxes and ceiling mechanical boxes not penetrating the building thermal envelope.
Recessed lighting | Recessed light fixtures are air tight, IC rated, and sealed to drywall.
Exception: Fixtures in conditioned space.

**N1102.4.23 (R402.4.23) Fireplaces.**
New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air. Where using tight-fitting doors on factory-built fireplaces listed and labeled in accordance with UL 127, the doors shall be tested and listed for the fireplace. Where using tight-fitting doors on masonry fireplaces, the doors shall be listed and labeled in accordance with UL 907. Site-built masonry fireplaces shall have dampers and comply with Section R1006 for combustion air.

**N1102.4.34 (R402.4.34) Fenestration air leakage.**
Windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot (1.5 L/s/m²), and swinging doors no more than 0.5 cfm per square foot (2.6 L/s/m²), when tested according to NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and listed and labeled by the manufacturer.

**Exception:** Site-built windows, skylights and doors.

**N1102.4.45 (R402.4.45) Rooms containing fuel-burning appliances.** Deleted.
In Climate Zones 3 through 8, where open combustion air ducts provide combustion air to open combustion fuel-burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room, isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table N1102.1.2, where the walls, floors and ceilings shall meet a minimum of the basement wall R-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section N1103. The combustion air duct shall be insulated where it passes through conditioned space to a minimum of R-8.

**Exceptions:**
1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.

2. Fireplaces and stoves complying with Sections N1102.4.2 and R1006.

N1102.4.56 (R402.4.56) Recessed lighting.
Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and labeled as having an air leakage rate not more than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E 283 at a 1.57 psf (75 Pa) pressure differential. All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering.

N1102.5 (R402.5) Maximum fenestration U-factor and SHGC (Mandatory).
The area-weighted average maximum fenestration U-factor permitted using tradeoffs from Section N1102.1.5 or N1105 shall be 0.48 in climate zones 4 and 5 and 0.40 in climate zones 6 through 8 for vertical fenestration, and 0.75 in climate zones 4 through 8 for skylights. The area-weighted average maximum fenestration SHGC permitted using tradeoffs from Section N1105 in climate zones 1 through 3 shall be 0.50. The area-weighted average maximum fenestration U-factor permitted using trade-offs from Section N1102.1.5 shall be 0.48. Maximum skylight U-factors shall be 0.65 in Zones 4 and 5 and 0.60 in Zone 3. The area-weighted average maximum fenestration SHGC permitted using trade-offs from Section N1105 in Zone 3 shall be 0.50.

Exception: A maximum of two glazed fenestration product assemblies having a U-factor no greater than 0.55 and a SHGC no greater than 0.70 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.

SECTION N1103 (R403)
SYSTEMS

N1103.1 (R403.1) Controls (Mandatory).
At least one thermostat shall be provided for each separate heating and cooling system.

N1103.1.1 (R403.1.1) Programmable thermostat.
When the primary heating system is a forced air furnace or heat pump, the thermostat controlling the primary heating or cooling system of the dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of the day. This thermostat shall include the capability to set back or temporarily operate the system to maintain zone temperatures down to 55°F (13°C) or up to 85°F (29°C). The thermostat shall initially be programmed by the manufacturer with a heating temperature set point no higher than 70°F (21°C) and a cooling temperature set point no lower than 78°F (26°C).

N1103.1.2 (R403.1.2) Heat pump supplementary heat (Mandatory).
Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load.
A heat strip outdoor temperature lockout thermostat shall be provided to prevent supplemental heat operation in response to the thermostat being changed to a warmer setting. The lockout shall be set no lower than 35°F (2°C) and no higher than 40°F (4°C).

Exceptions:

1. In lieu of a heat strip outdoor temperature lockout thermostat, the following time and temperature electric-resistance control may be used. After six minutes of compressor run time in heat mode, supplemental electric heat shall energize only if the leaving air temperature from the indoor coil is below 90°F (32°C). If the indoor coil leaving air temperature exceeds 100°F (38°C), supplemental heat shall automatically de-energize, but allow the compressor to continue to operate until the call is satisfied. No thermostat shall initiate supplemental electric heat at any time. Thermostat controlled emergency heat shall not be limited by outdoor temperature. Electric resistance supplemental heat during defrost shall operate normally without limitation.

2. In lieu of a heat strip outdoor temperature lockout thermostat, a programmable indoor thermostat with the capability to minimize the use of supplementary electrical resistance heat using an automatic temperature ramp up control feature shall be acceptable.

N1103.2 (R403.2) Hot water boiler outdoor temperature setback.
Hot water boilers that supply heat to the building through one- or two-pipe heating systems shall have an outdoor setback control that lowers the boiler water temperature based on the outdoor temperature.

N1103.3 (R403.3) Ducts.
Ducts and air handlers shall be in accordance with Sections N1103.3.1 through N1103.3.54.

N1103.3.1 (R403.3.1) Insulation (Prescriptive Mandatory).
Supply and return ducts in attics shall be insulated to a minimum of R-8 where 3 inches (76.2 mm) in diameter and greater and R-6 where less than 3 inches (76.2 mm) in diameter. Supply and return ducts in other portions of the building shall be insulated to a minimum of R-6 where 3 inches (76.2 mm) in diameter or greater and R-4.2 where less than 3 inches (76.2 mm) in diameter. Supply and return ducts in unconditioned space and outdoors shall be insulated to a minimum R-8. Supply ducts inside semi-conditioned space shall be insulated to a minimum R-4; return ducts inside conditioned and semi-conditioned space are not required to be insulated. Ducts located inside conditioned space are not required to be insulated other than as may be necessary for preventing the formation of condensation on the exterior of cooling ducts.

Exception: Ducts or portions thereof located completely inside the building thermal envelope.

N1103.3.2 (R403.3.2) Sealing (Mandatory).
Ducts, air handlers, and filter boxes and building cavities used as ducts shall be sealed. Joints and seams shall comply with either the International Mechanical Code or Section M1601.4.1 of this code, as applicable.
Exceptions:

1. Air-impermeable spray foam products shall be permitted to be applied without additional joint seals.

2. For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams, and locking-type joints and seams of other than the snap-lock and button-lock types. Deleted.

N1103.3.2.1 (R403.3.2.1) Sealed air handler. Deleted.
Air handlers shall have a manufacturer’s designation for an air leakage of no more than 2 percent of the design air flow rate when tested in accordance with ASHRAE 193.

N1103.3.3 (R403.3.3) Duct testing (Mandatory) Duct leakage (Prescriptive) and duct testing (Mandatory).
Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer’s air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.

2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exception: A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.

A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

N1103.3.4 (R403.3.4) Duct leakage (Prescriptive).
The total leakage of the ducts, where measured in accordance with Section R403.3.3, shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m²) of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3 cubic feet per minute (85 L/min) per 100 square feet (9.29 m²) of conditioned floor area.

2. Postconstruction test: Total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m²) of conditioned floor area.

Duct testing and duct leakage shall be verified by compliance with either Section N1103.3.3.1 or N1103.3.3.2. Duct testing shall be performed and reported by the permit holder, a North Carolina licensed general contractor, a North Carolina licensed HVAC
contractor, a North Carolina licensed home inspector, a registered design professional, a certified BPI envelope professional or a certified HERS rater. A single point depressurization, not temperature corrected, test is sufficient to comply with this provision, provided that the duct testing fan assembly(s) has been certified by the manufacturer to be capable of conducting tests in accordance with ASTM E1554-07.

The duct leakage information, including duct leakage test selected and result, tester name, date, and contact information, shall be included on the certificate described in Section N1101.14.

For the Test Criteria, the report shall be produced in the following manner: perform the HVAC system air leakage test and record the CFM25. Calculate the total square feet of Conditioned Floor Area (CFA) served by that system. Multiply CFM25 by 100, divide the result by the CFA and record the result. If the result is less than or equal to 5 CFM25/100SF for the “Total duct leakage test or less than or equal to 4 CFM25/100SF for the “Duct leakage to the outside” test, then the HVAC system air tightness is acceptable. Appendix E-3C contains optional sample worksheets for duct testing for the permit holder's use only.

Exceptions:

1. Duct systems or portions thereof inside the building thermal envelope shall not be required to be leak tested.

2. Installation of a partial system as part of replacement, renovation or addition does not require a duct leakage test.

N1103.3.3.1 Total duct leakage.
Total duct leakage less than or equal to 5 CFM (12 L/min) per 100 ft² (9.29 m²) of conditioned floor area served by that system when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure.

During testing:

1. Block, if present, ventilation air duct(s) connected to the conditioning system.

2. The duct air leakage testing equipment shall be attached to the largest return in the system or to the air handler.

3. The filter shall be removed and the air handler power shall be turned off.

4. Supply boots or registers and return boxes or grilles shall be taped, plugged, or otherwise sealed air tight.

5. The hose for measuring the 25 Pascals of pressure differential shall be inserted into the boot of the supply that is nominally closest to the air handler.

6. Specific instructions from the duct testing equipment manufacturer shall be followed to reach duct test pressure and measure duct air leakage.

N1103.3.3.2 Duct Leakage to the Outside.
Conduct the test using fan pressurization of distribution system and building at a fixed reference pressure for combined supply and return leak. Duct leakage to the outside shall be less than or equal to 4 CFM (12 L/min) per 100 ft\(^2\) (9.29 m\(^2\)) of conditioned floor area served by that system when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, relative to the outside, including the manufacturer’s air handler enclosure.

During testing:

1. Block, if present, the ventilation air duct(s) connected to the conditioning system.

2. The duct air leakage testing equipment shall be attached to the largest return in the system or to the air handler.

3. The filter shall be removed and the air handler power shall be turned off.

4. Supply boots or registers and return boxes or grilles shall be taped, plugged, or otherwise sealed air tight or as tight as possible.

5. The hose for measuring the 25 Pascals of pressure differential shall be inserted into the boot of the supply that is nominally closest to the air handler.

6. Open all interconnecting doors in the building, close dampers for fireplaces and other operable dampers.

7. Set up an envelope air moving/flow-regulating/flow measurement assembly, such as a blower door, following the manufacturer’s prescribed procedure.

8. Specific instructions from the duct testing equipment manufacturer shall be followed to reach duct test pressure and measure duct air leakage used in combination with a blower door. Typical steps are as follows:

   a. Depressurize the ductwork system to 25 Pa using the measurement hose in Step 5 above.

   b. Depressurize the house to 25 Pa using an envelope air moving/flow-regulating/flow measurement assembly, such as a blower door.

   c. Correct the duct pressure to measure 0 Pa of pressure differential between the house and the ductwork system.

   d. Read the CFM of duct leakage using the procedures for the specific equipment being used. (Note that most automatically calculating pressure gauges cannot compute the CFM25 automatically with a duct-to-house difference in pressure of 0 Pa, so the gauge setting should be set to read CFM instead of CFM25).

N1103.3.54 (R403.3.54) Building cavities (Mandatory).
Building framing cavities shall not be used as supply ducts or supply plenums.
N1103.4 (R403.4) Mechanical system piping insulation (Mandatory).
Mechanical system piping capable of carrying fluids above 105°F (41°C) or below 55°F (13°C) shall be insulated to a minimum of R-3.

N1103.4.1 (R403.4.1) Protection of piping insulation. Deleted.
Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted.

N1103.5 (R403.5) Service hot water systems.
Energy conservation measures for service hot water systems shall be in accordance with Sections N1103.5.1 and N1103.5.4. All circulating service hot water piping shall be insulated to at least R-2. Circulating hot water systems shall include an automatic or readily accessible manual switch that can turn off the hot water circulating pump when the system is not in use.

N1103.5.1 (R403.5.1) Heated water circulation and temperature maintenance systems (Mandatory). Deleted.
Heated water circulation systems shall be in accordance with Section R1103.5.1.1. Heat trace temperature maintenance systems shall be in accordance with Section R1103.5.1.2. Automatic controls, temperature sensors and pumps shall be accessible. Manual controls shall be readily accessible.

N1103.5.1.1 (R403.5.1.1) Circulation systems.
Heated water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermo-syphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water.

N1103.5.1.2 (R403.5.1.2) Heat trace systems.
Electric heat trace systems shall comply with IEEE 515.1 or UL 515. Controls for such systems shall automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy.

N1103.5.2 (R403.5.2) Demand recirculation systems. Deleted.
A water distribution system having one or more recirculation pumps that pump water from a heated water supply pipe back to the heated water source through a cold water supply pipe shall be a demand recirculation water system. Pumps shall have controls that comply with both of the following:

1. The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.

2. The control shall limit the temperature of the water entering the cold water piping to 104°F (40°C).
N1103.5.3 (R403.5.3) Hot water pipe insulation (Prescriptive). **Deleted.**
Insulation for hot water pipe with a minimum thermal resistance (R-value) of R-3 shall be applied to the following:

1. Piping 2\(\frac{1}{4}\) inch (19 mm) and larger in nominal diameter.
2. Piping serving more than one dwelling unit.
3. Piping located outside the conditioned space.
4. Piping from the water heater to a distribution manifold.
5. Piping located under a floor slab.
7. Supply and return piping in recirculation systems other than demand recirculation systems.

N1103.5.4 (R403.5.4) Drain water heat recovery units. **Deleted.**
Drain water heat recovery units shall comply with CSA 55.2. Drain water heat recovery units shall be tested in accordance with CSA 55.1. Potable water-side pressure loss of drain water heat recovery units shall be less than 3 psi (20.7 kPa) for individual units connected to one or two showers. Potable water-side pressure loss of drain water heat recovery units shall be less than 2 psi (13.8 kPa) for individual units connected to three or more showers.

N1103.6 (R403.6) Mechanical ventilation (Mandatory). The building shall be provided with ventilation that meets the requirements of Section M1507 of this code or the *International Mechanical Code*, as applicable, or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

N1103.6.1 (R403.6.1) Whole-house mechanical ventilation system fan efficacy. **Deleted.**
Mechanical ventilation system fans shall meet the efficacy requirements of Table N1103.6.1.

**Exception:** Where mechanical ventilation fans are integral to tested and listed HVAC equipment, they shall be powered by an electronically commutated motor.

**TABLE N1103.6.1 (R403.6.1)**
**MECHANICAL VENTILATION SYSTEM FAN EFFICACY**

<table>
<thead>
<tr>
<th>FAN LOCATION</th>
<th>AIR FLOW RATE MINIMUM (CFM)</th>
<th>MINIMUM EFFICACY (CFM/WATT)</th>
<th>AIR FLOW RATE MAXIMUM (CFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range hoods</td>
<td>Any</td>
<td>2.8 cfm/watt</td>
<td>Any</td>
</tr>
<tr>
<td>In-line fan</td>
<td>Any</td>
<td>2.8 cfm/watt</td>
<td>Any</td>
</tr>
<tr>
<td>Bathroom, utility room</td>
<td>10</td>
<td>1.4 cfm/watt</td>
<td>&lt; 90</td>
</tr>
</tbody>
</table>
N1103.7 (R403.7) Equipment sizing and efficiency rating (Mandatory).
Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies. New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law for the geographic location where the equipment is installed.

N1103.8 (R403.8) Systems serving multiple dwelling units (Mandatory).
Building mechanical systems and service water heating systems serving multiple dwelling units shall comply with Sections C403 and C404 of the IECC—Commercial Provisions in lieu of Section N1103.

N1103.9 (R403.9) Snow melt system controls (Mandatory).
Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F (10°C), and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4.8°C).

N1103.10 (R403.10) Pools and permanent spa energy consumption (Mandatory).
The energy consumption of pools and permanent spas shall be in accordance with Sections N1103.10.1 through N1103.10.

N1103.10.1 (R403.10.1) Residential pools and permanent residential spas.
Swimming pools and permanent spas that are accessory to detached one- and two-family dwellings and townhouses three stories or less in height above grade plane and that are available only to the household and its guests shall be in accordance with APSP-145.

N1103.10.2 (R403.10.2) Heaters.
The electric power to heaters shall be controlled by a readily accessible on-off switch that is an integral part of the heater mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. Gas-fired heaters shall not be equipped with continuously burning ignition pilots. All heaters shall be equipped with a readily accessible on-off switch that is mounted outside of the heater to allow shutting off the heater without adjusting the thermostat setting. Gas-fired heaters shall not be equipped with constant burning pilot lights.

N403.10.3 (R403.10.3) Time switches.
Time switches or other control methods that can automatically turn off and on according to a preset schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built-in time switches shall be in compliance with this section.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Pumps that operate solar- and waste-heat-recovery pool heating systems.

N1103.10.4 (R403.10.4) Covers.
Outdoor heated pools and outdoor permanent spas shall be provided with a vapor retardant cover or other approved vapor-retardant means.

Exception: Where more than 70 percent of the energy for heating, computed over an operation season, is from site-recovered energy, such as from a heat pump or solar energy source, covers or other vapor retardant means shall not be required. Pools deriving over 70 percent of the energy from heating from site-recovered or solar energy source.

N1103.11 (R403.11) Portable spas (Mandatory). Deleted.
The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP-14.

N1103.12 (R403.12) Residential pools and permanent residential spas.
Residential swimming pools and permanent residential spas that are accessory to detached one- and two-family dwellings and townhouses 3 stories or less in height above grade plane and that are available only to the household and its guests shall be in accordance with APSP-15.

SECTION N1104 (R404)
ELECTRICAL POWER AND LIGHTING SYSTEMS
(MANDATORY)

N1104.1 (R404.1) Lighting equipment (Mandatory).
Not less than 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficiency lamps or not less than 75 percent of the permanently installed lighting fixtures shall contain only high-efficiency lamps.

Exception: Low-voltage lighting.

N1104.1.1 (R404.1.1) Lighting equipment (Mandatory).
Fuel gas lighting systems shall not have continuously burning pilot lights.

SECTION N1105 (R405)
SIMULATED PERFORMANCE ALTERNATIVE
(PERFORMANCE)

N1105.1 (R405.1) Scope.
This section establishes criteria for compliance using simulated energy performance analysis. Such analysis shall include heating, cooling and service water heating energy only, those items identified in Table N1105.5.2(1), as applicable. A registered design professional is required to perform the analysis if required by North Carolina licensure laws.
N1105.2 (R405.2) Mandatory requirements.
Compliance with this section requires that the mandatory provisions identified in Section N1101.13(2) be met. All supply and return ducts not completely inside the building thermal envelope shall be insulated to a minimum of R-6.

N1105.3 (R405.3) Performance-based compliance.
Compliance based on simulated energy performance requires that a proposed residence (proposed design) be shown to have an annual energy cost that is less than or equal to the annual energy cost of the standard reference design. Energy prices shall be taken from a source approved by the building official, such as the Department of Energy, Energy Information Administration’s State Energy Price and Expenditure Report. Building officials shall be permitted to require time-of-use pricing in energy cost calculations.

Exception: The energy use based on source energy expressed in Btu (J) or Btu per square foot (J/m²) of conditioned floor area shall be permitted to be substituted for the energy cost. The source energy multiplier for electricity shall be 3.16. The source energy multiplier for fuels other than electricity shall be 1.1.

N1105.4 (R405.4) Documentation.
Documentation of the software used for the performance design and the parameters for the building shall be in accordance with Sections N1105.4.1 through N1105.4.3.

N1105.4.1 (R405.4.1) Compliance software tools.
Documentation verifying that the methods and accuracy of the compliance software tools conform to the provisions of this section shall be provided to the building official.

N1105.4.2 (R405.4.2) Compliance report.
Compliance software tools shall generate a report that documents that the proposed design complies with Section N1105.3. A compliance report on the proposed design shall be submitted with the application for the building permit. Upon completion of the building, a compliance report based on the as-built condition of the building shall be submitted to the code official before a certificate of occupancy is issued. Batch sampling of buildings to determine energy code compliance for all buildings in the batch shall be prohibited.

Compliance reports shall include information in accordance with Sections N1105.4.2.1 and N1105.4.2.2. Where the proposed design of a building could be built on different sites where the cardinal orientation of the building on each site is different, compliance of the proposed design for the purposes of the application for the building permit shall be based on the worst-case orientation, worst-case configuration, worst-case building air leakage and worst-case duct leakage. Such worst-case parameters shall be used as inputs to the compliance software for energy analysis.

N1105.4.2.1 (R405.4.2.1) Compliance report for permit application.
A compliance report submitted with the application for building permit shall include the following:

1. Building street address, or other building site identification.

2. A statement indicating that the proposed design complies with Section N1105.3.
3. An inspection checklist documenting the building component characteristics of the proposed design as indicated in Table N1105.5.2(1). The inspection checklist shall show results for both the standard reference design and the proposed design with user inputs to the compliance software to generate the results.

4. A site-specific energy analysis report that is in compliance with Section N1105.3.

5. The name of the individual performing the analysis and generating the report.

6. The name and version of the compliance software tool.

N1105.4.2.2 (R405.4.2.2) Compliance report for certificate of occupancy. A compliance report submitted for obtaining the certificate of occupancy shall include the following:

1. Building street address, or other building site identification.

2. A statement indicating that the as-built building complies with Section N1105.3.

3. A certificate indicating that the building passes the performance matrix for code compliance and listing the energy saving features of the buildings.

4. A site specific energy analysis report that is in compliance with Section N1105.3.

5. The name of the individual performing the analysis and generating the report.

6. The name and version of the compliance software tool.

N1105.4.3 (R405.4.3) Additional documentation. The building official shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the standard reference design.

2. A certification signed by the builder providing the building component characteristics of the proposed design as given in Table N1105.5.2(1).

3. Documentation of the actual values used in the software calculations for the proposed design.

N1105.5 (R405.5) Calculation procedure. Calculations of the performance design shall be in accordance with Sections N1105.5.1 and N1105.5.2.

N1105.5.1 (R405.5.1) General. Except as specified by this section, the standard reference design and proposed design shall be configured and analyzed using identical methods and techniques.
N1105.5.2 (R405.5.2) Residence specifications.
The standard reference design and proposed design shall be configured and analyzed as specified by Table N1105.5.2(1). Table N1105.5.2(1) shall include, by reference, all notes contained in Table N1102.1.2.

**TABLE N1105.5.2(1)[R405.5.2(1)]**
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

<table>
<thead>
<tr>
<th>BUILDING COMPONENT</th>
<th>STANDARD REFERENCE DESIGN</th>
<th>PROPOSED DESIGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above-grade walls</td>
<td>Type: mass wall if proposed wall is mass; otherwise wood frame.</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Gross area: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Solar absorptance = 0.75</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Remittance = 0.90</td>
<td>As proposed</td>
</tr>
<tr>
<td>Basement and crawl space walls</td>
<td>Type: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Gross area: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>U-factor: from Table N1102.1.4, with insulation layer on interior side of walls</td>
<td>As proposed</td>
</tr>
<tr>
<td>Above-grade floors</td>
<td>Type: wood frame</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Gross area: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>U-factor: as specified in Table N1102.1.4</td>
<td>As proposed</td>
</tr>
<tr>
<td>Ceilings</td>
<td>Type: wood frame</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Gross area: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>U-factor: as specified in Table N1102.1.4</td>
<td>As proposed</td>
</tr>
<tr>
<td>Roofs</td>
<td>Type: composition shingle on wood sheathing</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Gross area: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Solar absorptance = 0.75</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Emittance = 0.90</td>
<td>As proposed</td>
</tr>
<tr>
<td>Attics</td>
<td>Type: vented with aperture = (1 \text{ ft}^2 ) per (300 \text{ ft}^2) ceiling area</td>
<td>As proposed</td>
</tr>
<tr>
<td>Foundations</td>
<td>Type: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Foundation wall area above and below grade and soil characteristics: same as proposed</td>
<td>As proposed</td>
</tr>
<tr>
<td>Opaque doors</td>
<td>Area: (40 \text{ ft}^2)</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Orientation: North</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>U-factor: same as fenestration from Table N1102.1.4</td>
<td>As proposed</td>
</tr>
<tr>
<td>Vertical fenestration other than opaque doors</td>
<td>Total area (^{b}) = (a) The proposed glazing area, where the proposed glazing area is less than 15 percent of the conditioned floor area (b) 15 percent of the conditioned floor area, where the proposed glazing area is 15 percent or more of the conditioned floor area</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>Orientation: equally distributed to four cardinal compass orientations (N, E, S &amp; W).</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>U-factor: as specified in Table N1102.1.4</td>
<td>As proposed</td>
</tr>
<tr>
<td></td>
<td>SHGC: as specified in Table N1102.1.2 except that for climates with no requirement (NR) SHGC = 0.40 shall be used.</td>
<td>As proposed</td>
</tr>
<tr>
<td>BUILDING COMPONENT</td>
<td>STANDARD REFERENCE DESIGN</td>
<td>PROPOSED DESIGN</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>None, except where mechanical ventilation is specified by the proposed design, in which case: Annual vent fan energy use: kWh/yr $= 0.03942 \times CFA + 29.565 \times (N_{br} + 1)$ where: $CFA =$ conditioned floor area $N_{br} =$ number of bedrooms</td>
<td>As proposed</td>
</tr>
<tr>
<td>Internal gains</td>
<td>$IGain = 17,900 + 23.8 \times CFA + 4104 \times N_{br}$ (Btu/day per dwelling unit)</td>
<td>Same as standard reference design.</td>
</tr>
<tr>
<td>Internal mass</td>
<td>An internal mass for furniture and contents of 8 pounds per square foot of floor area.</td>
<td>Same as standard reference design, plus any additional mass specifically designed as a thermal storage element but not integral to the building envelope or structure.</td>
</tr>
<tr>
<td>Structural mass</td>
<td>For masonry floor slabs, 80 percent of floor area covered by R-2 carpet and pad, and 20 percent of floor directly exposed to room air.</td>
<td>As proposed</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Relevance</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>For masonry basement walls, as proposed, but with insulation required by Table R402.1.4 located on the interior side of the walls</td>
<td>As proposed</td>
<td></td>
</tr>
<tr>
<td>For other walls, for ceilings, floors, and interior walls, wood frame construction</td>
<td>As proposed</td>
<td></td>
</tr>
<tr>
<td>Heating systems</td>
<td>As proposed for other than electric heating without a heat pump, where the proposed design utilizes electric heating without a heat pump the standard reference design shall be an air source heat pump meeting the requirements of Section C403 of the IECC-Commercial Provisions. Capacity: sized in accordance with Section N1103.7</td>
<td>As proposed</td>
</tr>
<tr>
<td>Cooling systems</td>
<td>As proposed Capacity: sized in accordance with Section N1103.7.</td>
<td>As proposed</td>
</tr>
<tr>
<td>Service water heating</td>
<td>As proposed Use: same as proposed design</td>
<td>As proposed gal/day = 30 + (10 × ( N_{br} ))</td>
</tr>
<tr>
<td>Thermal distribution systems</td>
<td>Duct insulation: From Section N1103.2.1 N1103.3.1 A thermal distribution system efficiency (DSE) of 0.88 shall be applied to both the heating and cooling system efficiencies for all systems other than tested duct systems. For tested duct systems, the leakage rate shall be 4 cfm (113.3 L/min) per 100 ft(^2) (9.29 m(^2)) of conditioned floor area at a pressure of differential of 0.1 inches w.g. (25 Pa).</td>
<td>As tested or as specified in Table R405.5.2(2) N1105.5.2(2) if not tested. Duct insulation shall be as proposed the same as standard reference design.</td>
</tr>
<tr>
<td>Thermostat</td>
<td>Type: Manual, cooling temperature setpoint = 75°F; Heating temperature setpoint = 72°F</td>
<td>Same as standard reference</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.93 m\(^2\), 1 British thermal unit = 1055 J, 1 pound per square foot = 4.88 kg/m\(^2\), 1 gallon (US) = 3.785 L, °C = (°F - 32)/1.8, 1 degree = 0.79 rad.

a. Where required by the code official, testing shall be conducted by an approved party. Hourly calculations as specified in the ASHRAE Handbook of Fundamentals, or the equivalent shall be used to determine the energy loads resulting from infiltration.


c. Thermal storage element shall mean a component not part of the floors, walls or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase-change containers. A thermal storage element must be in the same room as fenestration that faces within 15 degrees (0.26 rad) of true south, or must be connected to such a room with pipes or ducts that allow the element to be actively charged.

d. For a proposed design with multiple heating, cooling or water heating systems using different fuel types, the applicable standard reference design system capacities and fuel types shall be weighted in accordance with their respective loads as calculated by accepted engineering practice for each equipment and fuel type present.

e. For a proposed design without a proposed heating system, a heating system with the prevailing federal minimum efficiency shall be assumed for both the standard reference design and proposed design.

f. For a proposed design home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the standard reference design and the proposed design.

g. For a proposed design with a nonstorage-type water heater, a 40-gallon storage-type water heater with the prevailing federal minimum energy factor for the same fuel as the predominant heating fuel type shall be assumed. For the case of a proposed design without a proposed water heater, a 40-gallon storage-type water heater shall be assumed.
TABLE N1105.5.2(2)[R405.5.2(2)]
DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR PROPOSED DESIGNS

<table>
<thead>
<tr>
<th>DISTRIBUTION SYSTEM CONFIGURATION AND CONDITION</th>
<th>FORCED AIR SYSTEMS</th>
<th>HYDRONIC SYSTEMS b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution system components located in unconditioned space</td>
<td>—</td>
<td>0.95</td>
</tr>
<tr>
<td>Untested distribution systems entirely located in conditioned space</td>
<td>0.88</td>
<td>1</td>
</tr>
<tr>
<td>&quot;Ductless&quot; systems</td>
<td>1</td>
<td>—</td>
</tr>
</tbody>
</table>

For SI: 1 cubic foot per minute = 0.47 L/s, 1 square foot = 0.093m², 1 pound per square inch = 6895 Pa, 1 inch water gauge = 1250 Pa.

a. Default values given by this table are for untested distribution systems, which must still meet minimum requirements for duct system insulation.
b. Hydronic systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed-loop piping and that do not depend on ducted, forced airflow to maintain space temperatures.
c. Entire system in conditioned space shall mean that no component of the distribution system, including the air handler unit, is located outside of the conditioned space.
d. Ductless systems shall be allowed to have forced airflow across a coil but shall not have any ducted airflow external to the manufacturer's air handler enclosure.

N1105.6 (R405.6) Calculation software tools.
Calculation software, where used, shall be in accordance with Sections N1105.6.1 through N1105.6.3.

N1105.6.1 (R405.6.1) Minimum capabilities.
Calculation procedures used to comply with this section shall be software tools capable of calculating the annual energy consumption of all building elements that differ between the standard reference design and the proposed design and shall include the following capabilities:

1. Computer generation of the standard reference design using only the input for the proposed design. The calculation procedure shall not allow the user to directly modify the building component characteristics of the standard reference design.

2. Calculation of whole-building (as a single zone) sizing for the heating and cooling equipment in the standard reference design residence in accordance with Section N1103.6.

3. Calculations that account for the effects of indoor and outdoor temperatures and part-load ratios on the performance of heating, ventilating and air-conditioning equipment based on climate and equipment sizing.

4. Printed building official inspection checklist listing each of the proposed design component characteristics from Table N1105.5.2(1) determined by the analysis to
provide compliance, along with their respective performance ratings (R-value, U-factor, SHGC, HSPF, AFUE, SEER, EF are some examples).

N1105.6.2 (R405.6.2) Specific approval.
Performance analysis tools meeting the applicable provisions of Section N1105 shall be permitted to be approved. Tools are permitted to be approved based on meeting a specified threshold for a jurisdiction. The building official shall be permitted to approve tools for a specified application or limited scope.

N1105.6.3 (R405.6.3) Input values.
When calculations require input values not specified by Sections N1102, N1103, N1104 and N1105, those input values shall be taken from an approved source.

SECTION N1106 (R406)
ENERGY RATING INDEX
COMPLIANCE ALTERNATIVE

N1106.1 (R406.1) Scope.
This section establishes criteria for compliance using an Energy Rating Index (ERI) analysis.

N1106.2 (R406.2) Mandatory requirements.
Compliance with this section requires that the mandatory provisions identified in Sections N1101.2 and N1103.5.3 N1101.14 through N1104 labeled as “mandatory” be met. The building thermal envelope shall be greater than or equal to levels of efficiency and Solar Heat Gain Coefficient in Table 402.1.2 or 402.1.4 of the 2009 International Energy Conservation Code Table 402.1.1 or Table 402.1.3 of the 2012 North Carolina Energy Conservation Code. Minimum standards associated with compliance shall be the ANSI/RESNET/ICC 301-2014 Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using an Energy Rating Index. A North Carolina registered design professional is required to perform the analysis if required by North Carolina licensure laws.

Exception: Supply and return ducts not completely inside the building thermal envelope shall be insulated to a minimum of R-6. Supply and return ducts in unconditioned space and outdoors shall be insulated to a minimum R-8. Supply ducts inside semi-conditioned space shall be insulated to a minimum R-4; return ducts inside conditioned and semi-conditioned space are not required to be insulated. Ducts located inside conditioned space are not required to be insulated other than as may be necessary for preventing the formation of condensation on the exterior of cooling ducts.

N1106.3 (R406.3) Energy rating index.
The Energy Rating Index (ERI) shall be a numerical integer value that is based on a linear scale constructed such that the ERI reference design has an Index value of 100 and a residential building that uses no net purchased energy has an Index value of 0. Each integer value on the scale shall represent a 1 percent change in the total energy use of the rated design relative to the total energy use of the ERI reference design. The ERI shall consider all energy used in the residential building.
N1106.3.1 (R406.3.1) ERI reference design.
The ERI reference design shall be configured such that it meets the minimum requirements of the 2006 International Energy Conservation Code prescriptive requirements.

The proposed residential building shall be shown to have an annual total normalized modified load less than or equal to the annual total loads of the ERI reference design.

N1106.4 (R406.4) ERI-based compliance.
Compliance based on an ERI analysis requires that the rated design be shown to have an ERI less than or equal to the appropriate value listed in Table N1106.4.1 or Table N1106.4.2, as applicable, when compared to the ERI reference design.

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>ENERGY RATING INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>51</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
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<tr>
<td>5</td>
<td>55</td>
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<tr>
<td>6</td>
<td>54</td>
</tr>
<tr>
<td>7</td>
<td>53</td>
</tr>
<tr>
<td>8</td>
<td>53</td>
</tr>
</tbody>
</table>

TABLE N1106.4 (R406.4) MAXIMUM ENERGY RATING INDEX

TABLE N1106.4.1 (R406.4.1) MAXIMUM ENERGY RATING INDEX
(without calculation of on-site renewable energy)

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>JAN. 1, 2019 – DEC. 31, 2022</th>
<th>JAN. 1, 2023 AND FORWARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>65</td>
<td>61</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>63</td>
</tr>
<tr>
<td>5</td>
<td>67</td>
<td>63</td>
</tr>
</tbody>
</table>

TABLE N1106.4.2 (R406.4.2) MAXIMUM ENERGY RATING INDEX
(including calculation of on-site renewable energy)

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>JAN. 1, 2019 – DEC. 31, 2022</th>
<th>JAN. 1, 2023 AND FORWARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>51</td>
<td>47</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>51</td>
</tr>
</tbody>
</table>

N1106.5 (R406.5) Verification by approved agency.
Verification of compliance with Section N1106 shall be completed by an approved third party performed by the registered design professional and the compliance documentation shall be provided to the code official. The code official shall inspect according to the requirements of Section N1106.6.2.
N1106.6 (R406.6) Documentation.
Documentation of the software used to determine the ERI and the parameters for the residential building shall be in accordance with Sections N1106.6.1 through N1106.6.3.

N1106.6.1 (R406.6.1) Compliance software tools.
Documentation verifying that the methods and accuracy of the compliance software tools conform to the provisions of this section shall be provided to the code official. Compliance software tools for this section shall be in compliance with ANSI/RESNET/ICC 301-2014.

N1106.6.2 (R406.6.2) Compliance report.
Compliance software tools shall generate a report that documents that the ERI of the rated design complies with Sections N1106.3 and N1106.4. The compliance documentation shall include the following information:

1. Address or other identification of the residential building.
2. An inspection checklist documenting the building component characteristics of the rated design. The inspection checklist shall show results for both the ERI reference design and the rated design, and shall document all inputs entered by the user necessary to reproduce the results.
3. Name of individual completing the compliance report.
4. Name and version of the compliance software tool.

Exception: Multiple orientations. Where an otherwise identical building model is offered in multiple orientations, compliance for any orientation shall be permitted by documenting that the building meets the performance requirements in each of the four (north, east, south and west) cardinal orientations.

N1106.6.3 (R406.6.3) Additional documentation. Deleted.
The code official shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the ERI reference design.
2. A certification signed by the builder providing the building component characteristics of the rated design.
3. Documentation of the actual values used in the software calculations for the rated design.

N1106.7 (R406.7) Calculation software tools.
Calculation software, where used, shall be in accordance with Sections N1106.7.1 through N1106.7.3.

N1106.7.1 R(406.7.1) Minimum capabilities.
Calculation procedures used to comply with this section shall be software tools capable of calculating the ERI as described in Section N1106.3 and shall be in compliance with ANSI/RESNET/ICC 301, and the software shall include the following capabilities:
1. Computer generation of the *ERI reference design* using only the input for the *rated design*.

The calculation procedure shall not allow the user to directly modify the building component characteristics of the *ERI reference design*.

2. Calculation of whole-building, as a single *zone*, sizing for the heating and cooling equipment in the *ERI reference design* residence in accordance with Section N1103.7.

3. Calculations that account for the effects of indoor and outdoor temperatures and part-load ratios on the performance of heating, ventilating and air-conditioning equipment based on climate and equipment sizing.

4. Printed *code official* inspection checklist listing each of the *rated design* component characteristics determined by the analysis to provide compliance, along with their respective performance ratings.

N1106.7.2 (406.7.2) Specific approval. **Deleted.**

Performance analysis tools meeting the applicable sections of Section N1106 shall be approved. Tools are permitted to be approved based on meeting a specified threshold for a jurisdiction. The code official shall approve tools for a specified application or limited scope.

N1106.7.3 (R406.7.3) Input values. **Deleted.**

When calculations require input values not specified by Sections N1102, N1103, N1104 and N1105, those input values shall be taken from an approved source.

**SECTION N1107 (R501)**

**EXISTING BUILDINGS—GENERAL**

N1107.1 (R501.1) Scope.

The provisions of Sections N1107 through N1111 shall control the *alteration*, repair, addition and change of occupancy of existing buildings and structures. When a section is identified to apply, the subsections to that section also apply.

N1107.1.1 (R501.1.1) Additions, alterations, or repairs: General.

Additions, alterations, or repairs to an existing building, building system or portion thereof shall comply with Section N1108, N1109 or N1110. Unaltered portions of the existing building or building supply system shall not be required to comply with this chapter.

N1107.2 (R501.2) Existing buildings.

Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing building or building system lawfully in existence at the time of adoption of this code.

N1107.3 (R501.3) Maintenance. **Deleted.**

Buildings and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems that are required by this code shall be maintained in conformance with the
The owner or the owner’s authorized agent shall be responsible for the maintenance of buildings and structures. The requirements of this chapter shall not provide the basis for removal or abrogation of energy conservation, fire protection and safety systems and devices in existing structures.

N1107.4 (R501.4) Compliance.

N1107.5 (R501.5) New and replacement materials.
Except as otherwise required or permitted by this code, materials permitted by the applicable code for new construction shall be used. Like materials shall be permitted for repairs, provided no hazard to life, health or property is created. Hazardous materials shall not be used where the code for new construction would not permit their use in buildings of similar occupancy, purpose and location.

N1107.6 (R501.6) Historic buildings.
No provision of this chapter relating to the construction, repair, alteration, restoration and movement of structures, and change of occupancy shall be mandatory for historic buildings provided a report has been submitted to the code official and signed by the owner, a registered design professional, or a representative of the State Historic Preservation Office or the historic preservation authority having jurisdiction, demonstrating that compliance with that provision would threaten, degrade or destroy the historic form, fabric or function of the building.

SECTION N1108 (R502)
ADDITIONS

N1108.1 (R502.1) General.
Additions to an existing building, building system or portion thereof shall conform to the provisions of this chapter as they relate to new construction without requiring the unaltered portion of the existing building or building system to comply with this chapter. Additions shall not create an unsafe or hazardous condition or overload existing building systems. An addition shall be deemed to comply with this chapter where the addition alone complies, where the existing building and addition comply with this chapter as a single building, or where the building with the addition uses no more energy than the existing building. Additions shall be in accordance with Section N1108.1.1 or N1108.1.2.

N1108.1.1 (R502.1.1) Prescriptive compliance.
Additions shall comply with Sections N1108.1.1.1 through N1108.1.1.4.

N1108.1.1.1 (R502.1.1.1) Building envelope.
New building envelope assemblies that are part of the addition shall comply with Sections N1102.1, N1102.2, N1102.3.1 through N1102.3.5, and N1102.4.
**Exception:** Where nonconditioned space is changed to conditioned space, the building envelope of the addition shall comply where the UA, as determined in Section N1102.1.4, of the existing building and the addition, and any alterations that are part of the project, is less than or equal to UA generated for the existing building.

**N1108.1.1.2 (R502.1.1.2) Heating and cooling systems.**
New heating, cooling and duct systems that are part of the addition shall comply with Sections N1103.1, N1103.2, N1103.3, N1103.5 N1103.4 and N1103.6. New heating and cooling appliances shall be sized in accordance with Section N1103.7. Extensions of ducts from an existing system to a new addition shall require that the existing system be evaluated for the new design.

**Exception:** Where ducts from an existing heating and cooling system are extended to an addition, duct systems with less than 40 linear feet (12.19 m) in unconditioned spaces shall not be required to be tested in accordance with Section N1103.2.2. Installation of an addition to an existing duct system shall not require a duct leakage test.

**N1108.1.1.3 (R502.1.1.3) Service hot water systems.**
New service hot water systems that are part of the addition shall comply with Section N1103.4 N1103.5.

**N1108.1.1.4 (R502.1.1.4) Lighting.**
New lighting systems that are part of the addition shall comply with Section N1104.1.

**N1108.1.2 (R502.1.2) Existing plus addition compliance (Simulated Performance Alternative for additions).**
Where nonconditioned space is changed to conditioned space, the addition shall comply where the annual energy cost or energy use of the addition and the existing building, and any alterations that are part of the project, is less than or equal to the annual energy cost of the existing building when modeled in accordance with Section N1105. The addition and any alterations that are part of the project shall comply with Section N1105 in its entirety, as applicable.

**SECTION N1109 (R503)**

**ALTERATIONS**

**N1109.1 (R503.1) General.**
Alterations to any building or structure shall comply with the requirements of the code for new construction. Alterations shall be such that the existing building or structure is no less conforming with the provisions of this chapter than the existing building or structure was prior to the alteration.

Alterations to an existing building, building system or portion thereof shall conform to the provisions of this chapter as they relate to new construction without requiring the unaltered portions of the existing building or building system to comply with this chapter. Alterations shall not create an unsafe or hazardous condition or overload existing building systems. Alterations shall be such that the existing building or structure uses no more energy than the existing building or structure prior to the alteration. Alterations to existing buildings shall comply with Sections N1109.1.1 through N1109.2.
N1109.1.1 (R503.1.1) Building envelope.  
Building envelope assemblies that are part of the alteration shall comply with Section N1102.1.2 or N1102.1.4, Sections N1102.2.1 through N1102.2.12, N1102.2.15, N1102.3.1, N1102.3.2, N1102.4.3 N1102.4.4 and N1102.4.4 N1102.4.6.

**Exception:** The following alterations to conditioned spaces need not comply with the requirements for new construction provided the energy use of the building is not increased:

1. Storm windows installed over existing fenestration.
2. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation. **Roof systems requiring air space for ventilation shall retain the ventilation space required.**
3. Construction where the existing roof, wall or floor cavity is not exposed.
4. Roof recovery and roof replacement such that the existing building or structure is no less conforming to the provisions of this code than the existing building or structure was prior to the alteration.
5. **Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either above or below the sheathing.** Deleted.
6. Surface applied window film installed on existing single pane fenestration assemblies to reduce solar heat gain **provided the code does not require the glazing or fenestration assembly to be replaced.**
7. Converting unconditioned attic space to conditioned attic space for one and two-family dwellings and townhouses. Ceilings shall be insulated to a minimum of R-30, walls shall be insulated to the exterior wall requirements in Table N1102.1.2 or Table N1102.1.4 and follow the backing requirements in Sections N1102.2.14 and N1102.2.15.

N1109.1.1.1 (R503.1.1.1) Replacement fenestration.  
Where some or all of an existing fenestration unit is replaced with a new fenestration product, including sash and glazing, the replacement fenestration unit shall meet the applicable requirements for **U**-factor and SHGC as provided in Table N1102.1.4. Where an entire existing fenestration unit is replaced with a new fenestration product, including frame, sash and glazing, the replacement fenestration unit shall meet the applicable requirements for **U**-factor and SHGC in Table N1102.1.2.

**Exception:** **Alterations** that replace less than 50 percent of entire fenestration units may be replaced with like or better fenestration units to match existing fenestration assemblies.
N1109.1.2 (R503.1.2) Heating and cooling systems.
New heating, cooling and duct systems that are part of the alteration shall comply with Sections N1103.1, N1103.2, N1103.3, N1103.4, and N1103.6, and N1103.7.

Exception: Where ducts from an existing heating and cooling system are extended, duct systems with less than 40 linear feet (12.19 m) in unconditioned spaces shall not be required to be tested in accordance with Section N1103.3.3. An alteration involving a partial system replacement to an existing duct system shall not require a duct leakage test.

N1109.1.3 (R503.1.3) Service hot water systems.
New service hot water systems that are part of the alteration shall comply with Section N1103.5.

N1109.1.4 (R503.1.4) Lighting.
New lighting systems that are part of the alteration shall comply with Section N1104.1.

Exception: Alterations that replace less than 50 percent of the luminaires in a space, provided that such alterations do not increase the installed interior lighting power.

N1109.2 (R503.2) Change in space conditioning.
Any nonconditioned or low energy space that is altered to become conditioned space shall be required to be brought into full compliance with this chapter. In addition to the requirements of Section N1109.1, projects changing unconditioned space to conditioned space and costing more than $10,000 shall require 10 percent of the project cost to be used toward meeting the requirements of this chapter. Project costs for the purpose of this section is the total project cost listed on all permits related to the work required to convert the unconditioned space to conditioned space and excludes the 10 percent added from this section. Under this section, existing building envelope elements that become a part of the building thermal envelope and are not changed are not required to be upgraded. The additional 10 percent of the project cost shall be appropriated for additional energy conservation features of choice that are addressed in this chapter. In addition to the 10 percent project cost, any existing wall, ceiling, or floor cavities that are exposed during construction shall at a minimum be insulated to comply with this chapter or be insulated to fill the cavity, whichever is less. Roof systems requiring air space for ventilation shall retain the ventilation space required. Projects costing less than $10,000 are not subject to the 10 percent project cost addition provision.

Exception: Where the simulated performance option in Section N1105 is used to comply with this section, the annual energy cost of the proposed design is permitted to be 110 percent of the annual energy cost otherwise allowed by Section N1105.3.

SECTION N1110 (R504)
REPAIRS

N1110.1 (R504.1) General.
Repair of the building systems shall not make the building less conforming than it was before the repair was undertaken. Buildings, structures and parts thereof shall be repaired in compliance with Section N1107.3 and this section. Work on nondamaged components necessary for the required repair of damaged components shall be considered part of the repair.
and shall not be subject to the requirements for alterations in this chapter. Routine maintenance required by Section N1107.3, ordinary repairs exempt from permit, and abatement of wear due to normal service conditions shall not be subject to the requirements for repairs in this section.

N1110.2 (R504.2) Application. Materials.
For the purposes of this code, the following shall be considered repairs:

1. Glass-only replacements in an existing sash and frame.

2. Roof repairs.

3. Repairs where only the bulb and/or ballast within the existing luminaires in a space are replaced provided that the replacement does not increase the installed interior lighting power.

Portions of walls that are part of the building thermal envelope shall be insulated in accordance with this code when the repair requires the removal of either the interior or exterior wall membrane such that the wall cavity is exposed during the repair.

   Exception: Wall cavities containing existing insulation material.

N1110.3 (R504.3) Glazing.
Repairs requiring the replacement of individual glass panes or sashes shall not require compliance with this code.

SECTION N1111 (R505)
CHANGE OF OCCUPANCY OR USE

N1111.1 (R505.1) General.
Spaces undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this code. Alterations performed in spaces undergoing a change in occupancy shall comply with the requirements of this code. Unaltered portions of the existing building or building supply system shall not be required to comply with this code.

N1111.2 (R505.2) General. Deleted.
Any space that is converted to a dwelling unit or portion thereof from another use or occupancy shall comply with this code.

   Exception: Where the simulated performance option in Section N1105 is used to comply with this section, the annual energy cost of the proposed design is permitted to be 110 percent of the annual energy cost otherwise allowed by Section N1105.3.
CHAPTER 12
MECHANICAL ADMINISTRATION

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1201
GENERAL

M1201.1 (101.2) Scope.
The provisions of Chapters 12 through 24 shall regulate the design, installation, maintenance, alteration and inspection of mechanical systems that are permanently installed and used to control environmental conditions within buildings. These chapters shall also regulate those mechanical systems, system components, equipment and appliances specifically addressed in this code.

M1201.2 Application.
In addition to the general administration requirements of Chapter 1, the administrative provisions of this chapter shall also apply to the mechanical requirements of Chapters 13 through 24.

SECTION M1202
EXISTING MECHANICAL SYSTEMS

M1202.1 (102.4) Additions, alterations or repairs.
Additions, alterations, renovations or repairs to a mechanical system shall conform to the requirements for a new mechanical system without requiring the existing mechanical system to comply with all of the requirements of this code. Additions, alterations or repairs shall not cause an existing mechanical system to become unsafe, hazardous or overloaded. Minor additions,
alterations or repairs to existing mechanical systems shall meet the provisions for new construction, unless such work is done in the same manner and arrangement as was in the existing system, is not hazardous, and is approved.

M1202.2 (102.2) Existing installations.
Except as otherwise provided for in this code, a provision in this code shall not require the removal, alteration or abandonment of, nor prevent the continued use and maintenance of, an existing mechanical system lawfully in existence at the time of the adoption of this code.

M1202.3 (102.3) Maintenance. Deleted.
Mechanical systems, both existing and new, and parts thereof shall be maintained in proper operating condition in accordance with the original design and in a safe and sanitary condition. Devices or safeguards that are required by this code shall be maintained in compliance with the code edition under which installed. The owner or the owner’s designated agent shall be responsible for maintenance of the mechanical systems. To determine compliance with this provision, the building official shall have the authority to require a mechanical system to be reinspected.

M1202.4 (102.6) Historic buildings.
The provisions of this code relating to the construction, alteration, repair, enlargement, restoration, relocation or moving of buildings or structures shall not be mandatory for existing buildings or structures identified and classified by the state or local jurisdiction as historic buildings where such buildings or structures are judged by the code official to be safe and in the public interest of health, safety and welfare regarding any proposed construction, alteration, repair, enlargement, restoration, relocation or moving of buildings.
CHAPTER 13
GENERAL MECHANICAL SYSTEM REQUIREMENTS

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1301
GENERAL

M1301.1 Scope.
The provisions of this chapter shall govern the installation of mechanical systems not specifically covered in other chapters applicable to mechanical systems. Installations of mechanical appliances, equipment and systems not addressed by this code shall comply with the applicable provisions of the International Mechanical Code and the International Fuel Gas Code.

M1301.1.1 Flood-resistant installation.
In flood hazard areas as established by Table R301.2(1), mechanical appliances, equipment and systems shall be located or installed in accordance with Section R322.1.6.

M1301.2 (301.3) Identification.
Each length of pipe and tubing and each pipe fitting utilized in a mechanical system shall bear the identification of the manufacturer as required by the listing or standard for the piping or tubing.

M1301.3 Installation of materials.
Materials shall be installed in strict accordance with the standards under which the materials are accepted and approved. In the absence of such installation procedures, the manufacturer’s instructions shall be followed. Where the requirements of referenced standards or manufacturer’s instructions do not conform to minimum provisions of this code, the provisions of this code shall apply.

M1301.4 (301.4) Plastic pipe, fittings and components. Deleted.
Plastic pipe, fittings and components shall be third-party certified as conforming to NSF 14.

M1301.5 Third-party testing and certification.
Piping, tubing and fittings shall comply with the applicable referenced standards, specifications and performance criteria of this code and shall be identified in accordance with Section M1301.2. Piping, tubing and fittings shall either be tested by an approved third-party testing agency or certified by an approved third-party certification agency.

SECTION M1302
APPROVAL

2018 North Carolina Residential Code
M1302.1 (301.7) Listed and labeled.
Appliances regulated by this code shall be listed and labeled for the application in which they are installed and used, unless otherwise approved in accordance with Section R104.11.

Exceptions:

1. Listing and labeling of equipment and appliances used for refrigeration shall be in accordance with Section 1101.2 of the North Carolina Mechanical Code.

2. Field erected equipment shall be deemed acceptable, provided it is assembled using listed components and parts, if the design thereof is by a registered design professional.

SECTION M1303
LABELING OF APPLIANCES

M1303.1 (301.9) Label information.
A permanent factory-applied nameplate(s) shall be affixed to appliances on which shall appear, in legible lettering, the manufacturer’s name or trademark, the model number, a serial number and the seal or mark of the testing agency. A label also shall include the following:

1. Electrical appliances. Electrical rating in volts, amperes and motor phase; identification of individual electrical components in volts, amperes or watts and motor phase; and in Btu/h (W) output and required clearances.

2. Absorption units. Hourly rating in Btu/h (W), minimum hourly rating for units having step or automatic modulating controls, type of fuel, type of refrigerant, cooling capacity in Btu/h (W) and required clearances.

3. Fuel-burning units. Hourly rating in Btu/h (W), type of fuel approved for use with the appliance and required clearances.

4. Electric comfort-heating appliances. The electric rating in volts, amperes and phase; Btu/h (W) output rating; individual marking for each electrical component in amperes or watts, volts and phase; and required clearances from combustibles.

5. Maintenance instructions. Required regular maintenance actions and title or publication number for the operation and maintenance manual for that particular model and type of product.

SECTION M1304
TYPE OF FUEL

M1304.1 (301.12) Fuel types.
Fuel-fired appliances shall be designed for use with the type of fuel to which they will be connected and the altitude at which they are installed. Appliances that comprise parts of the building mechanical system shall not be converted for the use of a different fuel, except where approved and converted in accordance with the manufacturer’s instructions. The fuel input rate shall not be increased or decreased beyond the limit rating for the altitude at which the

2018 North Carolina Residential Code
**SECTION M1305**
**APPLIANCE ACCESS**

**M1305.1 (306.1) Appliance access for inspection service, repair and replacement.**

*Appliances* shall be accessible for inspection, service, repair and replacement without removing permanent construction, other *appliances*, or any other piping or ducts not connected to the *appliance* being inspected, serviced, repaired or replaced. A level working space not less than 30 inches deep and 30 inches wide (762 mm by 762 mm) shall be provided in front of the control side to service an *appliance*.

**M1305.1.1 (306.1.1) Furnaces and air handlers.** *Deleted.*

Furnaces and air handlers within compartments or alcoves shall have a minimum working space clearance of 3 inches (76 mm) along the sides, back and top with a total width of the enclosing space being not less than 12 inches (305 mm) wider than the furnace or air handler. Furnaces having a firebox open to the atmosphere shall have not less than a 6-inch (152 mm) working space along the front combustion chamber side. Combustion air openings at the rear or side of the compartment shall comply with the requirements of Chapter 17.

**Exception:** This section shall not apply to replacement *appliances* installed in existing compartments and alcoves where the working space clearances are in accordance with the equipment or appliance manufacturer’s installation instructions.

**M1305.1.2 (306.2) Appliances in rooms.**

*Appliances* installed in a compartment, alcove, *basement* or similar space shall be accessed by an opening or door and an unobstructed passageway measuring not less than 24 inches (610 mm) wide and large enough to allow removal of the largest *appliance* in the space, provided there is a level service space of not less than 30 inches (762 mm) deep and the height of the *appliance*, but not less than 30 inches (762 mm), at the front or service side of the *appliance* with the door open.

**M1305.1.3 (306.3) Appliances in attics and above hard ceilings.**

*Attics* containing *appliances* shall be provided with an opening and a clear and unobstructed passageway large enough to allow removal of the largest *component of the appliance*, but not less than 30 inches (762 mm) high and 22 inches (559 mm) wide and not more than 20 feet (6096 mm) long measured along the centerline of the passageway from the opening to the *appliance*. The passageway shall have continuous solid flooring in accordance with Chapter 5 not less than 24 inches (610 mm) wide. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present along all sides of the *appliance* where access is required. The clear access opening dimensions shall be not less than 20 inches by 30 inches (508 mm by 762 mm), and large enough to allow removal of the largest *component of the appliance*.

**Exceptions:**

1. The passageway and level service space are not required where the *appliance* (or disassembled appliance) can be serviced and removed through the required opening.

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2. Where the passageway is unobstructed and not less than 6 feet (1829 mm) high and 22 inches (559 mm) wide for its entire length, the passageway shall be not more than 50 feet (15250 mm) long. Where the passageway is not less than 6 feet (1829 mm) high for its entire length, the passageway shall not be limited in length.

M1305.1.3.1 (306.3.1) Electrical requirements. Lighting outlet and receptacle. A luminaire controlled by a switch located at the required passageway opening and a receptacle outlet shall be installed at or near the appliance location in accordance with Chapter 39. Exposed lamps shall be protected from damage by location or lamp guards. For reference and coordination purposes only, refer to the North Carolina Electrical Code, Article 210.63 for receptacles, and Article 210.70 (3) for lighting outlet and switch locations.

M1305.1.4 (306.4) Appliances under floors and exterior grade installations. Underfloor spaces containing appliances shall be provided with an unobstructed passageway large enough to remove the largest component of the appliance, but not less than 30 inches (762 mm) high and 22 inches (559 mm) wide. Where the passageway is unobstructed and not less than 6 feet (1829 mm) high and 22 inches (559 mm) wide, it shall not be limited in length. Where the passageway is not less than 6 feet (1829 mm) high for its entire length, the passageway shall not be limited in length.

Exceptions:

1. The passageway is not required where the level service space is present when the access is open, and the appliance can be serviced and removed through the required opening.

2. Where the passageway is unobstructed and not less than 6 feet high (1929 mm) and 22 inches (559 mm) wide for its entire length, the passageway shall not be limited in length. Where the passageway is not less than 6 feet (1829 mm) high unobstructed and not less than 6 feet (1829 mm) high for its entire length, the passageway shall not be limited in length.

M1305.1.4.1 (304.10.1) Ground clearance. Equipment and appliances supported from the ground shall be level and firmly supported on a concrete slab or other approved material extending not less than 3 inches (76 mm) above the adjoining grade. Such support shall be in accordance with the manufacturer’s installation instructions. Appliances suspended from the floor shall have a clearance of not less than 6 inches (152 mm) from the ground.

M1305.1.4.1.1 (304.10.1) Exterior grade installations.
Equipment and appliances installed above grade level shall be supported on a solid base or approved material a minimum of 2 inches (51 mm) thick.

**M1305.1.4.1.2 (304.10.2) Under-floor installation.**
Suspended equipment shall be a minimum of 6 inches (152 mm) above the adjoining grade. See Section M1601.4.8 for ductwork support heights.

**M1305.1.4.1.3 (304.10.3) Crawl space supports.**
A support shall be provided at each corner of the unit not less than 8 inches by 8 inches (203.2 mm by 203.2 mm). The unit shall be supported a minimum of 2 inches (51 mm) above grade. When constructed of brick, the bricks shall be mortared together. All units stacked shall be mortared together. Fabricated units, formed concrete, or other approved materials shall be permitted.

**M1305.1.4.1.4 (304.10.4) Drainage.**
Below-grade installations shall be provided with a natural drain or an automatic lift or sump pump. For pit requirements, see Section M1305.1.4.2.

**M1305.1.4.2 (303.7) Excavations. Pit locations.**
Excavations for appliance installations shall extend to a depth of 6 inches (152 mm) below the appliance and 12 inches (305 mm) on all sides, except that the control side shall have a clearance of 30 inches (762 mm). Appliances installed in pits or excavations shall not come in direct contact with the surrounding soil. The sides of the pit or excavation shall be held back not less than 12 inches (305 mm) from the appliance. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry. Such concrete or masonry shall extend not less than 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse. The appliance shall be protected from flooding in an approved manner.

**M1305.1.4.3 Electrical requirements.**
A luminaire controlled by a switch located at the required passageway opening and a receptacle outlet shall be installed at or near the appliance location in accordance with Chapter 39 the North Carolina Electrical Code. Exposed lamps shall be protected from damage by location or lamp guards.

**SECTION M1306**
CLEARANCES FROM COMBUSTIBLE CONSTRUCTION

**M1306.1 (304.9) Appliance clearance.**
Appliances shall be installed with the clearances from unprotected combustible materials as indicated on the appliance label and in the manufacturer’s installation instructions. Heat-producing equipment and appliances shall be installed to maintain the required clearances to combustible construction as specified in the listing and manufacturer’s instructions. Such clearances shall be reduced only in accordance with Section M1306. Clearances to combustibles shall include such considerations as door swing, drawer pull, overhead projections or shelving and window swing, shutters, coverings and drapes. Devices such as doorstops or limits, closers, drapery ties or guards shall not be used to provide the required clearances.
Note: “A” equals the required clearance with no protection. “B” equals the reduced clearance permitted in accordance with Table M1306.2. The protection applied to the construction using combustible material shall extend far enough in each direction to make “C” equal to “A.”

FIGURE M1306.1
REDUCED CLEARANCE DIAGRAM
M1306.2 Clearance reduction.
The reduction of required clearances to combustible assemblies or combustible materials shall be based on Section M1306.2.1 or Section M1306.2.2.

**TABLE M1306.2**
REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION

<table>
<thead>
<tr>
<th>TYPE OF PROTECTION APPLIED TO</th>
<th>WHERE THE REQUIRED CLEARANCE WITHOUT PROTECTION FROM APPLIANCE, VENT CONNECTOR, OR SINGLE WALL METAL PIPE IS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36 inches</td>
</tr>
</tbody>
</table>

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### Allowable clearances with specified protection (Inches)

Use column 1 for clearances above an appliance or horizontal connector. Use column 2 for clearances from an appliance, vertical connector and single-wall metal pipe.

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Above column 1</th>
<th>Sides and rear column 2</th>
<th>Above column 1</th>
<th>Sides and rear column 2</th>
<th>Above column 1</th>
<th>Sides and rear column 2</th>
<th>Above column 1</th>
<th>Sides and rear column 2</th>
<th>Above column 1</th>
<th>Sides and rear column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 inch-thick masonry wall without ventilated air space</td>
<td>—</td>
<td>24</td>
<td>—</td>
<td>12</td>
<td>—</td>
<td>9</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>1/2 inch insulation board over 1-inch glass fiber or mineral wool batts</td>
<td>24</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) over 1-inch glass fiber or mineral wool batts reinforced with wire or rear face with a ventilated air space</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3/4 inch-thick masonry wall with ventilated air space</td>
<td>—</td>
<td>12</td>
<td>6</td>
<td>—</td>
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<td>—</td>
<td>6</td>
<td>—</td>
<td>6</td>
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</tr>
<tr>
<td>TYPE OF PROTECTIVE ASSEMBLY</td>
<td>REDUCED CLEARANCE WITH PROTECTION (inches)</td>
<td></td>
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</tr>
<tr>
<td>Galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) with a ventilated air space 1-inch off the combustible assembly</td>
<td>18 12 9 6 6 4 5 3 3 2</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2-inch-thick insulation board with ventilated air space</td>
<td>18 12 9 6 6 4 5 3 3 3</td>
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<tr>
<td>Galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) with ventilated air space over 24-gage sheet steel with a ventilated space</td>
<td>18 12 9 6 6 4 5 3 3 3</td>
<td></td>
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<tr>
<td>1-inch glass fiber or mineral wool batts sandwiched between two sheets of galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) with a ventilated air space</td>
<td>18 12 9 6 6 4 5 3 3 3</td>
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<tr>
<td>Required clearance to combustibles without protection (inches)</td>
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<tr>
<td>Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), mounted on 1-inch glass fiber or mineral wool batt reinforced with wire on the back, 1 inch off the combustible assembly</td>
<td>36  18  9  6   36  18  9  6</td>
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<tr>
<td>Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), spaced 1 inch off the combustible assembly</td>
<td>18  9  5  3   12  6  3  3</td>
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<tr>
<td>Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having a 1-inch airspace between layers, spaced 1 inch off the combustible assembly</td>
<td>18  9  5  3   12  6  3  3</td>
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<tr>
<td>Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having 1 inch of fiberglass insulation between layers, spaced 1 inch off the combustible assembly</td>
<td>18  9  5  3   12  6  3  3</td>
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<tr>
<td>0.5-inch inorganic insulating board, over 1 inch of fiberglass or mineral wool batt, against the combustible assembly</td>
<td>24  12  6  4   18  9  5  3</td>
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<tr>
<td>3 ( \frac{1}{2} )-inch brick wall, spaced 1 inch off the combustible wall</td>
<td>-    -   -   -   12  6  6  6</td>
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<tr>
<td>3 ( \frac{1}{2} )-inch brick wall, against the combustible wall</td>
<td>-    -   -   -   24  12  6  5</td>
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For SI: 1 inch = 25.4 mm, 1 pound per cubic foot = 16.019 kg/m³, \( ^\circ \text{C} = \left( ^\circ \text{F} - 32 \right) / 1.8 \), 1 Btu/(h × ft² × °F/in.) = 0.001442299 (W/cm² × °C/cm).

a. Reduction of clearances from combustible materials shall not interfere with combustion air, draft hood clearance and relief, and accessibility of servicing.
b. Clearances shall be measured from the surface of the heat producing appliance or equipment to the outer surface of the combustible material or combustible assembly.
c. Spacers and ties shall be of noncombustible material. Spacers and ties shall not be used directly opposite appliance or connector.
d. Where all clearance reduction systems use a ventilated air space, adequate provision for air circulation shall be provided as described. (See Figures M1306.1 and M1306.2.)
e. There shall be not less than 1 inch between clearance reduction systems and combustible walls and ceilings for reduction systems using ventilated air space.
f. If a wall protector is mounted on a single flat wall away from corners, adequate air circulation shall be permitted to be provided by leaving only the bottom and top edges or only the side and top edges open with not less than a 1-inch air gap.
g. Mineral wool and glass fiber batts (blanket or board) shall have a minimum density of 8 pounds per cubic foot and a minimum melting point of 1,500°F.
h. Insulation material used as part of a clearance reduction system shall have a thermal conductivity of 1.0 Btu inch per square foot per hour °F or less. Insulation board shall be formed of noncombustible material.
i. There shall be not less than 1 inch between the appliance and the protector. The clearance between the appliance and the combustible surface shall not be reduced below that allowed in this table.

j. All clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.

k. Listed single-wall connectors shall be permitted to be installed in accordance with the terms of their listing and the manufacturer’s instructions.

l. For limitations on clearance reduction for solid-fuel-burning appliances see Section M1306.2.3.

For SI: 1 inch = 25.4 mm.

**FIGURE M1306.2**
WALL PROTECTOR CLEARANCE REDUCTION SYSTEM

**M1306.2.1 (308.4.1) Labeled assemblies.**
The allowable clearance shall be based on an approved reduced clearance protective assembly that is listed and labeled in accordance with UL 1618. The allowable clearance reduction shall be based on an approved reduced clearance protective assembly that has been tested and bears the label of an approved agency.

**M1306.2.2 (308.4.2) Reduction table.**
Reduction of clearances shall be in accordance with the appliance manufacturer’s instructions and Table M1306.2. Forms of protection with ventilated air space shall conform to the following requirements:
1. Not less than 1-inch (25 mm) air space shall be provided between the protection and combustible wall surface.

2. Air circulation shall be provided by having edges of the wall protection open not less than 1 inch (25 mm).

3. If the wall protection is mounted on a single flat wall away from corners, air circulation shall be provided by having the bottom and top edges, or the side and top edges not less than 1 inch (25 mm).

4. Wall protection covering two walls in a corner shall be open at the bottom and top edges not less than 1 inch (25 mm).

M1306.2.3 Solid-fuel appliances.
Table M1306.2 shall not be used to reduce the clearance required for solid-fuel appliances listed for installation with minimum clearances of 12 inches (305 mm) or less. For appliances listed for installation with minimum clearances greater than 12 inches (305 mm), Table M1306.2 shall not be used to reduce the clearance to less than 12 inches (305 mm).

M1306.2.4 (308.4.2.2) Masonry chimneys.
The clearance reduction methods specified in Table M1306.2 shall not be utilized to reduce the clearances required for masonry chimneys as specified in Chapter 10 and the International Building Code.

M1306.2.5 (308.4.2.3) Chimney connector pass-throughs.
The clearance reduction methods specified in Table M1306.2 shall not be utilized to reduce the clearances required for chimney connector pass-throughs as specified in Table M1803.3.5 and Figure M1306.1.

M1306.2.6 (308.4.2.4) Masonry fireplaces.
The clearance reduction methods specified in Table M1306.2 shall not be utilized to reduce the clearances required for masonry fireplaces as specified in Chapter 10 and the International Building Code.

SECTION M1307
APPLIANCE INSTALLATION

M1307.1 (304.1) General.
Installation of appliances shall conform to the conditions of their listing and label and the manufacturer’s instructions. The manufacturer’s operating and installation instructions shall remain attached to the appliance. Equipment and appliances shall be installed as required by the terms of their approval, in accordance with the conditions of the listing, the manufacturer’s installation instructions and this code. Manufacturer’s installation instructions shall be available on the job site at the time of inspection.

M1307.2 Anchorage of appliances. Deleted.
Appliances designed to be fixed in position shall be fastened or anchored in an approved manner. In Seismic Design Categories D, D₁, and D₂, and in townhouses in Seismic Design Category C, water heaters and thermal storage units shall be anchored or strapped to resist horizontal displacement caused by earthquake motion in accordance with one of the following:
1. Anchorage and strapping shall be designed to resist a horizontal force equal to one-third of the operating weight of the water heater storage tank, acting in any horizontal direction. Strapping shall be at points within the upper one-third and lower one-third of the appliance’s vertical dimensions. At the lower point, the strapping shall maintain a minimum distance of 4 inches (102 mm) above the controls.

2. The anchorage strapping shall be in accordance with the appliance manufacturer’s recommendations.

M1307.3 (304.3) Elevation of ignition source.
Appliances having an ignition source shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor in garages. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate with a private garage through openings shall be considered to be part of the garage.

Exception: Elevation of the ignition source is not required for appliances that are listed as flammable-vapor-ignition resistant.

M1307.3.1 Protection from impact.
Appliances shall not be installed in a location subject to vehicle damage except where protected by approved barriers. Appliances located in private garages and carports shall be installed with a minimum clearance of 6 feet (1829 mm) above the floor. Appliances located out of the normal path of travel are not required to be protected.

Exception: The requirements of this section shall not apply where the appliances are protected from motor vehicle impact and installed in accordance with Section M1307.3.

M1307.4 (304.5) Hydrogen generating and refueling operations.
Ventilation shall be required in accordance with Section M1307.4.1, M1307.4.2 or M1307.4.3 in private garages that contain hydrogen-generating appliances or refueling systems. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

M1307.4.1 Natural ventilation.
Indoor locations intended for hydrogen-generating or refueling operations shall be limited to a maximum floor area of 850 square feet (79 m²) and shall communicate with the outdoors in accordance with Sections M1307.4.1.1 and M1307.4.1.2. The maximum rated output capacity of hydrogen-generating appliances shall not exceed 4 standard cubic feet per minute (1.9 L/s) of hydrogen for each 250 square feet (23 m²) of floor area in such spaces. The minimum cross-sectional dimension of air openings shall be 3 inches (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect. In those locations, equipment and appliances having an ignition source shall be located so that the source of ignition is not within 12 inches (305 mm) of the ceiling.

M1307.4.1.1 Two openings.
Two permanent openings shall be constructed within the garage. The upper opening shall be located entirely within 12 inches (305 mm) of the ceiling of the garage. The
lower opening shall be located entirely within 12 inches (305 mm) of the floor of the garage. Both openings shall be constructed in the same exterior wall. The openings shall communicate directly with the outdoors and shall have a minimum free area of \( \frac{1}{2} \) square foot per 1,000 cubic feet (1.7 \( m^2/1000 \ m^3 \)) of garage volume.

**M1307.4.1.2 Louvers and grilles.**
In calculating free area required by Section M1307.4.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have a 25-percent free area and metal louvers and grilles will have a 75-percent free area. Louvers and grilles shall be fixed in the open position.

**M1307.4.2 Mechanical ventilation.**
Indoor locations intended for hydrogen-generating or refueling operations shall be ventilated in accordance with Section 502.16 of the *International Mechanical Code*. In these locations, *equipment* and *appliances* having an *ignition source* shall be located so that the source of ignition is below the mechanical ventilation outlet(s).

**M1307.4.3 Specially engineered installations.**
As an alternative to the provisions of Sections M1307.4.1 and M1307.4.2, the necessary supply of air for ventilation and dilution of flammable gases shall be provided by an approved engineered system.

**M1307.5 Electrical appliances.**
Electrical *appliances* shall be installed in accordance with Chapters 14, 15, 19, and 20 and 34 through 43 of this code and the *North Carolina Electrical Code*.

**M1307.6 Plumbing connections.**
Potable water and drainage system connections to *equipment* and *appliances* regulated by this code shall be in accordance with Chapters 29 and 30.

**SECTION M1308**
**MECHANICAL SYSTEMS INSTALLATION**

**M1308.1 (302.3, 302.5) Drilling and notching.**
Wood-framed structural members shall be drilled, notched or altered in accordance with the provisions of Sections R502.8, R602.6, R602.6.1 and R802.7. Holes in load-bearing members of cold-formed steel light-frame construction shall be permitted only in accordance with Sections R505.2.6, R603.2.6 and R804.2.6. In accordance with the provisions of Sections R505.3.5, R603.3.4 and R804.3.3, cutting and notching of flanges and lips of load-bearing members of cold-formed steel light frame construction shall not be permitted. Structural insulated panels (SIPs) shall be drilled and notched or altered in accordance with the provisions of Section R610.7.

**M1308.2 (305.5) Protection against physical damage.**
Where piping will be concealed within light-frame construction assemblies, the piping shall be
protected against penetration by fasteners in accordance with Sections M1308.2.1 through M1308.2.3.

**Exception:** Cast iron piping and galvanized steel piping shall not be required to be protected.

**M1308.2.1 Piping through bored holes or notches.**
Where *piping* is installed through holes or notches in framing members and is located less than \( 1 \frac{1}{2} \) inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the pipe shall be protected by shield plates that cover the width of the pipe and the framing member and that extend 2 inches (51 mm) to each side of the framing member. Where the framing member that the piping passes through is a bottom plate, bottom track, top plate or top track, the shield plates shall cover the framing member and extend 2 inches (51 mm) above the bottom framing member(s) and 2 inches (51 mm) below the top framing member(s).

**M1308.2.2 Piping in other locations.**
Where piping is located within a framing member (i.e. steel studs) and is less than \( 1 \frac{1}{2} \) inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the piping shall be protected by shield plates that cover the width and length of the piping. Where piping is located outside of a framing member and is located less than \( 1 \frac{1}{2} \) inches (38 mm) from the nearest edge of the face of the framing member to which the membrane will be attached, the piping shall be protected by shield plates that cover the width and length of the piping.

**M1308.2.3 Shield plates.**
Shield plates shall be of steel material having a thickness of not less than 0.0575 inch (1.463 mm) (No. 16 gage).

**M1308.3 (305.5) Piping Support.**
Piping systems shall be supported in accordance with M2101.9.
CHAPTER 14
HEATING AND COOLING EQUIPMENT AND APPLIANCES

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1401
GENERAL

M1401.1 Installation.
Heating and cooling equipment and appliances shall be installed in accordance with the manufacturer's instructions and the requirements of this code.

M1401.2 Access.
Heating and cooling equipment and appliances shall be located with respect to building construction and other equipment and appliances to permit maintenance, servicing and replacement. Clearances shall be maintained to permit cleaning of heating and cooling surfaces; replacement of filters, blowers, motors, controls and vent connections; lubrication of moving parts; and adjustments.

Exception: Access shall not be required for ducts, piping, or other components approved for concealment.

M1401.3 (312.1) Equipment and appliance sizing.
Heating and cooling equipment and appliances shall be sized in accordance with ACCA Manual S or other approved sizing methodologies based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies.

Exception: Heating and cooling equipment and appliance sizing shall not be limited to the capacities determined in accordance with Manual S where either of the following conditions applies:

1. The specified equipment or appliance utilizes multistage technology or variable refrigerant flow technology and the loads calculated in accordance with the approved heating and cooling calculation methodology are within the range of the manufacturer’s published capacities for that equipment or appliance.

2. The specified equipment or appliance manufacturer’s published capacities cannot satisfy both the total and sensible heat gains calculated in accordance with the approved heating and cooling calculation methodology and the next larger standard size unit is specified.
For permitting, inspections, certificate of compliance or certificate of occupancy, verification of
calculation submittals and review shall not be required.

M1401.4 (303.5) Exterior installations.
Equipment and appliances installed outdoors shall be listed and labeled for outdoor installation.
Supports and foundations shall prevent excessive vibration, settlement or movement of the
equipment. Supports and foundations shall be in accordance with Section M1305.1.4.1.

M1401.5 Flood hazard.
In flood hazard areas as established by Table R301.2(1), heating and cooling equipment and
appliances shall be located or installed in accordance with Section R322.1.6.

SECTION M1402
CENTRAL FURNACES

M1402.1 (918.1) General.
Oil-fired central furnaces shall conform to ANSI/UL 727. Electric furnaces shall conform to UL
1995. Solid fuel furnaces shall be tested in accordance with UL 391.

M1402.2 Clearances.
Clearances shall be provided in accordance with the listing and the manufacturer’s installation
instructions.

M1402.3 Combustion air.
Combustion air shall be supplied in accordance with Chapter 17. Combustion air openings shall
be unobstructed for a distance of not less than 6 inches (152 mm) in front of the openings.

M1402.4 (918.3) Dampers.
Volume dampers shall not be placed in the air inlet to a furnace in a manner that will reduce the
required air to the furnace.

M1402.5 (918.4) Circulating air ducts for forced-air warm-air furnaces.
Circulating air for fuel-burning, forced-air-type, warm-air furnaces shall be conducted into the
blower housing from outside the furnace enclosure by continuous air-tight ducts.

M1402.6 (918.5) Outdoor and return air openings.
Outdoor intake openings shall be located in accordance with Section M1602.1. Return air
openings shall be located in accordance with Section M1602.2.

M1402.7 (918.6) Outdoor opening protection.
Outdoor air intake openings shall be protected in accordance with Section R303.6.

M1402.8 (918.7) Refrigeration coils in warm-air furnaces.
When a cooling coil is located in the supply plenum of a warm-air furnace, the furnace blower
shall be rated at not less than 0.5-inch water column (124 Pa) static pressure unless the furnace
is listed and labeled for use with a cooling coil. Cooling coils shall not be located upstream from
heat exchangers unless listed and labeled for such use. Conversion of existing furnaces for use
with cooling coils shall be permitted provided the furnace will operate within the temperature rise
specified for the furnace.
SECTION M1403
HEAT PUMP EQUIPMENT

M1403.1 (918.2) Heat pumps.
Electric heat pumps shall be listed and labeled in accordance with UL 1995 or UL/CSA/ANCE 60335-2-40.

SECTION M1404
REFRIGERATION COOLING EQUIPMENT

M1404.1 Compliance.
Refrigeration cooling equipment shall comply with Section M1411.

SECTION M1405
BASEBOARD CONVECTORS

M1405.1 (929.1) General.
Electric baseboard convectors shall be installed in accordance with the manufacturer’s instructions and Chapters 34 through 43 of this code. Electric baseboard heaters shall be listed and labeled in accordance with UL 1042.

SECTION M1406
RADIANT HEATING SYSTEMS

M1406.1 (927) General.
Electric radiant heating systems shall be installed in accordance with the manufacturer’s instructions and Chapters 34 through 43 of this code the North Carolina Electrical Code and shall be listed for the application.

M1406.2 Clearances.
Clearances for radiant heating panels or elements to any wiring, outlet boxes and junction boxes used for installing electrical devices or mounting luminaires shall comply with Chapters 34 through 43 of this code the North Carolina Electrical Code.

M1406.3 Installation of radiant panels.
Radiant panels installed on wood framing shall conform to the following requirements:

1. Heating panels shall be installed parallel to framing members and secured to the surface of framing members or mounted between framing members.

2. Mechanical fasteners shall penetrate only the unheated portions provided for this purpose. Panels shall not be fastened at any point closer than $\frac{1}{4}$ inch (6.4 mm) to an element. Other methods of attachment of the panels shall be in accordance with the panel manufacturer’s instructions.

3. Unless listed and labeled for field cutting, heating panels shall be installed as complete units.

2018 North Carolina Residential Code
M1406.4 Installation in concrete or masonry.
Radiant heating systems installed in concrete or masonry shall conform to the following requirements:

1. Radiant heating systems shall be identified as being suitable for the installation, and shall be secured in place as specified in the manufacturer’s installation instructions.

2. Radiant heating panels or radiant heating panel sets shall not be installed where they bridge expansion joints unless protected from expansion and contraction.

M1406.5 Finish surfaces.
Finish materials installed over radiant heating panels or systems shall be installed in accordance with the manufacturer’s instructions. Surfaces shall be secured so that nails or other fastenings do not pierce the radiant heating elements.

SECTION M1407
DUCT HEATERS

M1407.1 (930.1) General.
Electric duct heaters shall be installed in accordance with the manufacturer’s instructions and Chapters 34 through 43 of this code, the North Carolina Electrical Code. Electric duct heaters shall comply with UL 1996.

M1407.2 (930.2) Installation.
Electric duct heaters shall be installed so that they will not create a fire hazard. Class 1 ducts, duct coverings and linings shall be interrupted at each heater to provide the clearances specified in the manufacturer’s installation instructions. Such interruptions are not required for duct heaters listed and labeled for zero clearance to combustible materials. Insulation installed in the immediate area of each heater shall be classified for the maximum temperature produced on the duct surface.

M1407.3 (930.3) Installation with heat pumps and air conditioners.
Duct heaters located within 4 feet (1219 mm) of a heat pump or air conditioner shall be listed and labeled for such installations. The heat pump or air conditioner shall additionally be listed and labeled for such duct heater installations.

M1407.4 (930.4) Access.
Duct heaters shall be accessible for servicing, and clearance shall be maintained to permit adjustment, servicing and replacement of controls and heating elements.

M1407.5 (930.5) Fan interlock.
The fan circuit shall be provided with an interlock to prevent heater operation when the fan is not operating.

SECTION M1408
VENTED FLOOR FURNACES
M1408.1 (910.1) General.
Oil-fired vented floor furnaces shall comply with UL 729 and shall be installed in accordance with their listing, the manufacturer's instructions and the requirements of this code.

M1408.2 (910.4) Clearances.
Vented floor furnaces shall be installed in accordance with their listing and the manufacturer's instructions.

M1408.3 (910.2) Location.
Location of floor furnaces shall conform to the following requirements:

1. Floor registers of floor furnaces shall be installed not less than 6 inches (152 mm) from a wall.
2. Wall registers of floor furnaces shall be installed not less than 6 inches (152 mm) from the adjoining wall at inside corners.
3. The furnace register shall be located not less than 12 inches (305 mm) from doors in any position, draperies or similar combustible objects.
4. The furnace register shall be located not less than 5 feet (1524 mm) below any projecting combustible materials.
5. The floor furnace burner assembly shall not project into an occupied under-floor area.
6. The floor furnace shall not be installed in concrete floor construction built on grade.
7. The floor furnace shall not be installed where a door can swing within 12 inches (305 mm) of the grille opening.

M1408.4 Access.
An opening in the foundation not less than 18 inches by 24 inches (457 mm by 610 mm), or a trap door not less than 22 inches by 30 inches (559 mm by 762 mm) shall be provided for access to a floor furnace. The opening and passageway shall be large enough to allow replacement of any part of the equipment.

M1408.5 (910.4) Installation.
Floor furnace installations shall conform to the following requirements:

1. Thermostats controlling floor furnaces shall be located in the room in which the register of the floor furnace is located.
2. Floor furnaces shall be supported independently of the furnace floor register.
3. Floor furnaces shall be installed not closer than 6 inches (152 mm) to the ground. The minimum clearance shall be 2 inches (51 mm), where the lower 6 inches (152 mm) of the furnace is sealed to prevent water entry.
4. Where excavation is required for a floor furnace installation, the excavation shall extend 30 inches (762 mm) beyond the control side of the floor furnace and 12 inches (305 mm)
beyond the remaining sides. Excavations shall slope outward from the perimeter of the base of the excavation to the surrounding grade at an angle not exceeding 45 degrees (0.79 rad) from horizontal.

5. Floor furnaces shall not be supported from the ground.

SECTION M1409
VENTED WALL FURNACES

M1409.1 (909.1) General.
Oil-fired vented wall furnaces shall comply with UL 730 and shall be installed in accordance with their listing, the manufacturer’s instructions and the requirements of this code.

M1409.2 (909.2) Location.
The location of vented wall furnaces shall conform to the following requirements:

1. Vented wall furnaces shall be located where they will not cause a fire hazard to walls, floors, combustible furnishings or doors. Vented wall furnaces installed between bathrooms and adjoining rooms shall not circulate air from bathrooms to other parts of the building.

2. Vented wall furnaces shall not be located where a door can swing within 12 inches (305 mm) of the furnace air inlet or outlet measured at right angles to the opening. Doorstops or door closers shall not be installed to obtain this clearance.

M1409.3 (909.4) Installation.
Vented wall furnace installations shall conform to the following requirements:

1. Required wall thicknesses shall be in accordance with the manufacturer’s installation instructions.

2. Ducts shall not be attached to a wall furnace. Casing extensions or boots shall be installed only where listed as part of a listed and labeled appliance.

3. A manual shut off valve shall be installed ahead of all controls.

M1409.4 (909.6) Access.
Vented wall furnaces shall be provided with access for cleaning of heating surfaces; removal of burners; replacement of sections, motors, controls, filters and other working parts; and for adjustments and lubrication of parts requiring such attention. Panels, grilles and access doors that must be removed for normal servicing operations shall not be attached to the building construction.

SECTION M1410
VENTED ROOM HEATERS

M1410.1 (904.1, 922) General.
Vented room heaters shall be tested in accordance with ASTM E 1509 for pellet-fuel burning, UL 896 for oil-fired or UL 1482 for solid fuel-fired and installed in accordance with their listing, the manufacturer’s installation instructions and the requirements of this code.
M1410.2 Floor mounting.
Room heaters shall be installed on noncombustible floors or approved assemblies constructed of noncombustible materials that extend not less than 18 inches (457 mm) beyond the appliance on all sides.

Exceptions:

1. Listed room heaters shall be installed on noncombustible floors, assemblies constructed of noncombustible materials or floor protectors listed and labeled in accordance with UL 1618. The materials and dimensions shall be in accordance with the appliance manufacturer’s instructions.

2. Room heaters listed for installation on combustible floors without floor protection shall be installed in accordance with the appliance manufacturer’s instructions.

M1410.3 (905.3) Hearth extensions.
Hearth extensions for fireplace stoves shall be installed in accordance with the listing of the fireplace stove. The hearth extension shall be readily distinguishable from the surrounding floor area. Listed and labeled hearth extensions shall comply with UL 1618.

SECTION M1411
HEATING AND COOLING EQUIPMENT

M1411.1 Approved refrigerants.
Refrigerants used in direct refrigerating systems shall conform to the applicable provisions of ANSI/ASHRAE 34.

M1411.2 Refrigeration coils in warm-air furnaces.
Where a cooling coil is located in the supply plenum of a warm-air furnace, the furnace blower shall be rated at not less than 0.5-inch water column (124 Pa) static pressure unless the furnace is listed and labeled for use with a cooling coil. Cooling coils shall not be located upstream from heat exchangers unless listed and labeled for such use. Conversion of existing furnaces for use with cooling coils shall be permitted provided the furnace will operate within the temperature rise specified for the furnace. See Section M1402.8.

M1411.3 (307.2) Condensate disposal.
Condensate from cooling coils, condensing furnaces and evaporators shall be conveyed from the drain pan outlet to an approved place of disposal. Such piping shall maintain a minimum horizontal slope in the direction of discharge of not less than $\frac{1}{8}$ unit vertical in 12 units horizontal (1-percent slope). Where pumps are used, they shall be installed with a factory-equipped auxiliary high-level switch and shall shut off equipment served upon activation of the auxiliary high-level switch. Where damage to any building components will occur as a result of overflow from the pump, the pump shall also be located in the auxiliary drain pan or in a separate drain pan equipped with a separate drain line or water-level detection device. Condensate shall not discharge into a street, alley or other areas where it would cause a nuisance.
M1411.3.1 Auxiliary and secondary drain systems.
In addition to the requirements of Section M1411.3, a secondary drain or auxiliary drain pan shall be required for each cooling or evaporator coil where damage to any building components will occur as a result of overflow from the equipment drain pan or stoppage in the condensate drain piping. Such piping shall maintain a minimum horizontal slope in the direction of discharge of not less than $\frac{1}{8}$ unit vertical in 12 units horizontal (1-percent slope).

Drain piping shall be not less than $\frac{3}{4}$-inch (19 mm) nominal pipe size. One of the following methods shall be used:

1. An auxiliary drain pan with a separate drain shall be installed under the coils on which condensation will occur. The auxiliary pan drain shall discharge to a conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain. The pan shall have a minimum depth of 1.5 inches (38 mm), shall be not less than 3 inches (76 mm) larger than the unit or the coil dimensions in width and length and shall be constructed of corrosion-resistant material. Galvanized sheet steel pans shall have a minimum thickness of not less than 0.0236-inch (0.6010 mm) (No. 24 Gage). Nonmetallic pans shall have a minimum thickness of not less than 0.0625 inch (1.6 mm).
   
   a. Appliances with primary condensate pans above appliance components. Cooling coils mounted above the air handler or furnace shall have a secondary drain piped to auxiliary pan under air handler to avoid condensate migrating through appliance components before reaching the auxiliary drain pan.

2. A separate overflow drain line shall be connected to the drain pan installed with the equipment. This overflow drain shall discharge to a conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain. The overflow drain line shall connect to the drain pan at a higher level than the primary drain connection.

3. An auxiliary drain pan without a separate drain line shall be installed under the coils on which condensation will occur. This pan shall be equipped with a water level detection device conforming to UL 508 that will shut off the equipment served prior to overflow of the pan. The pan shall be equipped with a fitting to allow for drainage. The auxiliary drain pan shall be constructed in accordance with Item 1 of this section.

4. A water level detection device conforming to UL 508 shall be installed that will shut off the equipment served in the event that the primary drain is blocked. The device shall be installed in the primary drain line, upstream of the primary drain line trap, the overflow drain line or the equipment-supplied drain pan, located at a point higher than the primary drain line connection and below the overflow rim of such pan.

**Exception:** Fuel-fired appliances that automatically shut down operation in the event of a stoppage in the condensate drainage system.

M1411.3.1.1 (307.2.3.1) Water-level monitoring devices.
On down-flow units and other coils that do not have secondary drain or provisions to install a secondary or auxiliary drain pan, a water-level monitoring device shall be
installed inside the primary drain pan. This device shall shut off the equipment served in the event that the primary drain becomes restricted. Devices shall not be installed in the drain line.

**M1411.3.2 (307.2.2) Drain pipe materials and sizes.**
Components of the condensate disposal system shall be ABS, cast iron, copper, cross-linked polyethylene, CPVC, galvanized steel, PE-RT, polyethylene, polypropylene or PVC pipe or tubing. Components shall be selected for the pressure and temperature rating of the installation. Joints and connections shall be made in accordance with the applicable provisions of Chapter 30. Condensate waste and drain line size shall be not less than 3/4-inch (19 mm) nominal diameter from the drain pan connection to the place of condensate disposal. Where the drain pipes from more than one unit are manifolded together for condensate drainage, the pipe or tubing shall be sized in accordance with an approved method.

**M1411.3.3 Drain line maintenance.**
Condensate drain lines shall be configured to permit the clearing of blockages and performance of maintenance without requiring the drain line to be cut.

**M1411.3.4 (307.2.3.2) Appliances, equipment and insulation in pans.**
Where appliances, equipment or insulation are subject to water damage when auxiliary drain pans fill, those portions of the appliances, equipment and insulation shall be installed above the flood level rim of the pan. Supports located inside of the pan to support the appliance or equipment shall be water resistant and approved.

**M1411.3.5 (307.2.4) Traps.**
Condensate drains shall be trapped as required by the equipment or appliance manufacturer.

**M1411.3.5.1 (307.2.4.1) Ductless mini-split system traps.**
Ductless mini-split equipment that produces condensate shall be provided with an inline check valve located in the drain line, or a trap.

**M1411.4 (307.3) Condensate pumps.**
Condensate pumps located in uninhabitable spaces, such as attics and crawl spaces, shall be connected to the appliance or equipment served such that when the pump fails, the appliance or equipment will be prevented from operating. Pumps shall be installed in accordance with the manufacturer's instructions.

**M1411.5 Auxiliary drain pan.**
Category IV condensing appliances shall have an auxiliary drain pan where damage to any building component will occur as a result of stoppage in the condensate drainage system. These pans shall be installed in accordance with the applicable provisions of Section M1411.3.

**Exception:** Fuel-fired appliances that automatically shut down operation in the event of a stoppage in the condensate drainage system.

**M1411.6 Insulation of refrigerant piping.**
Piping and fittings for refrigerant vapor (suction) lines shall be insulated with insulation having a thermal resistivity of not less than $R = 4$ and having external surface permeance not...
exceeding 0.05 perm [2.87 ng/(s \cdot m^2 \cdot Pa)] when tested in accordance with ASTM E 96. 
Insulation shall be protected in accordance with N1103.3.1.

M1411.7 Location and protection of refrigerant piping. Deleted.
Refrigerant piping installed within 1 1/2 inches (38 mm) of the underside of roof decks shall be 
protected from damage caused by nails and other fasteners.

M1411.8 Locking access port caps. Deleted.
Refrigerant circuit access ports located outdoors shall be fitted with locking type tamper- 
resistant caps or shall be otherwise secured to prevent unauthorized access.

SECTION M1412
ABSORPTION COOLING EQUIPMENT
Deleted

M1412.1 Approval of equipment.
Absorption systems shall be installed in accordance with the manufacturer’s instructions.
Absorption equipment shall comply with UL 1995 or UL/CSA/ANCE 60335-2-40.

M1412.2 Condensate disposal.
Condensate from the cooling coil shall be disposed of as provided in Section M1411.3.

M1412.3 Insulation of piping.
Refrigerant piping, brine piping and fittings within a building shall be insulated to prevent 
condensation from forming on piping.

M1412.4 Pressure-relief protection.
Absorption systems shall be protected by a pressure-relief device. Discharge from the pressure-
relief device shall be located where it will not create a hazard to persons or property.

SECTION M1413
EVAPORATIVE COOLING EQUIPMENT
Deleted

M1413.1 General.
Evaporative cooling equipment and appliances shall comply with UL 1995 or UL/CSA/ANCE 
60335-2-40 and shall be installed:

1. In accordance with the manufacturer’s instructions.
2. On level platforms in accordance with Section M1305.1.4.1.
3. So that openings in exterior walls are flashed in accordance with Section R703.4.
4. So as to protect the potable water supply in accordance with Section P2902.
5. So that air intake opening locations are in accordance with Section R303.5.1.

SECTION M1414
FIREPLACE STOVES

M1414.1 (905.1) General.
Fireplace stoves shall be listed, labeled and installed in accordance with the terms of the listing. Fireplace stoves shall be tested in accordance with UL 737. Fireplace inserts intended for installation in fireplaces shall be listed and labeled in accordance with the requirements of UL 1482 and shall be installed in accordance with the manufacturer’s instructions.

M1414.2 (905.2) Connection to fireplace.
The connection of solid fuel appliances to chimney flues serving fireplaces shall comply with Sections M1803.4 and M1805.3.1.

M1414.3 (905.3) Hearth extensions.
Hearth extensions for fireplace stoves shall be installed in accordance with the listing of the fireplace stove. The supporting structure for a hearth extension for a fireplace stove shall be at the same level as the supporting structure for the fireplace unit. The hearth extension shall be readily distinguishable from the surrounding floor area.

SECTION M1415
MASONRY HEATERS

M1415.1 General.
Masonry heaters shall be constructed in accordance with Section R1002.

SECTION M1416
FACTORY-BUILT FIREPLACES

M1416.1 (R1004.1) General.
Factory-built fireplaces shall be listed and labeled and shall be installed in accordance with the conditions of the listing. Factory-built fireplaces shall be tested in accordance with UL 127.

M1416.2 (R1004.2) Hearth extensions.
Hearth extensions of approved factory-built fireplaces shall be installed in accordance with the listing of the fireplace. The hearth extension shall be readily distinguishable from the surrounding floor area. Listed and labeled hearth extensions shall comply with UL 1618.

M1416.3 (R1004.3) Decorative shrouds.
Decorative shrouds shall not be installed at the termination of chimneys for factory-built fireplace system and installed in accordance with the manufacturer’s instructions.

M1416.4 (R1004.4) Unvented gas log heaters.
An unvented gas log heater shall not be installed in a factory-built fireplace unless the fireplace system has been specifically tested, listed and labeled for such use in accordance with UL 127.

M1416.5 (R1004.5) Gasketed fireplace doors.
A gasketed fireplace door shall not be installed on a factory-built fireplace except where the fireplace system has been specifically tested, listed and labeled for such use in accordance with UL 127.
CHAPTER 15
EXHAUST SYSTEMS

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1501
GENERAL

M1501.1 (501.3) Outdoor discharge.
The air removed by every mechanical exhaust system shall be discharged to the outdoors in accordance with Section M1506.2. Air shall not be exhausted into an attic, soffit, ridge vent or crawl space. Exhaust shall not be directed onto walkways, balconies, decks, breezeways, covered walkways and similar horizontal projections.

Exceptions:

1. Whole-house ventilation-type attic fans that discharge into the attic space of dwelling units having private attics shall be permitted.

2. Where installed in accordance with the manufacturer’s instructions and where mechanical or natural ventilation is otherwise provided in accordance with Sections M1507 or R303.1, listed and labeled domestic ductless range hoods shall not be required to discharge to the outdoors.

SECTION M1502
CLOTHES DRYER EXHAUST

M1502.1 General.
Clothes dryers shall be exhausted in accordance with the manufacturer’s instructions.

M1502.2 Independent exhaust systems.
Dryer exhaust systems shall be independent of all other systems and shall convey the moisture to the outdoors.

Exception: This section shall not apply to listed and labeled condensing (ductless) clothes dryers.

M1502.3 (504.8.7) Duct termination.
Exhaust ducts shall terminate on the outside of the building. Exhaust duct terminations shall be in accordance with the dryer manufacturer’s installation instructions. If the manufacturer’s instructions do not specify a termination location, the exhaust duct shall terminate not less than 3 feet (914 mm) in any direction from openings into buildings. Exhaust duct terminations shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination or
weather cap outlet. Exhaust duct shall terminate not less than 12 inches (305 mm) above finished grade.

**Exception:** Where the duct termination is less than 12 inches (305 mm) above finished grade an areaway shall be provided with a cross-sectional area not less than 200 square inches (1290 cm²). The bottom of the duct termination shall be no less than 12 inches (305 mm) above the areaway bottom.

**M1502.4 (504.8) Dryer exhaust ducts.**
Dryer exhaust ducts shall conform to the requirements of Sections M1502.4.1 through M1502.4.7.

**M1502.4.1 Material and size.**
Exhaust ducts shall have a smooth interior finish and be constructed of metal having a minimum thickness of 0.0157 inches (0.3950 mm) (No. 28 gage) (28 ga galv. 26 ga Al). With the exception of the transition duct, flexible ducts are prohibited. The duct shall be 4 inches (102 mm) nominal in diameter.

**M1502.4.2 Duct installation.**
Exhaust ducts shall be supported at intervals not to exceed 12 feet (3658 mm) and shall be secured in place. The insert end of the duct shall extend into the adjoining duct or fitting in the direction of airflow. Exhaust duct joints shall be sealed in accordance with Section M1601.4.1 and shall be mechanically fastened. Ducts shall not be joined with screws or similar fasteners that protrude more than \( \frac{1}{8} \) inch (3.2 mm) into the inside of the duct. Ducts shall not be joined with screws or similar fasteners that protrude into the inside of the duct. Ducts shall be sealed in accordance with M1601.4.1.

a. Nonmetallic mechanical fasteners (tie-straps) shall be listed to UL 181B.

b. Metal band duct clamps are not required to be listed.

**M1502.4.3 (504.8.3) Transition duct.**
Transition ducts used to connect the dryer to the exhaust duct system shall be a single length that is listed and labeled in accordance with UL 2158A. Transition ducts shall be not greater than 8 feet (2438 mm) in length. Transition ducts shall not be concealed within construction and must remain entirely within the room in which the appliance is located.

**M1502.4.4 (504.8.4.3) Dryer exhaust duct power ventilators.**
Domestic dryer exhaust duct power ventilators shall conform to UL 705 for use in dryer exhaust duct systems. The dryer exhaust duct power ventilator shall be installed in accordance with the manufacturer’s instructions.

**M1502.4.5 (504.8.4) Duct length.**
The maximum allowable exhaust duct length shall be determined by one of the methods specified in Sections M1502.4.5.1 through M1502.4.5.3.

**M1502.4.5.1 Specified length.**
The maximum length of the exhaust duct shall be 35 feet (10 668 mm) from the connection to the transition duct from the dryer to the outlet terminal. Where fittings are
used, the maximum length of the exhaust duct shall be reduced in accordance with Table M1502.4.5.1. The maximum length of the exhaust duct does not include the transition duct.

**TABLE M1502.4.5.1**
DRYER EXHAUST DUCT FITTING EQUIVALENT LENGTH

<table>
<thead>
<tr>
<th>DRYER EXHAUST DUCT FITTING TYPE</th>
<th>EQUIVALENT LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inch radius mitered 45 degree elbow</td>
<td>2 feet 6 inches</td>
</tr>
<tr>
<td>4 inch radius mitered 90 degree elbow</td>
<td>5 feet</td>
</tr>
<tr>
<td>6 inch radius smooth 45 degree elbow</td>
<td>1 foot</td>
</tr>
<tr>
<td>6 inch radius smooth 90 degree elbow</td>
<td>1 foot 9 inches</td>
</tr>
<tr>
<td>8 inch radius smooth 45 degree elbow</td>
<td>1 foot</td>
</tr>
<tr>
<td>8 inch radius smooth 90 degree elbow</td>
<td>1 foot 7 inches</td>
</tr>
<tr>
<td>10 inch radius smooth 45 degree elbow</td>
<td>9 inches</td>
</tr>
<tr>
<td>10 inch radius smooth 90 degree elbow</td>
<td>1 foot 6 inches</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

**M1502.4.5.2 Manufacturer's instructions.**
The size and maximum length of the exhaust duct shall be determined by the dryer manufacturer’s installation instructions. The code official shall be provided with a copy of the installation instructions for the make and model of the dryer at the concealment inspection. In the absence of fitting equivalent length calculations from the clothes dryer manufacturer, Table M1502.4.4.1 shall be used.

**M1502.4.5.3 Dryer exhaust duct power ventilator.**
The maximum length of the exhaust duct shall be determined in accordance with the manufacturer’s instructions for the dryer exhaust duct power ventilator.

**M1502.4.6 Length identification.**
Where the exhaust duct equivalent length exceeds 35 feet (10 668 mm), the equivalent length of the exhaust duct shall be identified on a permanent label or tag. The label or tag shall be located within 6 feet (1829 mm) of the exhaust duct connection.

- Label shall be permanently stenciled, laminated, or commercially available plastic or metal tags.
- Labels shall state, at a minimum (fill in the blank):
  - Caution: Equivalent length _____ ft. Any installed dryer must be equipped with exhaust system that meets or exceeds this equivalent length requirement.
- Labels can be attached to wall or vent receptor.

**M1502.4.7 (504.8.5) Exhaust duct required.**
Where space for a clothes dryer is provided, an exhaust duct system shall be installed. Where the clothes dryer is not installed at the time of occupancy the exhaust duct shall be capped or plugged in the space in which it originates and identified and marked "future use."

**Exception:** Where a listed condensing clothes dryer is installed prior to occupancy of the structure.
M1502.5 (504.7) Protection required.
Protective shield plates shall be placed where nails or screws from finish or other work are likely to penetrate the clothes dryer exhaust duct. Shield plates shall be placed on the finished face of framing members where there is less than \( 1 \frac{1}{4} \) inches (32 mm) between the duct and the finished face of the framing member. Protective shield plates shall be constructed of steel, shall have a minimum thickness of 0.062-inch (1.6 mm) and shall extend not less than 2 inches (51 mm) above sole plates and below top plates.

SECTION M1503
RANGE HOODS

M1503.1 (505.1) General.
Range hoods shall discharge to the outdoors through a duct. The duct serving the hood shall have a smooth interior surface, shall be air tight, shall be equipped with a back-draft damper and shall be independent of all other exhaust systems. Ducts serving range hoods shall not terminate in an attic or crawl space or areas inside the building.

Exception: Where installed in accordance with the manufacturer’s instructions, and where mechanical or natural ventilation is otherwise provided, listed and labeled ductless range hoods shall not be required to discharge to the outdoors.

M1503.2 (505.1) Duct material.
Ducts serving range hoods shall be constructed of galvanized steel, stainless steel or copper.

Exception: Ducts for domestic kitchen cooking appliances equipped with down-draft exhaust systems shall be permitted to be constructed of schedule 40 PVC pipe and fittings provided that the installation complies with all of the following:

1. The duct is installed under a concrete slab poured on grade.
2. The underfloor trench in which the duct is installed is completely backfilled with sand or gravel.
3. The PVC duct extends not more than 1 inch (25 mm) above the indoor concrete floor surface.
4. The PVC duct extends not more than 1 inch (25 mm) above grade outside of the building.
5. The PVC ducts are solvent cemented.

M1503.3 Kitchen exhaust rates. Deleted.
Where domestic kitchen cooking appliances are equipped with ducted range hoods or down-draft exhaust systems, the fans shall be sized in accordance with Section M1507.4.

M1503.4 (505.2) Makeup air required.
Exhaust hood systems capable of exhausting in excess of 400 cubic feet per minute \((0.19 \text{ m}^3/\text{s})\) shall be mechanically or naturally provided with makeup air at a rate approximately equal to the
such makeup air systems shall be equipped with not less than one damper. Each damper shall be a gravity damper or an electrically operated damper that automatically opens when the exhaust system operates. Dampers shall be accessible for inspection, service, repair and replacement without removing permanent construction or any other ducts not connected to the damper being inspected, serviced, repaired or replaced.

Exhaust hood systems capable of exhausting in excess of 400 cubic feet per minute (0.19 m³/s) shall be provided with makeup air at a rate approximately equal to the exhaust air rate that is in excess of 400 cubic feet per minute (0.19 m³/s). Such makeup air systems shall be equipped with a means of closure and shall be automatically controlled to start and operate simultaneously with the exhaust system. Dampers shall be accessible for inspection, service, repair and replacement without removing permanent construction or any other ducts not connected to the damper being inspected, serviced, repaired or replaced.

**Exception:** Where all appliances in the house are direct-vent, power-vent, unvented, or electric, makeup air shall be provided where exhaust fans are capable of exhausting more than 600 cubic feet per minute (0.28 m³/s). Exhaust hood systems capable of exhausting more than 600 cubic feet per minute (0.28 m³/s) shall be provided with makeup air at a rate approximately equal to the exhaust air rate that is in excess of 600 cubic feet per minute (0.28 m³/s).

**M1503.4.1 Location.**
Kitchen exhaust makeup air shall be discharged into the same room in which the exhaust system is located or into rooms or *duct systems* that communicate through one or more permanent openings with the room in which such exhaust system is located. Such permanent openings shall have a net cross-sectional area not less than the required area of the makeup air supply openings.

**SECTION M1504**
**INSTALLATION OF MICROWAVE OVENS**

**M1504.1 (917.3) Installation of a microwave oven over a cooking appliance.**
The installation of a *listed* and *labeled* cooking *appliance* or microwave oven over a *listed* and *labeled* cooking *appliance* shall conform to the terms of the upper *appliance’s listing and label* and the manufacturer’s installation instructions. The microwave oven shall conform to UL 923.

**SECTION M1505**
**OVERHEAD EXHAUST HOODS**

**M1505.1 General.**
Domestic open-top broiler units shall have a metal exhaust hood, having a minimum thickness of 0.0157-inch (0.3950 mm) (No. 28 gage) with \( \frac{1}{4} \) inch (6.4 mm) clearance between the hood and the underside of combustible material or cabinets. A clearance of not less than 24 inches (610 mm) shall be maintained between the cooking surface and the combustible material or cabinet. The hood shall be not less than the width of the broiler unit, extend over the entire unit, discharge to the outdoors and be equipped with a backdraft damper or other means to control infiltration/extfiltration when not in operation. Broiler units incorporating an integral exhaust system, and *listed* and *labeled* for use without an exhaust hood, need not have an exhaust hood.
SECTION M1506
EXHAUST DUCTS AND EXHAUST OPENINGS

M1506.1 Duct construction.
Where exhaust duct construction is not specified in this chapter, construction shall comply with Chapter 16.

M1506.2 Duct length.
The length of exhaust and supply ducts used with ventilating equipment shall not exceed the lengths determined in accordance with Table M1506.2. Exhaust duct length shall comply with the manufacturer’s design criteria, standard duct airflow design methods, or where the flow rate of the installed ventilating equipment is verified by the installer or approved third party using a flow hood, flow grid or other airflow measuring device.

**Exception:** Duct length shall not be limited where the duct system complies with the manufacturer’s design criteria or where the flow rate of the installed ventilating equipment is verified by the installer or approved third party using a flow hood, flow grid or other airflow measuring device.

<table>
<thead>
<tr>
<th>DUCT TYPE</th>
<th>FLEX DUCT</th>
<th>SMOOTH-WALL DUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan airflow rating (CFM @ 0.25 inch wc)</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Diameter (inches)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Maximum length (feet)</td>
<td>114</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
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<td>7</td>
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<tr>
<td>7</td>
<td>8 and above</td>
<td>NL</td>
</tr>
<tr>
<td>8 and above</td>
<td>NL</td>
<td>NL</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.

a. Fan airflow rating shall be in accordance with ANSI/AMCA 210-ANSI/ASHRAE 51.
b. For noncircular ducts, calculate the diameter as four times the cross-sectional area divided by the perimeter.
c. This table assumes that elbows are not used. Fifteen feet of allowable duct length shall be deducted for each elbow installed in the duct run.
d. NL = no limit on duct length of this size.
e. X = not allowed. Any length of duct of this size with assumed turns and fittings will exceed the rated pressure drop.

M1506.3 (501.3.1) Exhaust openings.
Air exhaust openings shall terminate not less than 3 feet (914 mm) from property lines; 3 feet (914 mm) from operable and nonoperable openings into the building and 10 feet (3048 mm)
from mechanical air intakes except where the opening is located 3 feet (914 mm) above the air intake. Openings shall comply with Sections R303.5.2 and R303.6.

SECTION M1507
MECHANICAL VENTILATION

M1507.1 General.
Where local exhaust or whole-house mechanical ventilation is provided required, the equipment shall be designed in accordance with this section. Refer to Section R303.1 for natural ventilation.

M1507.2 Recirculation of air.
Exhaust air from bathrooms and toilet rooms shall not be recirculated within a residence or to another dwelling unit and shall be exhausted directly to the outdoors. Exhaust air from bathrooms and toilet rooms shall not discharge into an attic, crawl space or other areas inside the building.

M1507.3 Whole-house mechanical ventilation system.
Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1507.3.1 through M1507.3.3.

M1507.3.1 System design.
The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.

M1507.3.2 System controls.
The whole-house mechanical ventilation system shall be provided with controls that enable manual override.

M1507.3.3 (403.3.2) Mechanical ventilation rate.
The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate of not less than that determined in accordance with Table M1507.3.3(1).

Exception: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25-percent of each 4-hour segment and the ventilation rate prescribed in Table M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2).

<table>
<thead>
<tr>
<th>DWELLING UNIT FLOOR AREA (square feet)</th>
<th>NUMBER OF BEDROOMS</th>
<th>AIRFLOW IN CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1,500</td>
<td>0 – 1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2 – 3</td>
<td>45</td>
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<tr>
<td></td>
<td>4 – 5</td>
<td>60</td>
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<tr>
<td></td>
<td>6 – 7</td>
<td>75</td>
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<td></td>
<td>&gt; 7</td>
<td>90</td>
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<tr>
<td>1,501 – 3,000</td>
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<td>75</td>
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<td>90</td>
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<tr>
<td></td>
<td>&gt; 7</td>
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</tbody>
</table>
TABLE M1507.3.3(2) INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS\textsuperscript{a, b}

<table>
<thead>
<tr>
<th>RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT</th>
<th>25%</th>
<th>33%</th>
<th>50%</th>
<th>66%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor \textsuperscript{a}</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1.5</td>
<td>1.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

\begin{itemize}
\item[a.] For ventilation system run time values between those given, the factors are permitted to be determined by interpolation.
\item[b.] Extrapolation beyond the table is prohibited.
\end{itemize}

M1507.4 Local exhaust rates.

\textit{Local exhaust} systems shall be designed to have the capacity to exhaust the minimum air flow rate determined in accordance with Table M1507.4.

TABLE M1507.4 MINIMUM REQUIRED LOCAL EXHAUST RATES FOR ONE- AND TWO-FAMILY DWELLINGS

<table>
<thead>
<tr>
<th>AREA TO BE EXHAUSTED</th>
<th>EXHAUST RATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchens</td>
<td>100 cfm intermittent or 25 cfm continuous</td>
</tr>
<tr>
<td>Bathrooms-Toilet Rooms</td>
<td>Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous</td>
</tr>
</tbody>
</table>

For SI: 1 cubic foot per minute = 0.0004719 m\textsuperscript{3}/s.

SECTION M1508 (512) SUBSLAB SOIL EXHAUST SYSTEMS

M1508.1 (512.1) General.

Where a subslab soil exhaust system is provided, the system shall conform to the requirements of this section.

M1508.2 (512.2) Materials.

Subslab soil exhaust system duct material shall be air duct material \textit{listed} and \textit{labeled} to the requirements of UL 181 for Class 0 air ducts, or any of the following piping materials that comply with the \textit{International Plumbing Code} as building sanitary drainage and vent pipe: cast iron; galvanized steel; brass or copper pipe; copper tube of a weight not less than that of copper drainage tube, Type DWV; and plastic piping.
M1508.3 (512.3) Grade.
Exhaust system ducts shall not be trapped and shall have a minimum slope of one-eighth unit vertical in 12 units horizontal (1-percent slope).

M1508.4 (512.4) Termination.
Subslab soil exhaust system ducts shall extend through the roof and terminate not less than 6 inches (152 mm) above the roof and not less than 10 feet (3048 mm) from any operable openings or air intake.

M1508.5 (512.5) Identification.
Subslab soil exhaust ducts shall be permanently identified within each floor level by means of a tag, stencil or other approved marking.
CHAPTER 16
DUCT SYSTEMS

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1601
DUCT CONSTRUCTION

M1601.1 (601.1) Duct design. *Duct systems* serving heating, cooling and ventilation equipment shall be installed in accordance with the provisions of this section and ACCA Manual D, the appliance manufacturer’s installation instructions or other approved methods.

M1601.1.1 Above-ground duct systems. Above-ground duct systems shall conform to the following:

1. Equipment connected to duct systems shall be designed to limit discharge air temperature to not greater than 250°F (121°C).

2. Factory-made ducts shall be listed and labeled in accordance with UL 181 and installed in accordance with the manufacturer’s instructions.

3. Fibrous glass duct construction shall conform to the SMACNA Fibrous Glass Duct Construction Standards or NAIMA Fibrous Glass Duct Construction Standards.

4. Field-fabricated and shop-fabricated metal and flexible duct constructions shall conform to the SMACNA HVAC Duct Construction Standards—Metal and Flexible except as allowed by Table M1601.1.1. Galvanized steel shall conform to ASTM A 653.

5. The use of gypsum products to construct return air ducts or plenums is permitted, provided that the air temperature does not exceed 125°F (52°C) and exposed surfaces are not subject to condensation.

6. Duct systems shall be constructed of materials having a flame spread index of not greater than 200.

7. Stud wall cavities and the spaces between solid floor joists to be used as air plenums shall comply with the following conditions:

   7.1. These cavities or spaces shall not be used as a plenum for supply air.

   7.2. These cavities or spaces shall not be part of a required fire-resistance-rated assembly.
7.3. Stud wall cavities shall not convey air from more than one floor level.

7.4. Stud wall cavities and joist-space plenums shall be isolated from adjacent concealed spaces by tight-fitting fireblocking in accordance with Section R602.8.

7.5. Stud wall cavities in the outside walls of building envelope assemblies shall not be utilized as air plenums.

**TABLE M1601.1.1**

**DUCT CONSTRUCTION MINIMUM SHEET METAL THICKNESS FOR SINGLE DWELLING UNITS**

<table>
<thead>
<tr>
<th>ROUND DUCT DIAMETER (inches)</th>
<th>STATIC PRESSURE</th>
<th>1/2-inch water gage</th>
<th>1-inch water gage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thickness (inches)</td>
<td>Galvanized</td>
<td>Aluminum</td>
</tr>
<tr>
<td>≤ 12</td>
<td>0.013</td>
<td>0.018</td>
<td>0.013</td>
</tr>
<tr>
<td>12 to 14</td>
<td>0.013</td>
<td>0.018</td>
<td>0.016</td>
</tr>
<tr>
<td>15 to 17</td>
<td>0.016</td>
<td>0.023</td>
<td>0.019</td>
</tr>
<tr>
<td>18</td>
<td>0.016</td>
<td>0.023</td>
<td>0.024</td>
</tr>
<tr>
<td>19 to 20</td>
<td>0.019</td>
<td>0.027</td>
<td>0.024</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECTANGULAR DUCT DIMENSION (inches)</th>
<th>STATIC PRESSURE</th>
<th>1/2-inch water gage</th>
<th>1-inch water gage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thickness (inches)</td>
<td>Galvanized</td>
<td>Aluminum</td>
</tr>
<tr>
<td>≤ 8</td>
<td>0.013</td>
<td>0.018</td>
<td>0.013</td>
</tr>
<tr>
<td>9 to 10</td>
<td>0.013</td>
<td>0.018</td>
<td>0.016</td>
</tr>
<tr>
<td>11 to 12</td>
<td>0.016</td>
<td>0.023</td>
<td>0.019</td>
</tr>
<tr>
<td>13 to 16</td>
<td>0.019</td>
<td>0.027</td>
<td>0.019</td>
</tr>
<tr>
<td>17 to 18</td>
<td>0.019</td>
<td>0.027</td>
<td>0.024</td>
</tr>
<tr>
<td>19 to 20</td>
<td>0.024</td>
<td>0.034</td>
<td>0.024</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 inch water gage = 249 Pa.

a. Ductwork that exceeds 20 inches by dimension or exceeds a pressure of 1 inch water gage (250 Pa) shall be constructed in accordance with SMACNA HVAC Duct Construction Standards—Metal and Flexible.

<table>
<thead>
<tr>
<th>DUCT SIZE</th>
<th>MINIMUM THICKNESS (inches)</th>
<th>EQUIVALENT GAGE (galvanized)</th>
<th>ALUMINUM MINIMUM THICKNESS (inches) [gage]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round Ducts and Enclosed Rectangular Ducts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 inches or less</td>
<td>0.013</td>
<td>30</td>
<td>0.0159 [26]</td>
</tr>
<tr>
<td>Over 14 inches</td>
<td>0.016</td>
<td>28</td>
<td>0.0201 [24]</td>
</tr>
<tr>
<td>Exposed Rectangular Ducts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 inches or less</td>
<td>0.016</td>
<td>28</td>
<td>0.0201 [24]</td>
</tr>
<tr>
<td>Over 14 inches</td>
<td>0.019</td>
<td>26</td>
<td>0.0253 [22]</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm
M1601.1.2 (603.8) Underground duct systems.
Underground duct systems shall be constructed of approved concrete, clay, metal or plastic. The maximum duct temperature for plastic ducts shall not be greater than 150°F (66°C). Metal ducts shall be protected from corrosion in an approved manner or shall be completely encased in concrete not less than 2 inches (51 mm) thick. Nonmetallic ducts shall be installed in accordance with the manufacturer’s instructions. Plastic pipe and fitting materials shall conform to cell classification 12454-B of ASTM D 1248 or ASTM D 1784 and external loading properties of ASTM D 2412. Ducts shall slope to an accessible point for drainage. Where encased in concrete, ducts shall be sealed and secured prior to any concrete being poured. Metallic ducts having an approved protective coating and nonmetallic ducts shall be installed in accordance with the manufacturer’s instructions.

M1601.2 Vibration isolators. Flexible connections.
Vibration isolators Flexible connectors installed between mechanical equipment and metal ducts shall be fabricated from approved materials and shall not exceed 10 inches (254 mm) in length.

M1601.3 (604.4) Duct insulation materials.
Duct insulation materials shall conform to the following requirements:

1. Duct coverings and linings, including adhesives where used, shall have a flame spread index not higher than 25, and a smoke-developed index not over 50 when tested in accordance with ASTM E 84 or UL 723, using the specimen preparation and mounting procedures of ASTM E 2231.

Exception: Spray application of polyurethane foam to the exterior of ducts in attics and crawl spaces shall be permitted subject to all of the following:

1. The flame spread index is not greater than 25 and the smoke-developed index is not greater than 450 at the specified installed thickness.

2. The foam plastic is protected in accordance with the ignition barrier requirements of Sections R316.5.3 and R316.5.4.

3. The foam plastic complies with the requirements of Section R316.

2. Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C 411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250°F (121°C). Coverings and linings shall be listed and labeled.

3. External reflective duct insulation shall be legibly printed or identified at intervals not greater than 36 inches (914 mm) with the name of the manufacturer, the product R-value at the specified installed thickness and the flame spread and smoke-developed indices. The installed thickness of the external duct insulation shall include the enclosed air space(s). The product R-value for external reflective duct insulation shall be determined in accordance with ASTM C1668.

4. External duct insulation and factory-insulated flexible ducts shall be legibly printed or identified at intervals not longer than 36 inches (914 mm) with the name of the manufacturer, the thermal resistance R-value at the specified installed thickness and the
flame spread and smoke-developed indexes of the composite materials. Spray polyurethane foam manufacturers shall provide the same product information and properties, at the nominal installed thickness, to the customer in writing at the time of foam application. Nonreflective duct insulation product R-values shall be based on insulation only, excluding air films, vapor retarders or other duct components, and shall be based on tested C-values at 75°F (24°C) mean temperature at the installed thickness, in accordance with recognized industry procedures. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

4.1. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

4.2. For ductwrap, the installed thickness shall be assumed to be 75 percent (25-percent compression) of nominal thickness.

4.3. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

4.4. For spray polyurethane foam, the aged R-value per inch measured in accordance with recognized industry standards shall be provided to the customer in writing at the time of foam application. In addition, the total R-value for the nominal application thickness shall be provided.

M1601.4 Installation.
Duct installation shall comply with Sections M1601.4.1 through M1601.4.10.

M1601.4.1 Joints, seams and connections.
Longitudinal and transverse joints, seams and connections in metallic and nonmetallic ducts shall be constructed as specified in SMACNA HVAC Duct Construction Standards—Metal and Flexible and NAIMA Fibrous Glass Duct Construction Standards. Joints, longitudinal and transverse seams, and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, liquid sealants or tapes. Tapes and mastics used to seal fibrous glass ductwork shall be listed and labeled in accordance with UL 181A and shall be marked “181A-P” for pressure-sensitive tape, “181 A-M” for mastic or “181 A-H” for heat-sensitive tape.

Tapes and mastics used to seal metallic and flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked “181 B-FX” for pressure-sensitive tape or “181 BM” for mastic. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with UL 181B and shall be marked 181B-C. Crimp joints for round metallic ducts shall have a contact lap of not less than 1 inch (25 mm) and shall be mechanically fastened by means of not less than three sheet-metal screws or rivets equally spaced around the joint. Unlisted duct tape is not permitted as a sealant on any metal ducts.

Closure systems used to seal all ductwork shall be installed in accordance with the manufacturers’ instructions.

Exceptions:
1. Spray polyurethane foam shall be permitted to be applied without additional joint seals.

2. Where a duct connection is made that is partially inaccessible, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.

3. For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams and locking-type joints and seams of other than the snap-lock and button-lock types. Deleted.

Exceptions:

1. Continuously welded joints and seams in ducts.

2. Ducts exposed within the conditioned space that the ducts serve shall not be required to be sealed.

M1601.4.2 Duct lap.
Crimp joints for round and oval metal ducts shall be lapped not less than 1 inch (25 mm) and the male end of the duct shall extend into the adjoining duct in the direction of airflow.

M1601.4.3 Plastic duct joints.
Joints between plastic ducts and plastic fittings shall be made in accordance with the manufacturer’s installation instructions.

M1601.4.4 Support.
Factory-made ducts listed in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions. Field- and shop-fabricated fibrous glass ducts shall be supported in accordance with the SMACNA Fibrous Glass Duct Construction Standards or the NAIMA Fibrous Glass Duct Construction Standards. Field- and shop-fabricated metal and flexible ducts shall be supported in accordance with the SMACNA HVAC Duct Construction Standards—Metal and Flexible or in accordance with M1601.4.4.1.

All equipment shall be supported independently of the duct system except when the duct is used as a support base. When used as a support base, the duct shall be of sufficient strength and designed to support the weight of the unit. Listed bases shall be installed in accordance with the manufacturer’s installation instructions.

M1601.4.4.1 (603.10.1) Metal duct minimal support.
Metal ducts shall be securely supported. Where hung or suspended, metal straps a minimum of 1 inch (25 mm) in width and equivalent to or heavier gage than the duct being supported shall be used. Straps, when used, shall be at maximum 64-inch (1626 mm) intervals and shall be securely attached to the building structure. Straps shall be attached to the duct at a minimum of two points with screws or rivets.

M1601.4.5 Fireblocking.
Duct installations shall be fireblocked in accordance with Section R602.8.
**M1601.4.6 (604.1) Duct insulation.**

Duct insulation shall be installed in accordance with the following requirements:

1. A vapor retarder having a maximum permeance of 0.05 perm \([2.87 \text{ ng}/(\text{s} \cdot \text{m}^2 \cdot \text{Pa})]\) in accordance with ASTM E 96, or aluminum foil with a minimum thickness of 2 mils (0.05 mm), shall be installed on the exterior of insulation on cooling supply ducts that pass through unconditioned spaces conducive to condensation except where the insulation is spray polyurethane foam with a maximum water vapor permeance of 3 perm per inch \([1722 \text{ ng}/(\text{s} \cdot \text{m}^2 \cdot \text{Pa})]\) at the installed thickness.

2. Exterior *duct systems* shall be protected against the elements.

3. Duct coverings shall not penetrate a fireblocked wall or floor.

Replacement or addition of cooling equipment to existing ductwork located in an attic shall require the ductwork to be insulated. Replacement of heating or the addition of cooling equipment in a crawl space or conditioned basements shall not require the existing ductwork to be insulated. Unconditioned basement ductwork shall require insulation with the addition of cooling.

**M1601.4.7 Factory-made air ducts.**

Factory-made air ducts shall not be installed in or on the ground, in tile or metal pipe, or within masonry or concrete.

**M1601.4.8 (603.14) Duct separation.**

Ducts shall be installed with not less than 4 inches (102 mm) separation from earth except where they meet the requirements of Section M1601.1.2.

**M1601.4.9 Ducts located in garages.**

Ducts in garages shall comply with the requirements of Section R302.5.2.

**M1601.4.10 Flood hazard areas.**

In flood hazard areas as established by Table R301.2(1), *duct systems* shall be located or installed in accordance with Section R322.1.6.

**M1601.5 Under-floor plenums.**

Under-floor plenums shall be prohibited in new structures. Modification or repairs to under-floor plenums in existing structures shall conform to the requirements of this section.

**M1601.5.1 General.**

The space shall be cleaned of loose combustible materials and scrap, and shall be tightly enclosed. The ground surface of the space shall be covered with a moisture barrier having a minimum thickness of 4 mils (0.1 mm). Plumbing waste cleanouts shall not be located within the space.

Exception: Plumbing waste cleanouts shall be permitted to be located in unvented crawl spaces that receive *conditioned air* in accordance with Section R408.3.
M1601.5.2 Materials.
The under-floor space, including the sidewall insulation, shall be formed by materials having flame spread index values not greater than 200 when tested in accordance with ASTM E 84 or UL 723.

M1601.5.3 Furnace connections.
A duct shall extend from the furnace supply outlet to not less than 6 inches (152 mm) below the combustible framing. This duct shall comply with the provisions of Section M1601.1. A noncombustible receptacle shall be installed below any floor opening into the plenum in accordance with the following requirements:

1. The receptacle shall be securely suspended from the floor members and shall be not more than 18 inches (457 mm) below the floor opening.

2. The area of the receptacle shall extend 3 inches (76 mm) beyond the opening on all sides.

3. The perimeter of the receptacle shall have a vertical lip not less than 1 inch (25 mm) in height at the open sides.

M1601.5.4 Access.
Access to an under-floor plenum shall be provided through an opening in the floor with minimum dimensions of 18 inches by 24 inches (457 mm by 610 mm).

M1601.5.5 Furnace controls.
The furnace shall be equipped with an automatic control that will start the air-circulating fan when the air in the furnace bonnet reaches a temperature not higher than 150°F (66°C). The furnace shall additionally be equipped with an approved automatic control that limits the outlet air temperature to 200°F (93°C).

M1601.6 Independent garage HVAC systems.
Furnaces and air-handling systems that supply air to living spaces shall not supply air to or return air from a garage.

SECTION M1602
RETURN AIR

M1602.1 Outdoor air openings.
Outdoor intake openings shall be located in accordance with Section R303.5.1. Opening protection shall be in accordance with Section R303.6

M1602.2 Return air openings.
Return air openings for heating, ventilation and air conditioning systems shall comply with all of the following:

1. Openings shall not be located less than 10 feet (3048 mm) measured in any direction from an open combustion chamber or draft hood of another appliance located in the same room or space.
2. The amount of return air taken from any room or space shall be not greater than the flow rate of supply air delivered to such room or space.

3. Return and transfer openings shall be sized in accordance with the appliance or equipment manufacturers' installation instructions, Manual D or the design of the registered design professional.

4. Return air shall not be taken from a closet, bathroom, toilet room, kitchen, garage, mechanical room, boiler room, furnace room or unconditioned attic.

Exceptions:

1. Taking return air from a kitchen is not prohibited where such return air openings serve the kitchen only, and are located not less than 10 feet (3048 mm) from the cooking appliances.

2. Dedicated forced-air systems serving only the garage shall not be prohibited from obtaining return air from the garage.

3. Taking return air from an unconditioned crawl space shall not be accomplished through a direct connection to the return side of a forced-air furnace. Transfer openings in the crawl space enclosure shall not be prohibited. Deleted.

4. Return air from one dwelling unit shall not be discharged into another dwelling unit.
CHAPTER 17
COMBUSTION AIR

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1701
GENERAL

M1701.1 Scope.
Solid fuel-burning appliances shall be provided with combustion air in accordance with the appliance manufacturer’s installation instructions. Oil-fired appliances shall be provided with combustion air in accordance with NFPA 31. The methods of providing combustion air in this chapter do not apply to fireplaces, fireplace stoves and direct-vent appliances. The requirements for combustion and dilution air for gas-fired appliances shall be in accordance with Chapter 24.

M1701.2 Opening location.
In flood hazard areas as established in Table R301.2(1), combustion air openings shall be located at or above the elevation required in Section R322.2.1 or R322.3.2.

M1701.3 (701.2) Dampered openings.
Where combustion air openings are provided with volume dampers, the dampers shall be interlocked with the firing cycle of the appliances served, so as to prevent operation of any appliance that draws combustion air from the room or space when any of the dampers are closed. Manual dampers shall not be installed in combustion air ducts.
CHAPTER 18
CHIMNEYS AND VENTS

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1801
GENERAL

M1801.1 (801.1) Venting required.
Fuel-burning appliances shall be vented to the outdoors in accordance with their listing and label and manufacturer’s installation instructions except appliances listed and labeled for unvented use. Venting systems shall consist of approved chimneys or vents, or venting assemblies that are integral parts of labeled appliances. Gas-fired appliances shall be vented in accordance with Chapter 24.

M1801.2 Draft requirements.
A venting system shall satisfy the draft requirements of the appliance in accordance with the manufacturer’s installation instructions, and shall be constructed and installed to develop a positive flow to convey combustion products to the outside atmosphere.

M1801.3 Existing chimneys and vents.
Where an appliance is permanently disconnected from an existing chimney or vent, or where an appliance is connected to an existing chimney or vent during the process of a new installation, the chimney or vent shall comply with Sections M1801.3.1 through M1801.3.4.

M1801.3.1 Size.
The chimney or vent shall be resized as necessary to control flue gas condensation in the interior of the chimney or vent and to provide the appliance, or appliances served, with the required draft. For the venting of oil-fired appliances to masonry chimneys, the resizing shall be done in accordance with NFPA 31.

M1801.3.2 Flue passageways.
The flue gas passageway shall be free of obstructions and combustible deposits and shall be cleaned if previously used for venting a solid or liquid fuel-burning appliance or fireplace. The flue liner, chimney inner wall or vent inner wall shall be continuous and free of cracks, gaps, perforations, or other damage or deterioration that would allow the escape of combustion products, including gases, moisture and creosote.

M1801.3.3 (801.13) Cleanout.
Masonry chimneys shall be provided with a cleanout opening complying with Section R1003.17.

M1801.3.4 (801.18.4) Clearances.
Chimneys and vents shall have airspace clearance to combustibles in accordance with this code and the chimney or vent manufacturer’s installation instructions.
**Exception:** Masonry chimneys equipped with a chimney lining system tested and listed for installation in chimneys in contact with combustibles in accordance with UL 1777, and installed in accordance with the manufacturer’s instructions, shall not be required to have a clearance between combustible materials and exterior surfaces of the masonry chimney. Noncombustible firestopping shall be provided in accordance with this code.

M1801.4 (801.17) **Space around lining.**
The space surrounding a flue lining system or other vent installed within a masonry chimney shall not be used to vent any other appliance. This shall not prevent the installation of a separate flue lining in accordance with the manufacturer’s installation instructions and this code.

M1801.5 **Mechanical draft systems.**
A mechanical draft system shall be used only with appliances listed and labeled for such use. Provisions shall be made to prevent the flow of fuel to the equipment when the draft system is not operating. Forced draft systems and portions of induced draft systems under positive pressure during operation shall be designed and installed to prevent leakage of flue gases into a building.

M1801.6 **Direct-vent appliances.**
Direct-vent appliances shall be installed in accordance with the manufacturer’s instructions.

M1801.7 **Support.**
Venting systems shall be adequately supported for the weight of the material used.

M1801.8 **Duct penetrations.**
Chimneys, vents and vent connectors shall not extend into or through supply and return air ducts or plenums.

M1801.9 **Fireblocking.**
Vent and chimney installations shall be fireblocked in accordance with Section R602.8.

M1801.10 **Unused openings.**
Unused openings in any venting system shall be closed or capped.

M1801.11 **Multiple-appliance venting systems.**
Two or more listed and labeled appliances connected to a common natural draft venting system shall comply with the following requirements:

1. Appliances that are connected to common venting systems shall be located on the same floor of the dwelling.

   **Exception:** Engineered systems as provided for in Section G2427.

2. Inlets to common venting systems shall be offset such that no portion of an inlet is opposite another inlet.

3. Connectors serving appliances operating under a natural draft shall not be connected to any portion of a mechanical draft system operating under positive pressure.
M1801.12 Multiple solid fuel prohibited.
A solid fuel-burning appliance or fireplace shall not connect to a chimney passageway venting another appliance.

SECTION M1802
VENT COMPONENTS

M1802.1 Draft hoods.
Draft hoods shall be located in the same room or space as the combustion air openings for the appliances.

M1802.2 Vent dampers.
Vent dampers shall comply with Sections M1802.2.1 and M1802.2.2.

M1802.2.1 Manually operated.
Manually operated dampers shall not be installed except in connectors or chimneys serving solid fuel-burning appliances.

M1802.2.2 Automatically operated.
Automatically operated dampers shall conform to UL 17 and be installed in accordance with the terms of their listing and label. The installation shall prevent firing of the burner when the damper is not opened to a safe position.

M1802.3 Draft regulators.
Draft regulators shall be provided for oil-fired appliances that must be connected to a chimney. Draft regulators provided for solid fuel-burning appliances to reduce draft intensity shall be installed and set in accordance with the manufacturer's installation instructions.

M1802.3.1 Location.
Where required, draft regulators shall be installed in the same room or enclosure as the appliance so that a difference in pressure will not exist between the air at the regulator and the combustion air supply.

SECTION M1803
CHIMNEY AND VENT CONNECTORS

M1803.1 General.
Connectors shall be used to connect fuel-burning appliances to a vertical chimney or vent except where the chimney or vent is attached directly to the appliance.

M1803.2 (803.9) Connectors for oil and solid fuel appliances.
Connectors for oil and solid fuel-burning appliances shall be constructed of factory-built chimney material, Type L vent material or single-wall metal pipe having resistance to corrosion and heat and thickness not less than that of galvanized steel as specified in Table M1803.2.

TABLE M1803.2 (803.9(1))
THICKNESS FOR SINGLE-WALL METAL PIPE CONNECTORS

<table>
<thead>
<tr>
<th>DIAMETER OF CONNECTOR (inches)</th>
<th>GALVANIZED SHEET METAL GAGE NUMBER</th>
<th>MINIMUM THICKNESS (inch)</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
M1803.3 (803.10.5) Installation.
Vent and chimney connectors shall be installed in accordance with the manufacturer’s instructions and within the space where the appliance is located. Appliances shall be located as close as practical to the vent or chimney. Connectors shall be as short and straight as possible and installed with a slope of not less than $\frac{1}{4}$ inch (6 mm) rise per foot of run. Connectors shall be securely supported and joints shall be fastened with sheet metal screws or rivets. Devices that obstruct the flow of flue gases shall not be installed in a connector unless listed and labeled or approved for such installations.

M1803.3.1 (803.10.4) Floor, ceiling and wall penetrations.
A chimney connector or vent connector shall not pass through any floor or ceiling. A chimney connector or vent connector shall not pass through a wall or partition unless the connector is listed and labeled for wall pass-through, or is routed through a device listed and labeled for wall pass-through and is installed in accordance with the conditions of its listing and label. Connectors for oil-fired appliances listed and labeled for Type L vents, passing through walls or partitions shall be in accordance with the following:

1. Type L vent material for oil appliances shall be installed with not less than listed and labeled clearances to combustible material.

2. Single-wall metal pipe shall be guarded by a ventilated metal thimble not less than 4 inches (102 mm) larger in diameter than the vent connector. A minimum 6 inches (152 mm) of clearance shall be maintained between the thimble and combustibles.

M1803.3.2 Length.
The horizontal run of an uninsulated connector to a natural draft chimney shall not exceed 75 percent of the height of the vertical portion of the chimney above the connector. The horizontal run of a listed connector to a natural draft chimney shall not exceed 100 percent of the height of the vertical portion of the chimney above the connector.

M1803.3.3 Size.
A connector shall not be smaller than the flue collar of the appliance.

Exception: Where installed in accordance with the appliance manufacturer’s instructions.

M1803.3.4 (803.10.6) Clearance.
Connectors shall be installed with clearance to combustibles as set forth in Table M1803.3.4 or Table M1803.3.5. Reduced clearances to combustible materials shall be in accordance with Table M1306.2 and Figure M1306.1.

<table>
<thead>
<tr>
<th>Less than 6</th>
<th>26</th>
<th>0.019</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 10</td>
<td>24</td>
<td>0.024</td>
</tr>
<tr>
<td>Over 10 through 16</td>
<td>22</td>
<td>0.029</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
### TO COMBUSTIBLE MATERIALS

<table>
<thead>
<tr>
<th>TYPE OF CONNECTOR</th>
<th>MINIMUM CLEARANCE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-wall metal pipe connectors:</td>
<td></td>
</tr>
<tr>
<td>Oil and solid-fuel appliances</td>
<td>18</td>
</tr>
<tr>
<td>Oil appliances listed for use with Type L vents</td>
<td>9</td>
</tr>
<tr>
<td>Type L vent piping connectors:</td>
<td></td>
</tr>
<tr>
<td>Oil and solid-fuel appliances</td>
<td>9</td>
</tr>
<tr>
<td>Oil appliances listed for use with Type L vents</td>
<td>b</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. These minimum clearances apply to unlisted single-wall chimney and vent connectors. Reduction of required clearances is permitted as in Table M1306.2.

b. Where listed Type L vent piping is used, the clearance shall be in accordance with the vent listing.

### TABLE M1803.3.5 (803.10.4)

<table>
<thead>
<tr>
<th>CHIMNEY CONNECTOR SYSTEMS AND CLEARANCES TO COMBUSTIBLE WALL MATERIALS FOR DOMESTIC HEATING APPLIANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 3.5-inch-thick brick wall shall be framed into the combustible wall. An 0.625-inch-thick fire-clay liner (ASTM C 315 or equivalent) shall be firmly cemented in the center of the brick wall maintaining a 12-inch clearance to combustibles. The clay liner shall run from the outer surface of the bricks to the inner surface of the chimney liner.</td>
</tr>
<tr>
<td>A labeled solid-insulated factory-built chimney section (1-inch insulation) the same inside diameter as the connector shall be utilized. Sheet steel supports cut to maintain a 9-inch clearance to combustibles shall be fastened to the wall surface and to the chimney section. Fasteners shall not penetrate the chimney flue liner. The chimney length shall be flush with the masonry chimney liner and sealed to the masonry with water-insoluble refractory cement. Chimney manufacturers' parts shall be utilized to securely fasten the chimney connector to the chimney section.</td>
</tr>
<tr>
<td>A steel ventilated thimble having a minimum thickness of 0.0236 inch (No. 24 gage) having two 1-inch air channels shall be installed with a steel chimney connector. Steel supports shall be cut to maintain a 6-inch clearance between the thimble and combustibles. The chimney connector and steel supports shall have a minimum thickness of 0.0236 inch (No. 24 gage). One side of the support shall be fastened to the wall on all sides. Glass-fiber insulation shall fill the 6-inch space between the thimble and the supports.</td>
</tr>
<tr>
<td>A labeled solid-insulated factory-built chimney section (1-inch insulation) with a diameter 2 inches larger than the chimney connector shall be installed with a steel chimney connector having a minimum thickness of 0.0236 inch (24 gage). Sheet steel supports shall be positioned to maintain a 2-inch clearance to combustibles and to hold the chimney connector to ensure that a 1-inch airspace surrounds the chimney connector through the chimney section. The steel support shall be fastened to the wall on all sides and the chimney section shall be fastened to the supports. Fasteners shall not penetrate the liner of the chimney section.</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4 mm, 1.0 Btu x in/ft$^2$ • h • °F = 0.144 W/m$^2$ • K.
a. Insulation material that is part of the wall pass-through system shall be noncombustible and shall have a thermal conductivity of 1.0 Btu x in/ft$^2$ • h • °F or less.
b. All clearances and thicknesses are minimums.
c. Materials utilized to seal penetrations for the connector shall be noncombustible.
d. Connectors for all systems except System B shall extend through the wall pass-through system to the inner face of the flue liner.
e. ASTM C 315.

M1803.3.5 Access.
The entire length of a connector shall be accessible for inspection, cleaning and replacement.

M1803.4 Connection to fireplace flue.
Connection of appliances to chimney flues serving fireplaces shall comply with Sections M1803.4.1 through M1803.4.4.

M1803.4.1 Closure and accessibility.
A noncombustible seal shall be provided below the point of connection to prevent entry of room air into the flue. Means shall be provided for access to the flue for inspection and cleaning.

M1803.4.2 Connection to factory-built fireplace flue.
A different appliance shall not be connected to a flue serving a factory-built fireplace unless the appliance is specifically listed for such an installation. The connection shall be made in conformance with the appliance manufacturer’s instructions.

M1803.4.3 Connection to masonry fireplace flue.
A connector shall extend from the appliance to the flue serving a masonry fireplace to convey the flue gases directly into the flue. The connector shall be accessible or removable for inspection and cleaning of both the connector and the flue. Listed direct-connection devices shall be installed in accordance with their listing.

M1803.4.4 Size of flue.
The size of the fireplace flue shall be in accordance with Section M1805.3.1.

SECTION M1804
VENTS

M1804.1 Type of vent required.
Appliances shall be provided with a listed and labeled venting system as set forth in Table M1804.1.

TABLE M1804.1
VENT SELECTION CHART

<table>
<thead>
<tr>
<th>VENT TYPES</th>
<th>APPLIANCE TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type L oil vents</td>
<td>Oil-burning appliances listed and labeled for venting with Type L vents</td>
</tr>
<tr>
<td>Pellet vents</td>
<td>Pellet fuel-burning appliances listed and labeled for use with pellet vents</td>
</tr>
</tbody>
</table>

M1804.1.1 (801.20) Plastic vent joints.
Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer’s installation instructions. Solvent cement joints between ABS pipe and fittings shall be cleaned. Solvent cement joints between CPVC pipe and fittings or PVC pipe and fittings shall be primed. The primer shall be a contrasting color, or an ultraviolet primer may be used.

M1804.2 Termination.
Vent termination shall comply with Sections M1804.2.1 through M1804.2.6.

M1804.2.1 Through the roof.
Vents passing through a roof shall extend through flashing and terminate in accordance with the manufacturer’s installation requirements.

M1804.2.2 Decorative shrouds.
Decorative shrouds shall not be installed at the termination of vents except where the shrouds are listed and labeled for use with the specific venting system and are installed in accordance with the manufacturer’s instructions.

M1804.2.3 Natural draft appliances.
Vents for natural draft appliances shall terminate not less than 5 feet (1524 mm) above the highest connected appliance outlet, and natural draft gas vents serving wall furnaces shall terminate at an elevation not less than 12 feet (3658 mm) above the bottom of the furnace.

M1804.2.4 Type L vent.
Type L venting systems shall conform to UL 641 and shall terminate with a listed and labeled cap in accordance with the vent manufacturer’s installation instructions not less than 2 feet (610 mm) above the roof and not less than 2 feet (610 mm) above any portion of the building within 10 feet (3048 mm).

M1804.2.5 Direct vent terminations.
Vent terminals for direct-vent appliances shall be installed in accordance with the manufacturer’s instructions.

M1804.2.6 Mechanical draft systems.
Mechanical draft systems shall comply with UL 378 and shall be installed in accordance with their listing, the manufacturer’s instructions and, except for direct-vent appliances, the following requirements:

1. The vent terminal shall be located not less than 3 feet (914 mm) above a forced air inlet located within 10 feet (3048 mm).

2. The vent terminal shall be located not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from, or 1 foot (305 mm) above any door, window or gravity air inlet into a dwelling.

3. The vent termination point shall be located not closer than 3 feet (914 mm) to an interior corner formed by two walls perpendicular to each other.

4. The bottom of the vent terminal shall be located not less than 12 inches (305 mm) above finished ground level.
5. The vent termination shall not be mounted directly above or within 3 feet (914 mm) horizontally of an oil tank vent or gas meter.

6. Power exhauster terminations shall be located not less than 10 feet (3048 mm) from lot lines and adjacent buildings.

7. The discharge shall be directed away from the building.

**M1804.2.6.1 (804.3.4) Horizontal terminations.**
Vertical terminations shall comply with the following requirements:

1. Where located adjacent to walkways, the termination of mechanical draft systems shall be not less than 7 feet (2134 mm) above the level of the walkway.

2. Vents shall terminate at least 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm).

3. The vent system shall terminate at least 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from or 1 foot (305 mm) above any door, window or gravity air inlet into the building.

4. The vent termination point shall not be located closer than 3 feet (914 mm) to an interior corner formed by two walls perpendicular to each other.

5. The vent termination shall not be mounted directly above or within 3 feet (914 mm) horizontally from an oil tank vent or gas meter.

6. The bottom of the vent termination shall be located at least 12 inches (305 mm) above finished grade.

**M1804.2.6.2 (804.3.5) Vertical terminations.**
Vertical terminations shall comply with the following requirements:

1. Where located adjacent to walkways, the termination of mechanical draft systems shall be not less than 7 feet (2134 mm) above the level of the walkway.

2. Vents shall terminate not less than 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm) horizontally.

3. Where the vent termination is located below an adjacent roof structure, the termination point shall be located not less than 3 feet (914 mm) from such structure.

4. The vent shall terminate not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from or 1 foot (305 mm) above any door, window or gravity air inlet for the building.

5. A vent cap shall be installed to prevent rain from entering the vent system.
6. The vent termination shall be located not less than 3 feet (914 mm) horizontally from any portion of the roof structure.

**M1804.2.6.3 (804.3.8) Mechanical draft systems for manually fired appliances and fireplaces.**
A mechanical draft system shall be permitted to be used with manually fired appliances and fireplaces where such system complies with all of the following requirements:

1. The mechanical draft device shall be listed and labeled in accordance with UL 378, and shall be installed in accordance with the manufacturer’s instructions.

2. A device shall be installed that produces visible and audible warning upon failure of the mechanical draft device or loss of electrical power, at any time that the mechanical draft device is turned on. This device shall be equipped with a battery backup if it receives power from the building wiring.

3. A smoke detector shall be installed in the room with the appliance or fireplace. This device shall be equipped with a battery backup if it receives power from the building wiring.

**M1804.3 Installation.**
Type L and pellet vents shall be installed in accordance with the terms of their listing and label and the manufacturer’s instructions.

**M1804.3.1 Size of single-appliance venting systems.**
An individual vent for a single appliance shall have a cross-sectional area equal to or greater than the area of the connector to the appliance, but not less than 7 square inches (4515 mm$^2$) except where the vent is an integral part of a listed and labeled appliance.

**M1804.4 Door swing.**
Appliance and equipment vent terminals shall be located such that doors cannot swing within 12 inches (305 mm) horizontally of the vent terminals. Door stops or closers shall not be installed to obtain this clearance.

SECTION M1805
MASONRY AND FACTORY-BUILT CHIMNEYS

**M1805.1 General.**
Masonry and factory-built chimneys shall be built and installed in accordance with Sections R1003 and R1005, respectively. Flue lining for masonry chimneys shall comply with Section R1003.11.

**M1805.2 (803.10.3) Masonry chimney connection.**
A chimney connector shall enter a masonry chimney not less than 6 inches (152 mm) above the bottom of the chimney. Where it is not possible to locate the connector entry at least 6 inches (152 mm) above the bottom of the chimney flue, a cleanout shall be provided by installing a capped tee in the connector next to the chimney. A connector entering a masonry chimney shall extend through, but not beyond, the wall and shall be flush with the inner face of the liner. Connectors, or thimbles where used, shall be firmly cemented into the masonry.
M1805.3 Size of chimney flues.
The effective area of a natural draft chimney flue for one appliance shall be not less than the area of the connector to the appliance. The area of chimney flues connected to more than one appliance shall be not less than the area of the largest connector plus 50 percent of the areas of additional chimney connectors.

Exception: Chimney flues serving oil-fired appliances sized in accordance with NFPA 31.

M1805.3.1 Size of chimney flue for solid-fuel appliance.
Except where otherwise specified in the manufacturer’s installation instructions, the cross-sectional area of a flue connected to a solid-fuel-burning appliance shall be not less than the area of the flue collar or connector, and not larger than three times the area of the flue collar.

M1805.4 (805.6) Decorative shrouds.
Decorative shrouds shall not be installed at the termination of factory-built chimneys except where such shrouds are listed and labeled for use with the specific factory-built chimney system and are installed in accordance with manufacturer’s installation instructions.
CHAPTER 19
SPECIAL APPLIANCES, EQUIPMENT AND SYSTEMS

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M1901
RANGES AND OVENS

M1901.1 Clearances.
Freestanding or built-in ranges shall have a vertical clearance above the cooking top of not less than 30 inches (762 mm) to unprotected combustible material. Reduced clearances are permitted in accordance with the listing and labeling of the range hoods or appliances. The installation of a listed and labeled cooking appliance or microwave oven over a listed and labeled cooking appliance shall be in accordance with Section M1504.1. The clearances for a domestic open-top broiler unit shall be in accordance with Section M1505.1.

M1901.2 (917.2) Cooking appliances.
Cooking appliances shall be listed and labeled for household use and shall be installed in accordance with the manufacturer's instructions. The installation shall not interfere with combustion air or access for operation and servicing. Electric cooking appliances shall comply with UL 1026 or UL 858. Solid-fuel-fired fireplace stoves shall comply with UL 737.

M1901.3 (917.3) Installation of microwave oven over a cooking appliance.
The installation of a listed and labeled cooking appliance or microwave oven over a listed and labeled cooking appliance shall conform to the terms of the upper appliance's listing and label and the manufacturer's installation instructions.

SECTION M1902
SAUNA HEATERS

M1902.1 (914.1) Locations and protection.
Sauna heaters shall be protected from accidental contact by persons with a guard of material having a low thermal conductivity, such as wood. The guard shall not have a substantial effect on the transfer of heat from the heater to the room.

M1902.2 (914.2) Installation.
Sauna heaters shall be installed in accordance with the manufacturer's instructions. Sauna heaters shall comply with UL 875.

M1902.3 Combustion air.
Combustion air and venting for a nondirect vent-type heater shall be provided in accordance with Chapters 17 and 18, respectively.
M1902.4 Controls.
Sauna heaters shall be equipped with a thermostat that will limit room temperature to not greater than 194°F (90°C). Where the thermostat is not an integral part of the heater, the heat-sensing element shall be located within 6 inches (152 mm) of the ceiling.

M1902.5 (914.5) Sauna room.
A ventilation opening into the sauna room shall be provided as required by the manufacturer.

SECTION M1903
STATIONARY FUEL CELL POWER PLANTS

M1903.1 (924.1) General.
Stationary fuel cell power plants having a power output not exceeding 1,000 kW, shall comply with ANSI/CSA America FC 1 and shall be installed in accordance with the manufacturer’s instructions and NFPA 853.

SECTION M1904
GASEOUS HYDROGEN SYSTEMS

M1904.1 (926.1) Installation.
Gaseous hydrogen systems shall be installed in accordance with the applicable requirements of Sections M1307.4 and M1903.1 and the International Fuel Gas Code, the International Fire Code and the International Building Code.
CHAPTER 20
BOILERS AND WATER HEATERS

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

SECTION M2001
BOILERS

**M2001.1 Installation.**
In addition to the requirements of this code, the installation of boilers shall conform to the manufacturer's instructions. The manufacturer's rating data, the nameplate and operating instructions of a permanent type shall be attached to the boiler. Boilers shall have their controls set, adjusted and tested by the installer. A complete control diagram together with complete boiler operating instructions shall be furnished by the installer. Solid and liquid fuel-burning boilers shall be provided with combustion air as required by Chapter 17.

**M2001.1.1 Standards.**
Packaged oil-fired boilers shall be listed and labeled in accordance with UL 726. Packaged electric boilers shall be listed and labeled in accordance with UL 834. Solid fuel-fired boilers shall be listed and labeled in accordance with UL 2523. Boilers shall be designed, constructed and certified in accordance with the ASME *Boiler and Pressure Vessel Code*, Section I or IV. Controls and safety devices for boilers with fuel input ratings of 12,500,000 Btu/hr (3 663 388 watts) or less shall meet the requirements of ASME CSD-1. Gas-fired boilers shall conform to the requirements listed in Chapter 24.

**M2001.2 Clearance.**
Boilers shall be installed in accordance with their listing and label.

**M2001.3 Valves.**
Every boiler or modular boiler shall have a shutoff valve in the supply and return piping. For multiple boiler or multiple modular boiler installations, each boiler or modular boiler shall have individual shutoff valves in the supply and return piping.

**Exception:** Shutoff valves are not required in a system having a single low-pressure steam boiler.

**M2001.4 Flood-resistant installation.**
In flood hazard areas established in Table R301.2(1), boilers, water heaters and their control systems shall be located or installed in accordance with Section R322.1.6.

SECTION M2002
OPERATING AND SAFETY CONTROLS
M2002.1 (1006.4) Safety controls.
Electrical and mechanical operating and safety controls for boilers shall be listed and labeled.

M2002.2 (1010.1) Hot water boiler gauges.
Every hot water boiler shall have a pressure gauge and a temperature gauge, or combination pressure and temperature gauge. The gauges shall indicate the temperature and pressure within the normal range of the system’s operation.

M2002.3 (1010.2) Steam boiler gauges.
Every steam boiler shall have a water-gauge glass and a pressure gauge. The pressure gauge shall indicate the pressure within the normal range of the system’s operation. The gauge glass shall be installed so that the midpoint is at the normal water level.

M2002.4 Pressure-relief valve.
Boilers shall be equipped with pressure-relief valves with minimum rated capacities for the equipment served. Pressure-relief valves shall be set at the maximum rating of the boiler. Discharge shall be piped to drains by gravity to within 18 inches (457 mm) of the floor or to an open receptor.

M2002.5 (1007.1) Boiler low-water cutoff.
Steam and hot water boilers shall be protected with a low-water cutoff control.

Exception: A low-water cutoff is not required for coil-type and water-tube type boilers that require forced circulation of water through the boiler and that are protected with a flow sensing control.

M2002.6 Operation.
Low-water cutoff controls and flow sensing controls required by Section M2002.5 shall automatically stop the combustion operation of the appliance when the water level drops below the lowest safe water level as established by the manufacturer or when the water circulation flow is less than that required for safe operation of the appliance, respectively.

SECTION M2003
EXPANSION TANKS

M2003.1 General.
Hot water boilers shall be provided with expansion tanks. Nonpressurized expansion tanks shall be securely fastened to the structure or boiler and supported to carry twice the weight of the tank filled with water. Provisions shall be made for draining nonpressurized tanks without emptying the system.

M2003.1.1 Pressurized expansion tanks.
Pressurized expansion tanks shall be consistent with the volume and capacity of the system. Tanks shall be capable of withstanding a hydrostatic test pressure of two and one-half times the allowable working pressure of the system.

M2003.2 Minimum capacity.
The minimum capacity of expansion tanks shall be determined from Table M2003.2.

TABLE M2003.2

2018 North Carolina Residential Code
### EXPANSION TANK MINIMUM CAPACITY\(^a\)**

**FOR FORCED HOT-WATER SYSTEMS**

<table>
<thead>
<tr>
<th>SYSTEM VOLUME(^b) (gallons)</th>
<th>PRESSURIZED DIAPHRAGM TYPE</th>
<th>NONPRESSURIZED TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>20</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>30</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td>40</td>
<td>3.0</td>
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<tr>
<td>50</td>
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<td>7.5</td>
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<td>60</td>
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<td>80</td>
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<td>12.0</td>
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<tr>
<td>90</td>
<td>7.5</td>
<td>13.5</td>
</tr>
<tr>
<td>100</td>
<td>8.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

For SI: 1 gallon = 3.785 L, 1 pound per square inch gauge = 6.895 kPa,
\(\text{°C} = \frac{[(\text{°F}) - 32]}{1.8}\).

a. Based on average water temperature of 195°F (91°C), fill pressure of 12 psig and a maximum operating pressure of 30 psig.

b. System volume includes volume of water in boiler, convectors and piping, not including the expansion tank.

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### SECTION M2004

**WATER HEATERS USED FOR SPACE HEATING**

**M2004.1 General.**

Water heaters used to supply both potable hot water and hot water for space heating shall be installed in accordance with this chapter, Chapter 24, Chapter 28 and the manufacturer’s instructions. Water heaters utilized both to supply potable hot water and provide hot water for space-heating applications shall be listed and labeled for such applications by the manufacturer and shall be installed in accordance with the manufacturer’s instructions and the *International Plumbing Code*.

**M2004.1.1 (1002.2.1) Sizing.**

Water heaters utilized for both potable water heating and space-heating applications shall be sized to prevent the space-heating load from diminishing the required potable water-heating capacity.

**M2004.1.2 (1002.2.2) Temperature limitation.**

Where a combination potable water-heating and space-heating system requires water for space heating at temperatures higher than 140°F (60°C), a temperature-actuated mixing valve that conforms to ASSE 1017 shall be provided to temper the water supplied to the potable hot water distribution system to a temperature of 140°F (60°C) or less.

**M2004.2 (1002.3) Supplemental water-heating devices.**

Potable waterheating devices that utilize refrigerant-to-water heat exchangers shall be approved and installed in accordance with the *International Plumbing Code* and the manufacturer’s instructions.

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SECTION M2005

**WATER HEATERS**

2018 North Carolina Residential Code
Water heaters shall be installed in accordance with Chapter 28, the manufacturer's instructions and the requirements of this code. Water heaters installed in an attic shall comply with the requirements of Section M1305.1.3. Gas-fired water heaters shall comply with the requirements in Chapter 24. Domestic electric water heaters shall comply with UL 174. Oiled-fired water heaters shall comply with UL 732. Thermal solar water heaters shall comply with Chapter 23 and UL 174. Solid fuel-fired water heaters shall comply with UL 2523.

M2005.2 Prohibited locations. 
Fuel-fired water heaters shall not be installed in a room used as a storage closet. Water heaters located in a room or space accessed only through a bedroom or bathroom shall be installed in a sealed enclosure so that combustion air will not be taken from the living space accordance with Section G2406.2. Installation of direct-vent water heaters within an enclosure is not required.

M2005.2.1 Water heater access. 
Access to water heaters that are located in an attic or underfloor crawl space is permitted to be through a closet located in a sleeping room or bathroom where ventilation of those spaces is in accordance with this code and the requirements of Section G2406.2.

M2005.3 Electric water heaters. 
Electric water heaters shall also be installed in accordance with the applicable provisions of Chapters 34 through 43 the North Carolina Electrical Code.

M2005.4 (1002.3) Supplemental water-heating devices. 
Potable water heating devices that use refrigerant-to-water heat exchangers shall be approved and installed in accordance with the manufacturer's instructions.

SECTION M2006
POOL HEATERS

M2006.1 (916.1) General. 
Pool and spa heaters shall be installed in accordance with the manufacturer’s installation instructions. Oil-fired pool heaters shall comply with UL 726. Electric pool and spa heaters shall comply with UL 1261.

M2006.2 Clearances. 
The clearances shall not interfere with combustion air, draft hood or flue terminal relief, or accessibility for servicing.

M2006.3 Temperature-limiting devices. 
Pool heaters shall have temperature-relief valves.

M2006.4 Bypass valves. 
Where an integral bypass system is not provided as a part of the pool heater, a bypass line and valve shall be installed between the inlet and outlet piping for use in adjusting the flow of water through the heater.
CHAPTER 21
HYDRONIC PIPING

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

SECTION M2101
HYDRONIC PIPING SYSTEMS INSTALLATION

M2101.1 General.
Hydronic piping shall conform to Table M2101.1. Approved piping, valves, fittings and connections shall be installed in accordance with the manufacturer’s instructions. Pipe and fittings shall be rated for use at the operating temperature and pressure of the hydronic system. Used pipe, fittings, valves or other materials shall be free of foreign materials.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>USE CODE</th>
<th>STANDARD</th>
<th>JOINTS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe</td>
<td>1, 5</td>
<td>ASTM D 1527; ASTM F 2806; ASTM F 2969</td>
<td>Solvent cement joints</td>
<td></td>
</tr>
<tr>
<td>Brass pipe</td>
<td>1</td>
<td>ASTM B 43</td>
<td>Brazed, welded, threaded, mechanical and flanged fittings</td>
<td></td>
</tr>
<tr>
<td>Brass tubing</td>
<td>1</td>
<td>ASTM B 135</td>
<td>Brazed, soldered and mechanical fittings</td>
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</tr>
<tr>
<td>Chlorinated poly (vinyl chloride) (CPVC) pipe and tubing</td>
<td>1, 2, 3</td>
<td>ASTM D 2846</td>
<td>Solvent cement joints, compression joints and threaded adapters</td>
<td></td>
</tr>
<tr>
<td>Copper pipe</td>
<td>1</td>
<td>ASTM B 42, B 302</td>
<td>Brazed, soldered and mechanical fittings threaded, welded and flanged</td>
<td></td>
</tr>
<tr>
<td>Copper tubing (type K, L or M)</td>
<td>1, 2</td>
<td>ASTM B 75, B 88, B 251, B 306</td>
<td>Brazed, soldered and flared mechanical fittings</td>
<td>Joints embedded in concrete</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>1, 2, 3</td>
<td>ASTM F 876, F 877</td>
<td>(See PEX fittings)</td>
<td>Install in accordance with manufacturer’s instructions</td>
</tr>
<tr>
<td>Material Type</td>
<td>Code Numbers</td>
<td>Joint Type</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Cross-linked polyethylene/aluminum/cross-linked polyethylene-(PEX-AL-PEX) pressure pipe</td>
<td>1, 2 ASTM F 1281 or CAN/CSA B137.10</td>
<td>Mechanical, crimp/insert</td>
<td>Install in accordance with manufacturer's instructions</td>
<td></td>
</tr>
<tr>
<td>PEX fittings</td>
<td>ASTM F 877, ASTM F 1807, ASTM F 1960, ASTM F 2098, ASTM F 2159, ASTM F 2735</td>
<td>Copper-crimp/insert fittings, cold expansion fittings, stainless steel clamp, insert fittings</td>
<td>Install in accordance with manufacturer's instructions</td>
<td></td>
</tr>
<tr>
<td>Polybutylene (PB) pipe and tubing</td>
<td>1, 2, 3 ASTM D 3309</td>
<td>Heat-fusion, crimp/insert and compression</td>
<td>Joints in concrete shall be heat-fused</td>
<td></td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe</td>
<td>1, 2, 3 ASTM F 1282 CSA B 137.9</td>
<td>Mechanical, crimp/insert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>1, 2, 3 ISO 15874 ASTM F 2389</td>
<td>Heat-fusion joints, mechanical fittings, threaded adapters, compression joints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raised temperature polyethylene (PE-RT)</td>
<td>1, 2, 3 ASTM F 2623 ASTM F 2769</td>
<td>Copper crimp/insert fitting stainless steel clamp, insert fittings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raised Temperature Polyethylene (PE-RT) fittings</td>
<td>1, 2, 3 ASTM F 1807 ASTM F 2159 ASTM F 2735 ASTM F 2769 ASTM F 2098</td>
<td>Copper crimp/insert fitting stainless steel clamp, insert fittings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel pipe</td>
<td>1, 2 ASTM A 53, A 106</td>
<td>Brazed, welded, threaded, flanged and mechanical fittings</td>
<td>Joints in concrete shall be welded. Galvanized pipe shall not be welded or brazed.</td>
<td></td>
</tr>
<tr>
<td>Steel tubing</td>
<td>1 ASTM A 254</td>
<td>Mechanical fittings, welded</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: \( ^\circ C = \frac{(^\circ F) - 32}{1.8} \).

a. Use code:
1. Above ground.
2. Embedded in radiant systems.
3. Temperatures below 180°F only.
4. Low temperature (below 130°F) applications only.
5. Temperatures below 160°F only.

b. Standards as listed in Chapter 44.

**M2101.2 (1206.2) System drain down.**
Hydronic piping systems shall be installed to permit draining of the system. Where the system drains to the plumbing drainage system, the installation shall conform to the requirements of Chapters 25 through 32 of this code.
Exception: The buried portions of systems embedded underground or under floors.

M2101.3 (1206.3) Protection of potable water.
The potable water system shall be protected from backflow in accordance with the provisions listed in Section P2902.

M2101.4 (1206.4) Pipe penetrations.
Openings through concrete or masonry building elements shall be sleeved.

M2101.5 (1206.6) Contact with building material.
A hydronic piping system shall not be in direct contact with any building material that causes the piping material to degrade or corrode.

M2101.6 Drilling and notching.
Wood-framed structural members shall be drilled, notched or altered in accordance with the provisions of Sections R502.8, R602.6, R603.6.1 and R802.7. Holes in load bearing members of cold-formed steel light-frame construction shall be permitted only in accordance with Sections R505.2.6, R603.2.6 and R804.2.6. In accordance with the provisions of Sections R505.3.5, R603.3.4 and R804.3.3, cutting and notching of flanges and lips of load-bearing members of cold-formed steel light-frame construction shall not be permitted. Structural insulated panels (SIPs) shall be drilled and notched or altered in accordance with the provisions of Section R610.7.

M2101.7 Prohibited tee applications.
Fluid in the supply side of a hydronic system shall not enter a tee fitting through the branch opening.

M2101.8 Expansion, contraction and settlement.
Piping shall be installed so that piping, connections and equipment shall not be subjected to excessive strains or stresses. Provisions shall be made to compensate for expansion, contraction, shrinkage and structural settlement.

M2101.9 (305.4) Piping support.
Hangers and supports shall be of material of sufficient strength to support the piping, and shall be fabricated from materials compatible with the piping material. Piping shall be supported at intervals not exceeding the spacing specified in Table M2101.9.

<p>| TABLE M2101.9 |
| HANGER SPACING INTERVALS |</p>
<table>
<thead>
<tr>
<th>PIPING MATERIAL</th>
<th>MAXIMUM HORIZONTAL SPACING (feet)</th>
<th>MAXIMUM VERTICAL SPACING (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>4</td>
<td>10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CPVC ≤ 1-inch pipe or tubing</td>
<td>3</td>
<td>5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CPVC ≥ 1 1/4 inches</td>
<td>4</td>
<td>10&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
Copper or copper alloy pipe | 12 | 10
Copper or copper alloy tubing | 6 | 10
PB pipe or tubing | 2.67 | 4
PE pipe or tubing | 2.67 | 4
PE-RT ≤ 1 inch | 2.67 | 10
PE-RT ≥ 1/4 inches | 4 | 10
PEX tubing | 2.67 | 4
PP < 1-inch pipe or tubing | 2.67 | 4
PP > 1/4 inches | 4 | 10
PVC | 4 | 10
Steel pipe | 12 | 15
Steel tubing | 8 | 10

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. For sizes 2 inches and smaller, a guide shall be installed midway between required vertical supports. Such guides shall prevent pipe movement in a direction perpendicular to the axis of the pipe.

M2101.10 Tests.
Hydronic piping systems shall be tested hydrostatically at a pressure of one and one-half times the maximum system design pressure, but not less than 100 pounds per square inch (689 kPa). The duration of each test shall be not less than 15 minutes and not more than 20 minutes.

M2101.10.1 (1201.4) Test gauges.
Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 pounds per square inch (psi) (69 kPa) or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.

2. Tests requiring a pressure of greater than 10 psi (69 kPa) but less than or equal to 100 psi (689 kPa) shall utilize a testing gauge having increments of 1 psi (6.9 kPa) or less.

3. Tests requiring a pressure of greater than 100 psi (689 kPa) shall utilize a testing gauge having increments of 2 psi (14 kPa) or less.

M2101.10.2 (1209.2) Pressurizing during installation.
Piping to be embedded in concrete shall be pressure tested prior to pouring concrete. During pouring, the pipe shall be maintained at the proposed operating pressure.

M2101.11 (1206.11) Condensation.
Provisions shall be made to prevent the formation of condensation on the exterior of hydronic piping.

M2101.12 (1206.4) Pipe penetrations.
Openings for pipe penetrations in walls, floors or ceilings shall be larger than the penetrating pipe. Openings through concrete or masonry building elements shall be sleeved. The annular space surrounding pipe penetrations shall be protected in accordance with the International Building Code.
M2101.13 (1206.5) Clearance to combustibles.
A pipe in a hydronic piping system in which the exterior temperature exceeds 250°F (121°C) shall have a minimum clearance of 1 inch (25 mm) to combustible materials.

M2101.14 (1206.6) Contact with building material.
A hydronic piping system shall not be in direct contact with building materials that cause the piping material to degrade or corrode, or that interfere with the operation of the system.

M2101.15 (1206.7) Water hammer.
The flow velocity of the hydronic piping system shall be controlled to reduce the possibility of water hammer. Where a quick-closing valve creates water hammer, an approved water-hammer arrestor shall be installed. The arrestor shall be located within a range as specified by the manufacturer of the quick-closing valve.

M2101.16 (1206.8) Steam piping pitch.
Steam piping shall be installed to drain to the boiler or the steam trap. Steam systems shall not have drip pockets that reduce the capacity of the steam piping.

M2101.17 (1206.9) Strains and stresses.
Piping shall be installed so as to prevent detrimental strains and stresses in the pipe. Provisions shall be made to protect piping from damage resulting from expansion, contraction and structural settlement. Piping shall be installed so as to avoid structural stresses or strains within building components.

M2101.17.1 (1206.9.1) Flood hazard.
Piping located in a flood hazard area shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the design flood elevation.

SECTION M2102
BASEBOARD CONVECTORS
JOINTS AND CONNECTIONS

M2102.1-General.
Baseboard convector shall be installed in accordance with the manufacturer’s instructions. Convector shall be supported independently of the hydronic piping.

M2102.1 (1203.3) Joint preparation and installation.
Joints and connections shall be of an approved type. Joints and connections shall be tight for the pressure of the hydronic system. Joints between different piping materials shall be made with approved adapter fittings. Pipe shall be cut square, reamed and chamfered, and shall be free of burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

Where required by Sections M2102.2 through M2102.12, the preparation and installation of brazed, mechanical, soldered, solventcemented, threaded and welded joints shall comply with Sections M2102.1.1 through M2102.1.8.

M2102.1.1 (1203.3.1) Brazed joints.
Joint surfaces shall be cleaned. An approved flux shall be applied where required. The joint shall be brazed with a filler metal conforming to AWS A5.8.

M2102.1.2 (1203.3.2) Mechanical joints.
Mechanical joints shall be installed in accordance with the manufacturer's instructions.

M2102.1.3 (1203.3.3) Soldered joints.
Joint surfaces shall be cleaned. A flux conforming to ASTM B 813 shall be applied. The joint shall be soldered with a solder conforming to ASTM B 32.

M2102.1.4 (1203.3.4) Solvent-cemented joints.
Joint surfaces shall be clean and free of moisture. An approved primer shall be applied to CPVC and PVC pipe-joint surfaces. Joints shall be made while the cement is wet. Solvent cement conforming to the following standards shall be applied to all joint surfaces:

1. ASTM D 2235 for ABS joints.
2. ASTM F 493 for CPVC joints.
3. ASTM D 2564 for PVC joints.

CPVC joints shall be made in accordance with ASTM D 2846.

Exception: For CPVC pipe joint connections, a primer is not required where all of the following conditions apply:

1. The solvent cement used is third-party certified as conforming to ASTM F 493.
2. The solvent cement is yellow in color.
3. The solvent cement is used only for joining 1/2-inch (12.7 mm) through 2-inch (51 mm) diameter CPVC pipe and fittings.
4. The CPVC pipe and fittings are manufactured in accordance with ASTM D 2846.

M2102.1.5 (1203.3.5) Threaded joints.
Threads shall conform to ASME B1.20.1. Schedule 80 or heavier plastic pipe shall be threaded with dies specifically designed for plastic pipe. Thread lubricant, pipe-joint compound or tape shall be applied on the male threads only and shall be approved for application on the piping material.

M2102.1.6 (1203.3.6) Welded joints.
Joint surfaces shall be cleaned by an approved procedure. Joints shall be welded with an approved filler metal.

M2102.1.7 (1203.3.7) Grooved and shouldered mechanical joints.
Grooved and shouldered mechanical joints shall conform to the requirements of ASTM F 1476 and shall be installed in accordance with the manufacturer's instructions.

M2102.1.8 (1203.3.8) Mechanically formed tee fittings.
Mechanically extracted outlets shall have a height not less than three times the thickness of the branch tube wall.

**M2102.1.8.1 (1203.3.8.1) Full flow assurance.**
Branch tubes shall not restrict the flow in the run tube. A dimple/depth stop shall be formed in the branch tube to ensure that penetration into the outlet is of the correct depth. For inspection purposes, a second dimple shall be placed ¼ inch (6.4 mm) above the first dimple. Dimples shall be aligned with the tube run.

**M2102.1.8.2 (1203.3.8.2) Brazed joints.**
Mechanically formed tee fittings shall be brazed in accordance with Section M2102.1.1.

**M2102.2 (1203.4) ABS plastic pipe.**
Joints between ABS plastic pipe or fittings shall be solvent-cemented or threaded joints conforming to Section M2102.1.

**M2102.3 (1203.5) Brass pipe.**
Joints between brass pipe or fittings shall be brazed, mechanical, threaded or welded joints conforming to Section M2102.1.

**M2102.4 (1203.6) Brass tubing.**
Joints between brass tubing or fittings shall be brazed, mechanical or soldered joints conforming to Section M2102.1.

**M2102.5 (1203.7) Copper or copper-alloy pipe.**
Joints between copper or copper-alloy pipe or fittings shall be brazed, mechanical, soldered, threaded or welded joints conforming to Section M2102.1.

**M2102.6 (1203.8) Copper or copper-alloy tubing.**
Joints between copper or copper-alloy tubing or fittings shall be brazed, mechanical or soldered joints conforming to Section M2102.1, flared joints conforming to Section M2102.6.1, push-fit joints conforming to Section M2102.6.2 or press-type joints conforming to Section M2102.6.3.

**M2102.6.1 (1203.8.1) Flared joints.**
Flared joints shall be made by a tool designed for that operation.

**M2102.6.2 (1203.8.2) Push-fit joints.**
Push-fit joints shall be installed in accordance with the manufacturer’s instructions.

**M2102.6.3 (1203.8.3) Press joints.**
Press joints shall be installed in accordance with the manufacturer’s instructions.

**M2102.7 (1203.9) CPVC plastic pipe.**
Joints between CPVC plastic pipe or fittings shall be solvent-cemented or threaded joints conforming to Section M2102.1.

**M2102.8 (1203.10) Polybutylene plastic pipe and tubing.**
Joints between polybutylene plastic pipe and tubing or fittings shall be mechanical joints conforming to Section M2102.1 or heatfusion joints conforming to Section M2102.8.1.

**M2102.8.1 (1203.10.1) Heat-fusion joints.**
Joints shall be of the socket-fusion or butt-fusion type. Joint surfaces shall be clean and free of moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM D 3309.

**M2102.9 (1203.11) Cross-linked polyethylene (PEX) plastic tubing.**
Joints between cross-linked polyethylene plastic tubing and fittings shall conform to Sections M2102.9.1 and M2102.9.2 Mechanical joints shall conform to Section M2102.1.

**M2102.9.1 (1203.11.1) Compression-type fittings.**
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

**M2102.9.2 (1203.11.2) Plastic-to-metal connections.**
Soldering on the metal portion of the system shall be performed not less than 18 inches (457 mm) from a plastic-to-metal adapter in the same water line.

**M2102.10 (1203.12) PVC plastic pipe.**
Joints between PVC plastic pipe and fittings shall be solvent-cemented or threaded joints conforming to Section M2102.1.

**M2102.11 (1203.13) Steel pipe.**
Joints between steel pipe or fittings shall be mechanical joints that are made with an approved elastomeric seal, or shall be threaded or welded joints conforming to Section M2102.1.

**M2102.12 (1203.14) Steel tubing.**
Joints between steel tubing or fittings shall be mechanical or welded joints conforming to Section M2102.1.

**M2102.13 (1203.15) Polypropylene (PP) plastic.**
Joints between PP plastic pipe and fittings shall comply with Sections M2102.13.1 and M2102.13.2.

**M2102.13.1 (1203.15.1) Heat-fusion joints.**
Heat-fusion joints for polypropylene (PP) pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings, electro-fusion polypropylene fittings or by butt fusion. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F 2389.

**M2102.13.2 (1203.15.2) Mechanical and compression sleeve joints.**
Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s instructions.

**M2102.14 (1203.16) Raised temperature polyethylene (PE-RT) plastic tubing.**
Joints between raised temperature polyethylene tubing and fittings shall conform to Sections M2102.14.1 and M2102.14.2. Mechanical joints shall conform to Section M2102.1.

**M2102.14.1 (1203.16.1) Compression-type fittings.**
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

**M2102.14.2 (1203.16.2) PE-RT-to-metal connections.**
Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-RT pipe.

M2102.15 (1203.17) Polyethylene/aluminum/polyethylene (PE-ALPE) pressure pipe.
Joints between polyethylene/aluminum/polyethylene pressure pipe and fittings shall conform to Sections M2102.15.1 and M2102.15.2. Mechanical joints shall comply with Section M2102.1.

M2102.15.1 (1203.17.1) Compression-type fittings.
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

M2102.15.2 (1203.17.2) PE-AL-PE-to-metal connections.
Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-AL-PE pipe.

M2102.16 (1203.18) Cross-linked polyethylene/aluminum/crosslinked polyethylene (PEX-AL-PEX) pressure pipe.
Joints between cross-linked polyethylene/aluminum/cross-linked polyethylene pressure pipe and fittings shall conform to Sections M2102.16.1 and M2102.16.2. Mechanical joints shall comply with Section M2102.1.

M2102.16.1 (1203.18.1) Compression-type fittings.
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

M2102.16.2 (1203.18.2) PEX-AL-PEX-to-metal connections.
Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PEX-AL-PEX pipe.

SECTION M2103
FLOOR HEATING SYSTEMS

M2103.1 Piping materials.
Piping for embedment in concrete or gypsum materials shall be standard-weight steel pipe, copper and copper alloy pipe and tubing, cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pressure pipe, chlorinated polyvinyl chloride (CPVC), polybutylene, cross-linked polyethylene (PEX) tubing, polyethylene of raised temperature (PE-RT) or polypropylene (PP) with a minimum rating of 100 psi at 180°F (690 kPa at 82°C).

M2103.2 Thermal barrier required.
Radiant floor heating systems shall have a thermal barrier in accordance with Sections M2103.2.1 through M2103.2.4.

Exception: Insulation shall not be required in engineered systems where it can be demonstrated that the insulation will decrease the efficiency or have a negative effect on the installation.

M2103.2.1 Slab-on-grade installation.
Radiant piping used in slab-on-grade applications shall have insulating materials having a minimum R-value of 5 installed beneath the piping.
M2103.2.2 Suspended floor installation.
In suspended floor applications, insulation shall be installed in the joist bay cavity serving the heating space above and shall consist of materials having a minimum $R$-value of 11.

M2103.2.3 Thermal break required.
A thermal break consisting of asphalt expansion joint materials or similar insulating materials shall be provided at a point where a heated slab meets a foundation wall or other conductive slab.

M2103.2.4 Thermal barrier material marking.
Insulating materials used in thermal barriers shall be installed so that the manufacturer’s $R$-value mark is readily observable upon inspection.

M2103.3 Piping joints. Deleted.
Copper and copper alloy systems shall be soldered in accordance with ASTM B 828. Fluxes for soldering shall be in accordance with ASTM B 813. Brazing fluxes shall be in accordance with AWS A5.31. Piping joints that are embedded shall be installed in accordance with the following requirements:

1. Steel pipe joints shall be welded.

2. Copper tubing shall be joined by brazing complying with Section P3003.6.1.

3. Polybutylene pipe and tubing joints shall be installed with socket-type heat-fused polybutylene fittings.

4. CPVC tubing shall be joined using solvent cement joints.

5. Polypropylene pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings.

6. Cross-linked polyethylene (PEX) tubing shall be joined using cold expansion, insert or compression fittings.

7. Raised temperature polyethylene (PE-RT) tubing shall be joined using insert or compression fittings.

M2103.4 Testing. Deleted.
Piping or tubing to be embedded shall be tested by applying a hydrostatic pressure of not less than 100 psi (690 kPa). The pressure shall be maintained for 30 minutes, during which, the joints shall be visually inspected for leaks.

SECTION M2104
LOW TEMPERATURE PIPING

M2104.1 Piping materials.
Low temperature piping for embedment in concrete or gypsum materials shall be as indicated in Table M2101.1.
M2104.2 Piping joints.
Piping joints, other than those in Section M2103.3, that are embedded shall comply with the following requirements:

1. Cross-linked polyethylene (PEX) tubing shall be installed in accordance with the manufacturer’s instructions.

2. Polyethylene tubing shall be installed with heat fusion joints.

3. Polypropylene (PP) tubing shall be installed in accordance with the manufacturer’s instructions.

4. Raised temperature polyethylene (PE-RT) shall be installed in accordance with the manufacturer’s instructions.

M2104.3 Raised temperature polyethylene (PE-RT) plastic tubing.
Joints between raised temperature polyethylene tubing and fittings shall conform to Sections M2104.3.1, M2104.3.2 and M2104.3.3. Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

M2104.3.1 Compression-type fittings.
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting such inserts and ferrules or O-rings.

M2104.3.2 PE-RT-to-metal connections.
Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-RT pipe.

M2104.3.3 PE-RT insert fittings.
PE-RT insert fittings shall be installed in accordance with the manufacturer’s instructions.

M2104.4 Polyethylene/Aluminum/Polyethylene (PE-AL-PE) pressure pipe.
Joints between polyethylene/aluminum/polyethylene pressure pipe and fittings shall conform to Sections M2104.4.1 and M2104.4.2. Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

M2104.4.1 Compression-type fittings.
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting such inserts and ferrules or O-rings.

M2104.4.2 PE-AL-PE to metal connections.
Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-AL-PE pipe.

SECTION M2105
GROUND-SOURCE HEAT-PUMP SYSTEM LOOP PIPING

M2105.1 (1210.1) Plastic ground-source heat-pump loop piping.
Plastic piping and tubing material used in water-based ground-source heat-pump ground-loop systems shall conform to the standards specified in this section.
M2105.2 (1210.2) Used materials.
Reused pipe, fittings, valves, and other materials shall not be used in ground-source heat-pump loop systems.

M2105.3 (1210.3) Material rating.
Pipe and tubing shall be rated for the operating temperature and pressure of the ground-source heat-pump loop system. Fittings shall be suitable for the pressure applications and recommended by the manufacturer for installation with the pipe and tubing material installed. Where used underground, materials shall be suitable for burial.

M2105.4 (1210.4) Piping and tubing materials standards.
Ground-source heat-pump ground-loop pipe and tubing shall conform to the standards listed in Table M2105.4.

### TABLE M2105.4
**GROUND-SOURCE LOOP PIPE**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D 2846; ASTM F 437; ASTM F 438; ASTM F 439; ASTM F 441; ASTM F 442; CSA B137.6</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F 876; ASTM F 877; CSA B137.5</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe</td>
<td>ASTM F 1282; CSA B137.9; AWWA C 903</td>
</tr>
<tr>
<td>High-density Polyethylene (HDPE)</td>
<td>ASTM D 2737; ASTM D 3035; ASTM F 714; AWWA C901; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polypropylene (PP-R)</td>
<td>ASTM F 2389; CSA B137.11</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC)</td>
<td>ASTM D 1785; ASTM D 2241; CSA 137.3</td>
</tr>
<tr>
<td>Raised temperature polyethylene (PE-RT)</td>
<td>ASTM F 2623; ASTM F 2769</td>
</tr>
</tbody>
</table>

M2105.5 (1210.5) Fittings.
Ground-source heat-pump pipe fittings shall be approved for installation with the piping materials to be installed, shall conform to the standards listed in Table M2105.5 and, where installed underground, shall be suitable for burial.

### TABLE M2105.5
**GROUND-SOURCE LOOP PIPE FITTINGS**

<table>
<thead>
<tr>
<th>PIPE MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D 2846; ASTM F 437; ASTM F 438; ASTM F 439; ASTM F 1970; CSA B137.6</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F 877; ASTM F 1807; ASTM F 1960; ASTM F 2080; ASTM F 2159; ASTM F 2434; CSA B137.5</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE)</td>
<td>ASTM F 2434; ASTM F 1282; CSA B137.9</td>
</tr>
</tbody>
</table>
High-density Polyethylene (HDPE) | ASTM D 2683; ASTM D 3261; ASTM F 1055; CSA B137.1; CSA C448; NSF 358-1
Polypropylene (PP-R) | ASTM F 2389; CSA B137.11; NSF 358-2
Polyvinyl chloride (PVC) | ASTM D 2464; ASTM D 2466; ASTM D 2467; ASTM F 1970, CSA B137.2; CSA B137.3
Raised temperature polyethylene (PE-RT) | ASTM D 3261; ASTM F 1807; ASTM F 2159; F 2769; B137.1

M2105.6 (1210.6) Joints and connections.
Joints and connections shall be of an approved type. Joints and connections shall be tight for the pressure of the ground-source loop system. Joints used underground shall be approved for such applications.

M2105.6.1 (1210.6.1) Joints between different piping materials.
Joints between different piping materials shall be made with approved transition fittings.

M2105.7 (1210.6.2) Preparation of pipe ends.
Pipe shall be cut square, reamed, and shall be free of burrs and obstructions. CPVC, PE and PVC pipe shall be chamfered. Pipe ends shall have full-bore openings and shall not be undercut.

M2105.8 (1210.6.3) Joint preparation and installation.
Where required by Sections M2105.9 through M2105.11, the preparation and installation of mechanical and thermoplastic-welded joints shall comply with Sections M2105.8.1 and M2105.8.2.

M2105.8.1 (1210.6.3.1) Mechanical joints.
Mechanical joints shall be installed in accordance with the manufacturer's instructions.

M2105.8.2 (1210.6.3.2) Thermoplastic-welded joints.
Joint surfaces for thermoplastic-welded joints shall be cleaned by an approved procedure. Joints shall be welded in accordance with the manufacturer's instructions.

M2105.9 (1210.6.4) CPVC plastic pipe.
Joints between CPVC plastic pipe or fittings shall be solvent-cemented in accordance with Section P2906.9.1.2. Threaded joints between fittings and CPVC plastic pipe shall be in accordance with Section M2105.9.1.

M2105.9.1 Threaded joints.
Threads shall conform to ASME B1.20.1. The pipe shall be Schedule 80 or heavier plastic pipe and shall be threaded with dies specifically designed for plastic pipe. Thread lubricant, pipe-joint compound or tape shall be applied on the male threads only and shall be approved for application on the piping material.

M2105.10 (1210.6.5) Cross-linked polyethylene (PEX) plastic tubing.
Joints between cross-linked polyethylene plastic tubing and fittings shall comply with Sections M2105.10.1 and M2105.10.2. Mechanical joints shall comply with Section M2105.8.1.
M2105.10.1 (1210.6.5.1) Compression-type fittings.  
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

M2105.10.2 (1210.6.5.2) Plastic-to-metal connections.  
Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to plastic pipe or tubing.

M2105.11 (1210.6.6) Polyethylene plastic pipe and tubing.  
Joints between polyethylene plastic pipe and tubing or fittings for ground-source heat-pump loop systems shall be heat-fusion joints complying with Section M2105.11.1, electrofusion joints complying with Section M2105.11.2, or stab-type insertion joints complying with Section M2105.11.3.

M2105.11.1 (1210.6.6.1) Heat-fusion joints.  
Joints shall be of the socket-fusion, saddle-fusion or butt-fusion type, and joined in accordance with ASTM D 2657. Joint surfaces shall be clean and free of moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D 2683 or ASTM D 3261.

M2105.11.2 (1210.6.6.1) Electrofusion joints.  
Joints shall be of the electrofusion type. Joint surfaces shall be clean and free of moisture, and scoured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for the period of time specified by the manufacturer. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F 1055.

M2105.11.3 (1210.6.6.3) Stab-type insert fittings.  
Joint surfaces shall be clean and free of moisture. Pipe ends shall be chamfered and inserted into the fittings to full depth. Fittings shall be manufactured in accordance with ASTM F 1924.

M2105.12 (1210.6.7) Polypropylene (PP) plastic.  
Joints between PP plastic pipe and fittings shall comply with Sections M2105.12.1 and M2105.12.2.

M2105.12.1 (1210.6.7.1) Heat-fusion joints.  
Heat-fusion joints for polypropylene (PP) pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings, electrofusion polypropylene fittings or by butt fusion. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F 2389.

M2105.12.2 (1210.6.7.2) Mechanical and compression sleeve joints.  
Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s instructions.

M2105.13 (1210.6.8) Raised temperature polyethylene (PE-RT) plastic tubing.  
Joints between raised temperature polyethylene tubing and fittings shall comply with Sections M2105.13.1 and M2105.13.2. Mechanical joints shall comply with Section M2105.8.1.
M2105.13.1 (1210.6.8.1) Compression-type fittings.
Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

M2105.13.2 (1210.6.8.2) PE-RT-to-metal connections.
Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-RT pipe or tubing.

M2105.14 (1210.6.9) PVC plastic pipe.
Joints between PVC plastic pipe or fittings shall be solvent-cemented in accordance with Section P2906.9.1.4. Threaded joints between fittings and PVC plastic pipe shall be in accordance with Section M2105.9.1.

M2105.15 (1210.7) Shutoff valves.
Shutoff valves shall be installed in ground-source loop piping systems in the locations indicated in Sections M2105.15.1 through M2105.15.6.

M2105.15.1 Heat exchangers.
Shutoff valves shall be installed on the supply and return side of a heat exchanger.

Exception: Shutoff valves shall not be required where heat exchangers are integral with a boiler or are a component of a manufacturer’s boiler and heat exchanger packaged unit and are capable of being isolated from the hydronic system by the supply and return valves required by Section M2001.3.

M2105.15.2 Central systems.
Shutoff valves shall be installed on the building supply and return of a central utility system.

M2105.15.3 Pressure vessels.
Shutoff valves shall be installed on the connection to any pressure vessel.

M2105.15.4 Pressure-reducing valves.
Shutoff valves shall be installed on both sides of a pressure-reducing valve.

M2105.15.5 Equipment and appliances.
Shutoff valves shall be installed on connections to mechanical equipment and appliances. This requirement does not apply to components of ground-source loop systems such as pumps, air separators, metering devices, and similar equipment.

M2105.15.6 Expansion tanks.
Shutoff valves shall be installed at connections to nondiaphragm-type expansion tanks.

M2105.16 (1210.7.7) Reduced pressure.
A pressure relief valve shall be installed on the low-pressure side of a hydronic piping system that has been reduced in pressure. The relief valve shall be set at the maximum pressure of the system design. The valve shall be installed in accordance with Section M2002.

M2105.17 (1210.8) Installation.
Piping, valves, fittings, and connections shall be installed in accordance with the manufacturer’s instructions.
M2105.18 (1210.8.1) Protection of potable water.
Where ground-source heat-pump ground-loop systems have a connection to a potable water supply, the potable water system shall be protected from backflow in accordance with Section P2902.

M2105.19 (1210.8.2) Pipe penetrations.
Openings for pipe penetrations in walls, floors and ceilings shall be larger than the penetrating pipe. Openings through concrete or masonry building elements shall be sleeved. The annular space surrounding pipe penetrations shall be protected in accordance with Section P2606.1.

M2105.20 (1210.8.3) Clearance from combustibles.
A pipe in a ground-source heat pump piping system having an exterior surface temperature exceeding 250°F (121°C) shall have a clearance of not less than 1 inch (25 mm) from combustible materials.

M2105.21 (1210.8.4) Contact with building material.
A ground-source heat-pump ground-loop piping system shall not be in direct contact with building materials that cause the piping or fitting material to degrade or corrode, or that interfere with the operation of the system.

M2105.22 (1210.8.5) Strains and stresses.
Piping shall be installed so as to prevent detrimental strains and stresses in the pipe. Provisions shall be made to protect piping from damage resulting from expansion, contraction and structural settlement. Piping shall be installed so as to avoid structural stresses or strains within building components.

M2105.22.1 Flood hazard.
Piping located in a flood hazard area shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the design flood elevation.

M2105.23 (1210.8.7) Pipe support.
Pipe shall be supported in accordance with Section M2101.9.

M2105.24 (1210.8.8) Velocities.
Ground-source heat-pump ground-loop systems shall be designed so that the flow velocities do not exceed the maximum flow velocity recommended by the pipe and fittings manufacturer. Flow velocities shall be controlled to reduce the possibility of water hammer.

M2105.25 (1210.8.9) Labeling and marking.
Ground-source heat-pump ground-loop system piping shall be marked with tape, metal tags or other methods where it enters a building. The marking shall state the following words: "GROUND-SOURCE HEAT-PUMP LOOP SYSTEM." The marking shall indicate if antifreeze is used in the system and shall indicate the chemicals by name and concentration.

M2105.26 (1210.8.10) Chemical compatibility.
Antifreeze and other materials used in the system shall be chemically compatible with the pipe, tubing, fittings and mechanical systems.

M2105.27 (1210.9) Makeup water.
The transfer fluid shall be compatible with the makeup water supplied to the system.
M2105.28 (1210.10) Testing.
Before connection header trenches are backfilled, the assembled loop system shall be pressure tested with water at 100 psi (689 kPa) for 15 minutes without observed leaks. Flow and pressure loss testing shall be performed and the actual flow rates and pressure drops shall be compared to the calculated design values. If actual flow rate or pressure drop values differ from calculated design values by more than 10 percent, the cause shall be identified and corrective action taken.

M2105.29 (1210.11) Embedded piping.
Ground-source heat-pump ground-loop piping to be embedded in concrete shall be pressure tested prior to pouring concrete. During pouring, the pipe shall be maintained at the proposed operating pressure.

SECTION M2106
BASEBOARD CONVECTORS

M2106.1 General.
Baseboard convectors shall be installed in accordance with the manufacturer’s instructions. Convectors shall be supported independently of the hydronic piping.
CHAPTER 22
SPECIAL FUEL OIL PIPING AND STORAGE SYSTEMS

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M2201
OIL TANKS

M2201.1 Materials.
Supply tanks shall be listed and labeled and shall conform to UL 58 for underground tanks, UL 142 for above-ground tanks, and UL 80 for indoor tanks.

M2201.2 (1309.2) Above-ground tanks.
The maximum amount of fuel oil stored above ground or inside of a building shall be 660 gallons (2498 L). The supply tank shall be supported on rigid noncombustible supports to prevent settling or shifting.

Exception: The storage of fuel oil, used for space or water heating, above ground or inside buildings in quantities exceeding 660 gallons (2498 L) shall comply with NFPA 31.

M2201.2.1 (1309.2.1) Tanks within buildings.
Supply tanks for use inside of buildings shall be of such size and shape to permit installation and removal from dwellings as whole units. Supply tanks larger than 10 gallons (38 L) shall be placed not less than 5 feet (1524 mm) from any fire or flame either within or external to any fuel-burning appliance.

M2201.2.2 (1309.2.2) Outside above-ground tanks.
Tanks installed outside above ground shall be a minimum of 5 feet (1524 mm) from an adjoining property line. Such tanks shall be suitably protected from the weather and from physical damage.

M2201.3 (1309.3) Underground tanks.
Excavations for underground tanks shall not undermine the foundations of existing structures. The clearance from the tank to the nearest wall of a basement, pit or property line shall be not less than 1 foot (305 mm). Tanks shall be set on and surrounded with noncorrosive inert materials such as clean earth, sand or gravel well tamped in place. Tanks shall be covered with not less than 1 foot (305 mm) of earth. Corrosion protection shall be provided in accordance with Section M2203.7.

M2201.4 (1309.4) Multiple tanks.
Cross connection of two supply tanks shall be permitted in accordance with Section M2203.6.

M2201.5 (1309.5, 1306.3) Oil gauges.
Inside tanks shall be provided with a device to indicate when the oil in the tank has reached a
predetermined safe level. Glass gauges or a gauge subject to breakage that could result in the escape of oil from the tank shall not be used. Liquid-level indicating gauges shall comply with UL 180.

**M2201.6 (1309.6) Flood-resistant installation.**
In flood hazard areas as established by Table R301.2(1), tanks shall be installed at or above the elevation required in Section R322.2.1 or R322.3.2 or shall be anchored to prevent flotation, collapse and lateral movement under conditions of the design flood.

**M2201.7 (1301.5) Tanks abandoned or removed.**
Exterior above-grade fill piping shall be removed when tanks are abandoned or removed. Tank abandonment and removal shall be in accordance with the *International Fire Code*. Tank abandonment and removal shall be in accordance with Section 5704.2.13 of the *International Fire Code*.

### SECTION M2202
**OIL PIPING, FITTING AND CONNECTIONS**

**M2202.1 Materials.**
Piping shall consist of steel pipe, copper and copper alloy pipe and tubing or steel tubing conforming to ASTM A 539. Aluminum tubing shall not be used between the fuel-oil tank and the burner units.

**M2202.2 Joints and fittings.**
Piping shall be connected with standard fittings compatible with the piping material. Cast iron fittings shall not be used for oil piping. Unions requiring gaskets or packings, right or left couplings, and sweat fittings employing solder having a melting point less than 1,000°F (538°C) shall not be used for oil piping. Threaded joints and connections shall be made tight with a lubricant or pipe thread compound.

**M2202.3 Flexible connectors.**
Flexible metallic hoses shall be listed and labeled in accordance with UL 536 and shall be installed in accordance with their listing and labeling and the manufacturer's installation instructions. Connectors made from combustible materials shall not be used inside of buildings or above ground outside of buildings.

**M2202.1 (1302.1) General.**
Piping materials shall conform to the standards cited in this section.

**M2202.2 (1302.2) Rated for system.**
All materials shall be rated for the operating temperatures and pressures of the system, and shall be compatible with the type of liquid.

**M2202.3 (1302.3) Pipe standards.**
Fuel oil pipe shall comply with one of the standards listed in Table M2202.3.

#### TABLE M2202.3 (1302.3)
**FUEL OIL PIPING**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Material</th>
<th>ASTM Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper or copper-alloy pipe</td>
<td>ASTM B 42; ASTM B 43; ASTM B 302</td>
</tr>
<tr>
<td>Copper or copper-alloy tubing (Type K, L or M)</td>
<td>ASTM B 75; ASTM B 88; ASTM B 280</td>
</tr>
<tr>
<td>Labeled pipe</td>
<td>(See Section 1302.4)</td>
</tr>
<tr>
<td>Nonmetallic pipe</td>
<td>ASTM D 2996</td>
</tr>
<tr>
<td>Steel pipe</td>
<td>ASTM A 53; ASTM A 106</td>
</tr>
<tr>
<td>Steel tubing</td>
<td>ASTM A 254; ASTM A 539</td>
</tr>
</tbody>
</table>

**M2202.4 (1302.4) Nonmetallic pipe.**
Nonmetallic pipe shall be listed and labeled as being acceptable for the intended application for flammable and combustible liquids. Nonmetallic pipe shall be installed only outside, underground.

**M2202.5 (1302.5) Fittings and valves.**
Fittings and valves shall be approved for the piping systems, and shall be compatible with, or shall be of the same material as, the pipe or tubing.

**M2202.6 (1302.6) Bending of pipe.**
Pipe shall be approved for bending. Pipe bends shall be made with approved equipment. The bend shall not exceed the structural limitations of the pipe.

**M2202.7 (1302.7) Pumps.**
Pumps that are not part of an appliance shall be of a positive-displacement type. The pump shall automatically shut off the supply when not in operation. Pumps shall be listed and labeled in accordance with UL 343.

**M2202.8 (1302.8) Flexible connectors and hoses.**
Flexible connectors and hoses shall be listed and labeled in accordance with UL 536.

**M2202.9 (1303.1) Approval.**
Joints and connections shall be approved and of a type approved for fuel-oil piping systems. Threaded joints and connections shall be made tight with suitable lubricant or pipe compound. Unions requiring gaskets or packings, right or left couplings, and sweat fittings employing solder having a melting point of less than 1,000°F (538°C) shall not be used in oil lines. Cast-iron fittings shall not be used. Joints and connections shall be tight for the pressure required by test.

**M2202.9.1 (1303.1.1) Joints between different piping materials.**
Joints between different piping materials shall be made with approved adapter fittings. Joints between different metallic piping materials shall be made with approved dielectric fittings or brass converter fittings.

**M2202.10 (1303.2) Preparation of pipe ends.**
Pipe shall be cut square, reamed and chamfered and be free from all burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

**M2202.11 (1303.3) Joint preparation and installation.**
Where required by Sections M2202.12 through M2202.18 the preparation and installation of brazed, mechanical, threaded and welded joints shall comply with Sections M2202.11.1 through M2202.11.4.
M2202.11.1 (1303.3.1) Brazed joints.
All joint surfaces shall be cleaned. An approved flux shall be applied where required. The joints shall be brazed with a filler metal conforming to AWS A5.8.

M2202.11.2 (1303.3.2) Mechanical joints.
Mechanical joints shall be installed in accordance with the manufacturer’s instructions. Press connect joints shall conform to one of the standards listed in Table 1302.3.

M2202.11.3 (1303.3.3) Threaded joints.
Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

M2202.11.4 (1303.3.4) Welded joints.
All joint surfaces shall be cleaned by an approved procedure. The joint shall be welded with an approved filler metal.

M2202.12 (1303.4) Brass pipe.
Joints between brass pipe or fittings shall be brazed, mechanical, threaded or welded joints complying with Section M2202.11.

M2202.13 (1303.5) Brass tubing.
Joints between brass tubing or fittings shall be brazed or mechanical joints complying with Section M2202.11.

M2202.14 (1303.6) Copper or copper-alloy pipe.
Joints between copper or copper-alloy pipe or fittings shall be brazed, mechanical, threaded or welded joints complying with Section M2202.11.

M2202.15 (1303.7) Copper or copper-alloy tubing.
Joints between copper or copper-alloy tubing or fittings shall be brazed or mechanical joints complying with Section M2202.11 or flared joints. Flared joints shall be made by a tool designed for that operation.

M2202.16 (1303.8) Nonmetallic pipe.
Joints between nonmetallic pipe or fittings shall be installed in accordance with the manufacturer’s instructions for the labeled pipe and fittings.

M2202.17 (1303.9) Steel pipe.
Joints between steel pipe or fittings shall be threaded or welded joints complying with Section M2202.11 or mechanical joints complying with Section M2202.17.1.

M2202.17.1 (1303.9.1) Mechanical joints.
Joints shall be made with an approved elastomeric seal. Mechanical joints shall be installed in accordance with the manufacturer’s instructions. Mechanical joints shall be installed outside, underground, unless otherwise approved.

M2202.18 (1303.10) Steel tubing.
Joints between steel tubing or fittings shall be mechanical or welded joints complying with Section M2202.11.

M2202.19 (1303.11) Piping protection.
Proper allowance shall be made for expansion, contraction, jarring and vibration. Piping other than tubing, connected to underground tanks, except straight fill lines and test wells, shall be provided with flexible connectors, or otherwise arranged to permit the tanks to settle without impairing the tightness of the piping connections.

SECTION M2203
INSTALLATION

M2203.1 General.
Piping shall be installed in a manner to avoid placing stresses on the piping, and to accommodate expansion and contraction of the piping system.

M2203.2 Supply piping.
Supply piping used in the installation of oil burners and appliances shall be not smaller than 3/8-inch (9 mm) pipe or 3/8-inch (9 mm) outside diameter tubing. Copper tubing and fittings shall be a minimum of Type L. The fuel oil system shall be sized for the maximum capacity of fuel oil required. The minimum size of a supply line shall be 3/8-inch (9.5 mm) inside diameter nominal pipe or 3/8-inch (9.5 mm) od tubing. The minimum size of a return line shall be 1/4-inch (6.4 mm) inside diameter nominal pipe or 5/16-inch (7.9 mm) outside diameter tubing. Copper tubing shall have 0.035-inch (0.9 mm) nominal and 0.032-inch (0.8 mm) minimum wall thickness.

M2203.2.1 (1305.3) Supply piping installation.
Supply piping shall connect to the top of the fuel oil tank. Fuel oil shall be supplied by a transfer pump or automatic pump or by other approved means.

Exception: This section shall not apply to inside or aboveground fuel oil tanks.

M2203.2.2 (1305.4) Return piping.
Return piping shall connect to the top of the fuel oil tank. Valves shall not be installed on return piping.

M2203.2.3 (1305.5) System pressure.
The system shall be designed for the maximum pressure required by the fuel-oil-burning appliance. Air or other gases shall not be used to pressurize tanks.

M2203.2.4 (1308.1) Testing required.
Fuel oil piping shall be tested in accordance with NFPA 31.

M2203.2.4.1 (1201.4) Test gauges.
Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 pounds per square inch (psi) (69 kPa) or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.

2. Tests requiring a pressure of greater than 10 psi (69 kPa) but less than or equal to 100 psi (689 kPa) shall utilize a testing gauge having increments of 1 psi (6.9 kPa) or less.
3. Tests requiring a pressure of greater than 100 psi (689 kPa) shall utilize a testing gauge having increments of 2 psi (14 kPa) or less.

M2203.3 (1305.6) Fill piping.
Fill piping shall terminate outside of buildings at a point not less than 2 feet (610 mm) from any building opening at the same or lower level. Fill openings shall be equipped with a tight metal cover.

M2203.4 (1305.7) Vent piping.
Vent piping shall be not smaller than $\frac{1}{4}$-inch (32 mm) pipe. Vent piping shall be laid to drain toward the tank without sags or traps in which the liquid can collect. Vent pipes shall not be cross connected with fill pipes, lines from burners or overflow lines from auxiliary tanks. The lower end of a vent pipe shall enter the tank through the top and shall extend into the tank not more than 1 inch (25 mm).

M2203.5 (1305.7) Vent termination.
Vent piping shall terminate outside of buildings at a point not less than 2 feet (610 mm), measured vertically or horizontally, from any building opening. Outer ends of vent piping shall terminate in a weather-proof cap or fitting having an unobstructed area at least equal to the cross-sectional area of the vent pipe, and shall be located sufficiently above the ground to avoid being obstructed by snow and ice. Liquid fuel vent pipes shall terminate outside of buildings at a point not less than 2 feet (610 mm) measured vertically or horizontally from any building opening. Outer ends of vent pipes shall terminate in a weatherproof vent cap or fitting or be provided with a weatherproof hood. Vent caps shall have a minimum free open area equal to the cross-sectional area of the vent pipe and shall not employ screens finer than No. 4 mesh. Vent pipes shall terminate sufficiently above the ground to avoid being obstructed with snow or ice. Vent pipes from tanks containing heaters shall be extended to a location where oil vapors discharging from the vent will be readily diffused. If the static head with a vent pipe filled with oil exceeds 10 pounds per square inch (psi) (69 kPa), the tank shall be designed for the maximum static head that will be imposed.

M2203.6 (1309.7) Cross connection of tanks.
Cross connection of two supply tanks, not exceeding 660 gallons (2498 L) aggregate capacity, with gravity flow from one tank to another, shall be acceptable providing that the two tanks are on the same horizontal plane.

M2203.7 (1309.8) Corrosion protection.
Underground tanks and buried piping shall be protected by corrosion-resistant coatings or special alloys or fiberglass-reinforced plastic.

SECTION M2204
OIL PUMPS AND VALVES

M2204.1 Pumps.
Oil pumps shall be positive displacement types that automatically shut off the oil supply when stopped. Automatic pumps shall be listed and labeled in accordance with UL 343 and shall be installed in accordance with their listing.
M2204.2 (1307.1) Building shutoff. Shutoff valves. A readily accessible manual shutoff valve shall be installed between the oil supply tank and the burner. Where the shutoff valve is installed in the discharge line of an oil pump, a pressure relief valve shall be incorporated to bypass or return surplus oil. Valves shall comply with UL 842. A shutoff valve shall be installed on the fuel-oil supply line at the entrance to the building. Inside or above-ground tanks are permitted to have valves installed at the tank. The valve shall be capable of stopping the flow of fuel oil to the building or to the appliance served where the valve is installed at a tank inside the building.

M2204.3 (1307.2) Appliance shutoff. Maximum pressure. Pressure at the oil supply inlet to an appliance shall be not greater than 3 pounds per square inch (20.7 kPa). A shutoff valve shall be installed at the connection to each appliance where more than one fuel-oil-burning appliance is installed.

M2204.4 (1307.3) Pump relief valve. Relief valves. Fuel-oil lines incorporating heaters shall be provided with relief valves that will discharge to a return line when excess pressure exists. A relief valve shall be installed on the pump discharge line where a valve is located downstream of the pump and the pump is capable of exceeding the pressure limitations of the fuel oil system.

M2204.5 (1307.4) Fuel-oil heater relief valve. A relief valve shall be installed on the discharge line of fuel-oil-heating appliances.

M2204.6 (1307.5) Relief valve operation. The relief valve shall discharge fuel oil when the pressure exceeds the limitations of the system. The discharge line shall connect to the fuel oil tank.

SECTION M2205 (1306) OIL GAUGING

M2205.1 (1306.1) Level indication. Tanks in which a constant oil level is not maintained by an automatic pump shall be equipped with a method of determining the oil level.

M2205.2 (1306.2) Test wells. Test wells shall not be installed inside buildings. For outside service, test wells shall be equipped with a tight metal cover designed to discourage tampering.

M2205.3 (1306.3) Inside tanks. The gauging of inside tanks by means of measuring sticks shall not be permitted. An inside tank provided with fill and vent pipes shall be provided with a device to indicate either visually or audibly at the fill point when the oil in the tank has reached a predetermined safe level.

M2205.4 (1306.4) Gauging devices. Gauging devices such as liquid level indicators or signals shall be designed and installed so that oil vapor will not be discharged into a building from the liquid fuel supply system. Liquid-level indicating gauges shall comply with UL 180.

M2205.5 (1306.5) Gauge glass.
A tank used in connection with any oil burner shall not be equipped with a glass gauge or any gauge which, when broken, will permit the escape of oil from the tank.
CHAPTER 23
SOLAR THERMAL ENERGY SYSTEMS

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M2301
THERMAL SOLAR ENERGY SYSTEMS

M2301.1 (1401.1) General.
This section provides for the design, construction, installation, alteration and repair of equipment and systems using thermal solar energy to provide space heating or cooling, hot water heating and swimming pool heating.

M2301.2 Design and installation.
The design and installation of thermal solar energy systems shall comply with Sections M2301.2.1 through M2301.2.13.

M2301.2.1 Access.
Solar energy collectors, controls, dampers, fans, blowers and pumps shall be accessible for inspection, maintenance, repair and replacement.

M2301.2.2 Collectors and panels.
Solar collectors and panels shall comply with Sections M2301.2.2.1 and M2301.2.2.2.

M2301.2.2.1 Roof-mounted collectors.
The roof shall be constructed to support the loads imposed by roof-mounted solar collectors. Roof-mounted solar collectors that serve as a roof covering shall conform to the requirements for roof coverings in Chapter 9 of this code. Where mounted on or above the roof coverings, the collectors and supporting structure shall be constructed of noncombustible materials or fire-retardant-treated wood equivalent to that required for the roof construction.

M2301.2.2.2 Collector sensors.
Collector sensor installation, sensor location and the protection of exposed sensor wires from ultraviolet light shall be in accordance with SRCC 300.

M2301.2.3 Pressure and temperature relief valves and system components.
System components containing fluids shall be protected with temperature and pressure relief valves or pressure relief valves. Relief devices shall be installed in sections of the system so that a section cannot be valved off or isolated from a relief device. Direct systems and the potable water portion of indirect systems shall be equipped with a relief valve in accordance with Section P2804. For indirect systems, pressure relief valves in solar loops shall comply with SRCC 300. System components shall have a working pressure rating of not less than the setting of the pressure relief device.
**M2301.2.4 Vacuum relief.**
System components that might be subjected to pressure drops below atmospheric pressure during operation or shutdown shall be protected by a vacuum-relief valve.

**M2301.2.5 Piping insulation.**
Piping shall be insulated in accordance with the requirements of Chapter 11. Exterior insulation shall be protected from ultraviolet degradation. The entire solar loop shall be insulated. Where split-style insulation is used, the seam shall be sealed. Fittings shall be fully insulated.

**Exceptions:**

1. Those portions of the piping that are used to help prevent the system from overheating shall not be required to be insulated.

2. Those portions of piping that are exposed to solar radiation, made of the same material as the solar collector absorber plate and are covered in the same manner as the solar collector absorber, or that are used to collect additional solar energy, shall not be required to be insulated.

3. Piping in thermal solar systems using unglazed solar collectors to heat a swimming pool shall not be required to be insulated.

**M2301.2.6 Protection from freezing.**
System components shall be protected from damage resulting from freezing of heat-transfer liquids at the winter design temperature provided in Table R301.2(1). Freeze protection shall be provided by heating, insulation, thermal mass and heat transfer fluids with freeze points lower than the winter design temperature, heat tape or other approved methods, or combinations thereof.

**Exception:** Where the winter design temperature is greater than 32°F (0°C).

**M2301.2.7 Storage tank sensors.**
Storage tank sensors shall comply with SRCC 300.

**M2301.2.8 Expansion tanks.**
Expansion tanks in solar energy systems shall be installed in accordance with Section M2003 in solar collector loops that contain pressurized heat transfer fluid. Where expansion tanks are used, the system shall be designed in accordance with SRCC 300 to provide an expansion tank that is sized to withstand the maximum operating pressure of the system.

**Exception:** Expansion tanks shall not be required in drain-back systems.

**M2301.2.9 Roof and wall penetrations.**
Roof and wall penetrations shall be flashed and sealed in accordance with Chapter 9 of this code to prevent entry of water, rodents and insects.

**M2301.2.10 Description and warning labels.**
Solar thermal systems shall comply with description label and warning label requirements of Section M2301.2.11.2 and SRCC 300.
M2301.2.11 Solar loop.
Solar loops shall be in accordance with Sections M2301.2.11.1 and M2301.2.11.2.

M2301.2.11.1 Solar loop isolation.
Valves shall be installed to allow the solar collectors to be isolated from the remainder of the system.

M2301.2.11.2 Drain and fill valve labels and caps.
Drain and fill valves shall be labeled with a description and warning that identifies the fluid in the solar loop and a warning that the fluid might be discharged at high temperature and pressure. Drain caps shall be installed at drain and fill valves.

M2301.2.12 Maximum temperature limitation.
Systems shall be equipped with means to limit the maximum water temperature of the system fluid entering or exchanging heat with any pressurized vessel inside the dwelling to 180°F (82°C). This protection is in addition to the required temperature- and pressure-relief valves required by Section M2301.2.3.

M2301.2.13 Thermal storage unit seismic bracing.
In Seismic Design Categories D₀, D₁, and D₂ and in townhouses in Seismic Design Category C, thermal storage units shall be anchored in accordance with Section M1307.2.

M2301.3 Labeling.
Labeling shall comply with Sections M2301.3.1 and M2301.3.2.

M2301.3.1 Collectors and panels.
Solar thermal collectors and panels shall be listed and labeled in accordance with SRCC 100 or SRCC 600. Collectors and panels shall be listed and labeled to show the manufacturer’s name, model number, serial number, collector weight, collector maximum allowable temperatures and pressures, and the type of heat transfer fluids that are compatible with the collector or panel. The label shall clarify that these specifications apply only to the collector or panel.

M2301.3.2 Thermal storage units.
Pressurized thermal storage units shall be listed and labeled to show the manufacturer’s name, model number, serial number, storage unit maximum and minimum allowable operating temperatures and pressures, and the type of heat transfer fluids that are compatible with the storage unit. The label shall clarify that these specifications apply only to the thermal storage unit.

M2301.4 Heat transfer gasses or liquids and heat exchangers.
Essentially toxic transfer fluids, ethylene glycol, flammable gases and flammable liquids shall not be used as heat transfer fluids. Heat transfer gasses and liquids shall be rated to withstand the system’s maximum design temperature under operating conditions without degradation. Heat exchangers used in solar thermal systems shall comply with Section P2902.5.2 and SRCC 300.
Heat transfer fluids shall be in accordance with SRCC 300. The flash point of the heat transfer fluids utilized in solar thermal systems shall be not less than 50°F (28°C) above the design maximum nonoperating or no-flow temperature attained by the fluid in the collector.

M2301.5 (1401.2) Backflow protection.
Connections from the potable water supply to solar systems shall comply with Section P2902.5.5.

M2301.6 Filtering.
Air provided to occupied spaces that passes through thermal mass storage systems by mechanical means shall be filtered for particulates at the outlet of the thermal mass storage system.

M2301.7 Solar thermal systems for heating potable water.
Where a solar thermal system heats potable water to supply a potable hot water distribution system, the solar thermal system shall be in accordance with Sections M2301.7.1, M2301.7.2 and P2902.5.5.

M2301.7.1 Indirect systems.
Heat exchangers that are components of indirect solar thermal heating systems shall comply with Section P2902.5.2.

M2301.7.2 Direct systems.
Where potable water is directly heated by a solar thermal system, the pipe, fittings, valves and other components that are in contact with the potable water in the solar heating system shall comply with the requirements of Chapter 29.
Part VI—Fuel Gas

CHAPTER 24
FUEL GAS

The text of this chapter is extracted from the 2015 2018 edition of the International North Carolina Fuel Gas Code and has been modified where necessary to conform to the scope of application of the International North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the International North Carolina Fuel Gas Code.

SECTION G2401
(101) GENERAL

G2401.1 (101.2) Application.
This chapter covers those fuel gas piping systems, fuel-gas appliances and related accessories, venting systems and combustion air configurations most commonly encountered in the construction of one- and two-family dwellings and structures regulated by this code.

Coverage of piping systems shall extend from the point of delivery to the outlet of the appliance shutoff valves (see definition of “Point of delivery”). Piping systems requirements shall include design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance. Requirements for gas appliances and related accessories shall include installation, combustion and ventilation air and venting and connections to piping systems.

The omission from this chapter of any material or method of installation provided for in the International Fuel Gas Code shall not be construed as prohibiting the use of such material or method of installation. Fuel-gas piping systems, fuel-gas appliances and related accessories, venting systems and combustion air configurations not specifically covered in these chapters shall comply with the applicable provisions of the International Fuel Gas Code.

Gaseous hydrogen systems shall be regulated by Chapter 7 of the International Fuel Gas Code.

This chapter shall not apply to the following:

1. Liquified natural gas (LNG) installations.

2. Temporary LP-gas piping for buildings under construction or renovation that is not to become part of the permanent piping system.
3. Except as provided in Section G2412.1.1, gas piping, meters, gas pressure regulators, and other appurtenances used by the serving gas supplier in the distribution of gas, other than undiluted LP-gas.

4. Portable LP-gas appliances and equipment of all types that is not connected to a fixed fuel piping system.

5. Portable fuel cell appliances that are neither connected to a fixed piping system nor interconnected to a power grid.


G2401.2 (102.6) Historic buildings.
The provisions of this code relating to the construction, alteration, repair, enlargement, restoration, relocation or moving of buildings or structures shall not be mandatory for existing buildings or structures identified and classified by the state or local jurisdiction as historic buildings where such buildings or structures are judged by the code official to be safe and in the public interest of health, safety and welfare regarding any proposed construction, alteration, repair, enlargement, restoration, relocation or moving of buildings.

SECTION G2402 (201)
GENERAL

G2402.1 (201.1) Scope.
Unless otherwise expressly stated, the following words and terms shall, for the purposes of this chapter, have the meanings indicated in this chapter.

G2402.2 (201.2) Interchangeability.
Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural, the singular.

G2402.3 (201.3) Terms defined in other codes.
Where terms are not defined in this code and are defined in the International Building Code, International Fire Code, International Mechanical Code, International Fuel Gas Code or International Plumbing Code, such terms shall have meanings ascribed to them as in those codes.

SECTION G2403 (202)
GENERAL DEFINITIONS
(Deleted. See Chapter 2.)

ACCESS (TO). That which enables a device, appliance or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel, door or similar obstruction (see also “Ready access”).
AIR CONDITIONER, GAS-FIRED. A gas-burning, automatically operated appliance for supplying cooled and/or dehumidified air or chilled liquid.

AIR CONDITIONING. The treatment of air so as to control simultaneously the temperature, humidity, cleanliness and distribution of the air to meet the requirements of a conditioned space.

AIR, EXHAUST. Air being removed from any space or piece of equipment or appliance and conveyed directly to the atmosphere by means of openings or ducts.

AIR-HANDLING UNIT. A blower or fan used for the purpose of distributing supply air to a room, space or area.

AIR, MAKEUP. Any combination of outdoor and transfer air intended to replace exhaust air and exfiltration.

ALTERATION. A change in a system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

ANODELESS RISER. A transition assembly in which plastic piping is installed and terminated above ground outside of a building.

APPLIANCE. Any apparatus or device that utilizes a fuel or raw material to produce light, heat, power, refrigeration or air conditioning.

APPLIANCE, AUTOMATICALLY CONTROLLED. Appliances equipped with an automatic burner ignition and safety shut-off device and other automatic devices, which accomplish complete turn-on and shut-off of the gas to the main burner or burners, and graduate the gas supply to the burner or burners, but do not affect complete shut-off of the gas.

APPLIANCE, FAN-ASSISTED COMBUSTION. An appliance equipped with an integral mechanical means to either draw or force products of combustion through the combustion chamber or heat exchanger.

APPLIANCE, UNVENTED. An appliance designed or installed in such a manner that the products of combustion are not conveyed by a vent or chimney directly to the outside atmosphere.

APPLIANCE, VENTED. An appliance designed and installed in such a manner that all of the products of combustion are conveyed directly from the appliance to the outside atmosphere through an approved chimney or vent system.

APPROVED. Acceptable to the code official.

APPROVED AGENCY. An established and recognized agency that is regularly engaged in conducting tests or furnishing inspection services, where such agency has been approved by the code official.

ATMOSPHERIC PRESSURE. The pressure of the weight of air and water vapor on the surface of the earth, approximately 14.7 pounds per square inch (psia) (101 kPa absolute) at sea level.
AUTOMATIC IGNITION. Ignition of gas at the burner(s) when the gas controlling device is turned on, including reignition if the flames on the burner(s) have been extinguished by means other than by the closing of the gas controlling device.

BAROMETRIC DRAFT REGULATOR. A balanced damper device attached to a chimney, vent connector, breeching or flue gas manifold to protect combustion appliances by controlling chimney draft. A double-acting barometric draft regulator is one whose balancing damper is free to move in either direction to protect combustion appliances from both excessive draft and backdraft.

BOILER, LOW-PRESSURE. A self-contained appliance for supplying steam or hot water.

- **Hot water heating boiler.** A boiler in which no steam is generated, from which hot water is circulated for heating purposes and then returned to the boiler, and that operates at water pressures not exceeding 160 pounds per square inch gauge (psig) (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

- **Hot water supply boiler.** A boiler, completely filled with water, which furnishes hot water to be used externally to itself, and that operates at water pressures not exceeding 160 psig (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

- **Steam heating boiler.** A boiler in which steam is generated and that operates at a steam pressure not exceeding 15 psig (100 kPa gauge).

BONDING JUMPER. A conductor installed to electrically connect metallic gas piping to the grounding electrode system.

BRAZING. A metal joining process wherein coalescence is produced by the use of a nonferrous filler metal having a melting point above 1,000°F (538°C), but lower than that of the base metal being joined. The filler material is distributed between the closely fitted surfaces of the joint by capillary action.

BTU. Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound (454 g) of water 1°F (0.56°C) (1 Btu = 1055 J).

BURNER. A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone.

- **Induced-draft.** A burner that depends on draft induced by a fan that is an integral part of the appliance and is located downstream from the burner.

- **Power.** A burner in which gas, air or both are supplied at pressures exceeding, for gas, the line pressure, and for air, atmospheric pressure, with this added pressure being applied at the burner.

CHIMNEY. A primarily vertical structure containing one or more flues, for the purpose of carrying gaseous products of combustion and air from an appliance to the outside atmosphere.
**Factory-built chimney.** A listed and labeled chimney composed of factory-made components, assembled in the field in accordance with manufacturer’s instructions and the conditions of the listing.

**Masonry chimney.** A field-constructed chimney composed of solid masonry units, bricks, stones or concrete.

**CLEARANCE.** The minimum distance through air measured between the heat-producing surface of the mechanical appliance, device or equipment and the surface of the combustible material or assembly.

**CLOTHES DRYER.** An appliance used to dry wet laundry by means of heated air.

   **Type 1.** Factory-built package, multiple production. Primarily used in the family living environment. Usually the smallest unit physically and in-function output.

**CODE.** These regulations, subsequent amendments thereto, or any emergency rule or regulation that the administrative authority having jurisdiction has lawfully adopted.

**CODE OFFICIAL.** The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

**COMBUSTIBLE ASSEMBLY.** Wall, floor, ceiling or other assembly constructed of one or more component materials that are not defined as noncombustible.

**COMBUSTIBLE MATERIAL.** Any material not defined as noncombustible.

**COMBUSTION.** In the context of this code, refers to the rapid oxidation of fuel accompanied by the production of heat or heat and light.

**COMBUSTION AIR.** Air necessary for complete combustion of a fuel, including theoretical air and excess air.

**COMBUSTION CHAMBER.** The portion of an appliance within which combustion occurs.

**COMBUSTION PRODUCTS.** Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inert gases, but excluding excess air.

**CONCEALED LOCATION.** A location that cannot be accessed without damaging permanent parts of the building structure or finish surface. Spaces above, below or behind readily removable panels or doors shall not be considered as concealed.

**CONCEALED PIPING.** Piping that is located in a concealed location (see “Concealed location”).

**CONDENSATE.** The liquid that condenses from a gas (including flue gas) caused by a reduction in temperature or increase in pressure.

**CONNECTOR, APPLIANCE (Fuel).** Rigid metallic pipe and fittings, semirigid metallic tubing and fittings or a listed and labeled device that connects an appliance to the gas piping system.

**CONNECTOR, CHIMNEY OR VENT.** The pipe that connects an appliance to a chimney or vent.
CONTROL. A manual or automatic device designed to regulate the gas, air, water or electrical supply to, or operation of, a mechanical system.

CONVERSION BURNER. A unit consisting of a burner and its controls for installation in an appliance originally utilizing another fuel.

CUBIC FOOT. The amount of gas that occupies 1 cubic foot (0.02832 m\(^3\)) when at a temperature of 60ºF (16ºC), saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury (101 kPa).

DAMPER. A manually or automatically controlled device to regulate draft or the rate of flow of air or combustion gases.

DECORATIVE APPLIANCE, VENTED. A vented appliance wherein the primary function lies in the aesthetic effect of the flames.

DECORATIVE APPLIANCES FOR INSTALLATION IN VENTED FIREPLACES. A vented appliance designed for installation within the fire chamber of a vented fireplace, wherein the primary function lies in the aesthetic effect of the flames.

DEMAND. The maximum amount of gas input required per unit of time, usually expressed in cubic feet per hour, or Btu/h (1 Btu/h = 0.2931 W).

DESIGN FLOOD ELEVATION. The elevation of the “design flood,” including wave height, relative to the datum specified on the community’s legally designated flood hazard map. In areas designated as Zone AO, the design flood elevation shall be the elevation of the highest existing grade of the building’s perimeter plus the depth number, in feet, specified on the flood hazard map. In areas designated as Zone AO where a depth number is not specified on the map, the depth number shall be taken as being equal to 2 feet (610 mm).

DILUTION AIR. Air that is introduced into a draft hood and is mixed with the flue gases.

DIRECT-VENT APPLIANCES. Appliances that are constructed and installed so that all air for combustion is derived directly from the outside atmosphere and all flue gases are discharged directly to the outside atmosphere.

DRAFT. The pressure difference existing between the appliance or any component part and the atmosphere, that causes a continuous flow of air and products of combustion through the gas passages of the appliance to the atmosphere.

- Mechanical or induced draft. The pressure difference created by the action of a fan, blower or ejector that is located between the appliance and the chimney or vent termination.

- Natural draft. The pressure difference created by a vent or chimney because of its height, and the temperature difference between the flue gases and the atmosphere.

DRAFT HOOD. A nonadjustable device built into an appliance, or made as part of the vent connector from an appliance, that is designed to (1) provide for ready escape of the flue gases from the appliance in the event of no draft, backdraft, or stoppage beyond the draft hood, (2)
prevent a backdraft from entering the appliance, and (3) neutralize the effect of stack action of the chimney or gas vent upon operation of the appliance.

**DRAFT REGULATOR.** A device that functions to maintain a desired draft in the appliance by automatically reducing the draft to the desired value.

**DRIP.** The container placed at a low point in a system of piping to collect condensate and from which the condensate is removable.

**DUCT FURNACE.** A warm-air furnace normally installed in an air-distribution duct to supply warm air for heating. This definition shall apply only to a warm-air heating appliance that depends for air circulation on a blower not furnished as part of the furnace.

**DWELLING UNIT.** A single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

**EQUIPMENT.** Apparatus and devices other than appliances.

**EXCESS FLOW VALVE (EFV).** A valve designed to activate when the fuel gas passing through it exceeds a prescribed flow rate.

**EXTERIOR MASONRY CHIMNEYS.** Masonry chimneys exposed to the outdoors on one or more sides below the roof line.

**FIREPLACE.** A fire chamber and hearth constructed of noncombustible material for use with solid fuels and provided with a chimney.

  - **Factory-built fireplace.** A fireplace composed of listed factory-built components assembled in accordance with the terms of listing to form the completed fireplace.
  - **Masonry fireplace.** A hearth and fire chamber of solid masonry units such as bricks, stones, listed masonry units or reinforced concrete, provided with a suitable chimney.

**FLAME SAFEGUARD.** A device that will automatically shut off the fuel supply to a main burner or group of burners when the means of ignition of such burners becomes inoperative, and when flame failure occurs on the burner or group of burners.

**FLASHBACK ARRESTOR CHECK VALVE.** A device that will prevent the backflow of one gas into the supply system of another gas and prevent the passage of flame into the gas supply system.

**FLOOD HAZARD AREA.** The greater of the following two areas:

1. The area within a floodplain subject to a 1 percent or greater chance of flooding in any given year.

2. This area designated as a flood hazard area on a community’s flood hazard map, or otherwise legally designated.
**FLOOR FURNACE.** A completely self-contained furnace suspended from the floor of the space being heated, taking air for combustion from outside such space and with means for observing flames and lighting the appliance from such space.

**FLUE, APPLIANCE.** The passage(s) within an appliance through which combustion products pass from the combustion chamber of the appliance to the draft hood inlet opening on an appliance equipped with a draft hood or to the outlet of the appliance on an appliance not equipped with a draft hood.

**FLUE COLLAR.** That portion of an appliance designed for the attachment of a draft hood, vent connector or venting system.

**FLUE GASES.** Products of combustion plus excess air in appliance flues or heat exchangers.

**FLUE LINER (LINING).** A system or material used to form the inside surface of a flue in a chimney or vent, for the purpose of protecting the surrounding structure from the effects of combustion products and for conveying combustion products without leakage to the atmosphere.

**FUEL GAS.** A natural gas, manufactured gas, liquefied petroleum gas or mixtures of these gases.

**FURNACE.** A completely self-contained heating unit that is designed to supply heated air to spaces remote from or adjacent to the appliance location.

**FURNACE, CENTRAL.** A self-contained appliance for heating air by transfer of heat of combustion through metal to the air, and designed to supply heated air through ducts to spaces remote from or adjacent to the appliance location.

**FURNACE PLENUM.** An air compartment or chamber to which one or more ducts are connected and which forms part of an air distribution system.

**GAS CONVENIENCE OUTLET.** A permanently mounted, manually operated device that provides the means for connecting an appliance to, and disconnecting an appliance from, the supply piping. The device includes an integral, manually operated valve with a nondisplaceable valve member and is designed so that disconnection of an appliance only occurs when the manually operated valve is in the closed position.

**GAS PIPING.** An installation of pipe, valves or fittings installed on a premises or in a building and utilized to convey fuel gas.

**HAZARDOUS LOCATION.** Any location considered to be a fire hazard for flammable vapors, dust, combustible fibers or other highly combustible substances. The location is not necessarily categorized in the International Building Code as a high-hazard use group classification.

**HOUSE PIPING.** See “Piping system.”

**IGNITION PILOT.** A pilot that operates during the lighting cycle and discontinues during main burner operation.
IGNITION SOURCE. A flame spark or hot surface capable of igniting flammable vapors or fumes. Such sources include appliance burners, burner ignitors and electrical switching devices.

INFRARED RADIANT HEATER. A heater which directs a substantial amount of its energy output in the form of infrared radiant energy into the area to be heated. Such heaters are of either the vented or unvented type.

JOINT, FLARED. A metal-to-metal compression joint in which a conical spread is made on the end of a tube that is compressed by a flare nut against a mating flare.

JOINT, MECHANICAL. A general form of gas-tight joints obtained by the joining of metal parts through a positive holding mechanical construction, such as press joint, flanged joint, threaded joint, flared joint or compression joint.

JOINT, PLASTIC ADHESIVE. A joint made in thermoset plastic piping by the use of an adhesive substance which forms a continuous bond between the mating surfaces without dissolving either one of them.

LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LEAK CHECK. An operation performed on a gas-piping system to verify that the system does not leak.

LIQUEFIED PETROLEUM GAS or LPG (LP-GAS). Liquefied petroleum gas composed predominately of propane, propylene, butanes or butylenes, or mixtures thereof that is gaseous under normal atmospheric conditions, but is capable of being liquefied under moderate pressure at normal temperatures.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

LIVING SPACE. Space within a dwelling unit utilized for living, sleeping, eating, cooking, bathing, washing and sanitation purposes.

LOG LIGHTER. A manually operated solid-fuel ignition appliance for installation in a vented solid-fuel burning fireplace.

MAIN BURNER. A device or group of devices essentially forming an integral unit for the final conveyance of gas or a mixture of gas and air to the combustion zone, and on which combustion takes place to accomplish the function for which the appliance is designed.

METER. The instrument installed to measure the volume of gas delivered through it.
MODULATING. Modulating or throttling is the action of a control from its maximum to minimum position in either predetermined steps or increments of movement as caused by its actuating medium.

NONCOMBUSTIBLE MATERIALS. Materials that, when tested in accordance with ASTM E 136, have at least three of four specimens tested meeting all of the following criteria:

1. The recorded temperature of the surface and interior thermocouples shall not at any time during the test rise more than 54ºF (30ºC) above the furnace temperature at the beginning of the test.

2. There shall not be flaming from the specimen after the first 30 seconds.

3. If the weight loss of the specimen during testing exceeds 50 percent, the recorded temperature of the surface and interior thermocouples shall not at any time during the test rise above the furnace air temperature at the beginning of the test, and there shall not be flaming of the specimen.

OFFSET (VENT). A combination of approved bends that make two changes in direction bringing one section of the vent out of line, but into a line parallel with the other section.

OUTLET. The point at which a gas-fired appliance connects to the gas piping system.

OXYGEN DEPLETION SAFETY SHUTOFF SYSTEM (ODS). A system designed to act to shut off the gas supply to the main and pilot burners if the oxygen in the surrounding atmosphere is reduced below a predetermined level.

PILOT. A small flame that is utilized to ignite the gas at the main burner or burners.

PIPING. Where used in this code, “piping” refers to either pipe or tubing, or both.

Pipe. A rigid conduit of iron, steel, copper, brass or plastic.

Tubing. Semirigid conduit of copper, aluminum, plastic or steel.

PIPING SYSTEM. All fuel piping, valves and fittings from the outlet of the point of delivery to the outlets of the appliance shutoff valves.

PLASTIC, THERMOPLASTIC. A plastic that is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

POINT OF DELIVERY. For natural gas systems, the point of delivery is the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where a meter is not provided. Where a valve is provided at the outlet of the service meter assembly, such valve shall be considered to be downstream of the point of delivery. For undiluted liquefied petroleum gas systems, the point of delivery shall be considered to be the outlet of the service pressure regulator, exclusive of line gas regulators, in the system.
PRESSURE DROP. The loss in pressure due to friction or obstruction in pipes, valves, fittings, regulators and burners.

PRESSURE TEST. An operation performed to verify the gas-tight integrity of gas piping following its installation or modification.

PURGE. To free a gas conduit of air or gas, or a mixture of gas and air.

READY ACCESS (TO). That which enables a device, appliance or equipment to be directly reached, without requiring the removal or movement of any panel, door or similar obstruction. (See “Access.”)

REGULATOR. A device for controlling and maintaining a uniform gas supply pressure, either pounds-to-inches water column (MP regulator) or inches-to-inches water column (appliance regulator).

REGULATOR, GAS APPLIANCE. A pressure regulator for controlling pressure to the manifold of the gas appliance.

REGULATOR, LINE GAS PRESSURE. A device placed in a gas line between the service pressure regulator and the appliance for controlling, maintaining or reducing the pressure in that portion of the piping system downstream of the device.

REGULATOR, MEDIUM-PRESSURE (MP Regulator). A line pressure regulator that reduces gas pressure from the range of greater than 0.5 psig (3.4 kPa) and less than or equal to 5 psig (34.5 kPa) to a lower pressure.

REGULATOR, PRESSURE. A device placed in a gas line for reducing, controlling and maintaining the pressure in that portion of the piping system downstream of the device.

REGULATOR, SERVICE PRESSURE. For natural gas systems, a device installed by the serving gas supplier to reduce and limit the service line pressure to delivery pressure. For undiluted liquefied petroleum gas systems, the regulator located upstream from all line gas pressure regulators, where installed, and downstream from any first stage or a high pressure regulator in the system.

RELIEF OPENING. The opening provided in a draft hood to permit the ready escape to the atmosphere of the flue products from the draft hood in the event of no draft, backdraft or stoppage beyond the draft hood, and to permit air into the draft hood in the event of a strong chimney updraft.

RELIEF VALVE (DEVICE). A safety valve designed to forestall the development of a dangerous condition by relieving either pressure, temperature or vacuum in the hot water supply system.

RELIEF VALVE, PRESSURE. An automatic valve that opens and closes a relief vent, depending on whether the pressure is above or below a predetermined value.

RELIEF VALVE, TEMPERATURE.
**Manual reset type.** A valve that automatically opens a relief vent at a predetermined temperature and that must be manually returned to the closed position.

**Reseating or self-closing type.** An automatic valve that opens and closes a relief vent, depending on whether the temperature is above or below a predetermined value.

**RELIEF VALVE, VACUUM.** A valve that automatically opens and closes a vent for relieving a vacuum within the hot water supply system, depending on whether the vacuum is above or below a predetermined value.

**RISER, GAS.** A vertical pipe supplying fuel gas.

**ROOM HEATER, UNVENTED.** See “Unvented room heater.”

**ROOM HEATER, VENTED.** A free-standing heating unit used for direct heating of the space in and adjacent to that in which the unit is located. (See also “Vented room heater.”)

**SAFETY SHUTOFF DEVICE.** See “Flame safeguard.”

**SHAFT.** An enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and the roof.

**SPECIFIC GRAVITY.** As applied to gas, specific gravity is the ratio of the weight of a given volume to that of the same volume of air, both measured under the same condition.

**THERMOSTAT.**

**Electric switch type.** A device that senses changes in temperature and controls electrically, by means of separate components, the flow of gas to the burner(s) to maintain selected temperatures.

**Integral gas valve type.** An automatic device, actuated by temperature changes, designed to control the gas supply to the burner(s) in order to maintain temperatures between predetermined limits, and in which the thermal actuating element is an integral part of the device.

1. **Graduating thermostat.** A thermostat in which the motion of the valve is approximately in direct proportion to the effective motion of the thermal element induced by temperature change.

2. **Snap-acting thermostat.** A thermostat in which the thermostatic valve travels instantly from the closed to the open position, and vice-versa.

**THIRD-PARTY CERTIFICATION AGENCY.** An approved agency operating a product or material certification system that incorporates initial product testing, assessment and surveillance of a manufacturer’s quality control system.

**THIRD-PARTY CERTIFIED.** Certification obtained by the manufacturer indicating that the function and performance characteristics of a product or material have been determined by testing and ongoing surveillance by an approved third-party certification agency. Assertion of
certification is in the form of identification in accordance with the requirements of the third-party certification agency.

**THIRD-PARTY TESTED.** Procedure by which an approved testing laboratory provides documentation that a product, material or system conforms to specified requirements.

**TRANSITION FITTINGS, PLASTIC TO STEEL.** An adapter for joining plastic pipe to steel pipe. The purpose of this fitting is to provide a permanent, pressure-tight connection between two materials that cannot be joined directly one to another.

**UNIT HEATER.**

**High-static pressure type.** A self-contained, automatically controlled, vented appliance having integral means for circulation of air against 0.2 inch w.c. (50 Pa) or greater static pressure. Such appliance is equipped with provisions for attaching an outlet air duct and, where the appliance is for indoor installation remote from the space to be heated, is also equipped with provisions for attaching an inlet air duct.

**Low-static pressure type.** A self-contained, automatically controlled, vented appliance, intended for installation in the space to be heated without the use of ducts, having integral means for circulation of air. Such units are allowed to be equipped with louvers or face extensions made in accordance with the manufacturer’s specifications.

**UNVENTED ROOM HEATER.** An unvented heating appliance designed for stationary installation and utilized to provide comfort heating. Such appliances provide radiant heat or convection heat by gravity or fan circulation directly from the heater and do not utilize ducts.

**VALVE.** A device used in piping to control the gas supply to any section of a system of piping or to an appliance.

**Appliance shutoff.** A valve located in the piping system, used to isolate individual appliances for purposes such as service or replacement.

**Automatic.** An automatic or semiautomatic device consisting essentially of a valve and an operator that control the gas supply to the burner(s) during operation of an appliance. The operator shall be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means or by other approved means.

**Automatic gas shutoff.** A valve used in conjunction with an automatic gas shutoff device to shut off the gas supply to a water-heating system. It shall be constructed integrally with the gas shutoff device or shall be a separate assembly.

**Individual main burner.** A valve that controls the gas supply to an individual main burner.

**Main burner control.** A valve that controls the gas supply to the main burner manifold.

**Manual main gas control.** A manually operated valve in the gas line for the purpose of completely turning on or shutting off the gas supply to the appliance, except to pilot or pilots that are provided with independent shutoff.
**Manual reset.** An automatic shutoff valve installed in the gas supply piping and set to shut off when unsafe conditions occur. The device remains closed until manually reopened.

**Service shutoff.** A valve, installed by the serving gas supplier between the service meter or source of supply and the customer piping system, to shut off the entire piping system.

**VENT.** A pipe or other conduit composed of factory-made components, containing a passageway for conveying combustion products and air to the atmosphere, listed and labeled for use with a specific type or class of appliance.

**Special gas vent.** A vent listed and labeled for use with listed Category II, III and IV gas appliances.

**Type B vent.** A vent listed and labeled for use with appliances with draft hoods and other Category I appliances that are listed for use with Type B vents.

**Type BW vent.** A vent listed and labeled for use with wall furnaces.

**Type L vent.** A vent listed and labeled for use with appliances that are listed for use with Type L or Type B vents.

**VENT CONNECTOR.** See “Connector.”

**VENT PIPING.**

**Breather.** Piping run from a pressure-regulating device to the outdoors, designed to provide a reference to atmospheric pressure. If the device incorporates an integral pressure relief mechanism, a breather vent can also serve as a relief vent.

**Relief.** Piping run from a pressure-regulating or pressure-limiting device to the outdoors, designed to provide for the safe venting of gas in the event of excessive pressure in the gas piping system.

**VENTED APPLIANCE CATEGORIES.** Appliances that are categorized for the purpose of vent selection are classified into the following four categories:

**Category I.** An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.

**Category II.** An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that is capable of causing excessive condensate production in the vent.

**Category III.** An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.

**Category IV.** An appliance that operates with a positive vent static pressure and with a vent gas temperature that is capable of causing excessive condensate production in the vent.
VENTED ROOM HEATER. A vented self-contained, free-standing, nonrecessed appliance for furnishing warm air to the space in which it is installed, directly from the heater without duct connections.

VENTED WALL FURNACE. A self-contained vented appliance complete with grilles or equivalent, designed for incorporation in or permanent attachment to the structure of a building, mobile home or travel trailer, and furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing. This definition shall exclude floor furnaces, unit heaters and central furnaces as herein defined.

VENTING SYSTEM. A continuous open passageway from the flue collar or draft hood of an appliance to the outdoor atmosphere for the purpose of removing flue or vent gases. A venting system is usually composed of a vent or a chimney and vent connector, if used, assembled to form the open passageway.

WALL HEATER, UNVENTED TYPE. A room heater of the type designed for insertion in or attachment to a wall or partition. Such heater does not incorporate concealed venting arrangements in its construction and discharges all products of combustion through the front into the room being heated.

WATER HEATER. Any heating appliance or equipment that heats potable water and supplies such water to the potable hot water distribution system.

SECTION G2404 (301)
GENERAL

G2404.1 (301.1) Scope.
This section shall govern the approval and installation of all equipment and appliances that comprise parts of the installations regulated by this code in accordance with Section G2401.

G2404.2 (301.1.1) Other fuels.
The requirements for combustion and dilution air for gas-fired appliances shall be governed by Section G2407. The requirements for combustion and dilution air for appliances operating with fuels other than fuel gas shall be regulated by Chapter 17.

G2404.3 (301.3) Listed and labeled.
Appliances regulated by this code shall be listed and labeled for the application in which they are used unless otherwise approved in accordance with Section R104.11. The approval of unlisted appliances in accordance with Section R104.11 shall be based upon approved engineering evaluation.

G2404.4 (301.8) Vibration isolation.
Where means for isolation of vibration of an appliance is installed, an approved means for support and restraint of that appliance shall be provided.

G2404.5 (301.9) Repair.
Defective material or parts shall be replaced or repaired in such a manner so as to preserve the original approval or listing.
G2404.6 (301.10) Wind resistance.
Appliances and supports that are exposed to wind shall be designed and installed to resist the wind pressures determined in accordance with this code.

G2404.7 (301.11) Flood hazard.
For structures located in flood hazard areas, the appliance, equipment and system installations regulated by this code shall be located at or above the elevation required by Section R322 for utilities and attendant equipment.

Exception: The appliance, equipment and system installations regulated by this code are permitted to be located below the elevation required by Section R322 for utilities and attendant equipment provided that they are designed and installed to prevent water from entering or accumulating within the components and to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to such elevation.

G2404.8 (301.12) Seismic resistance.
When earthquake loads are applicable in accordance with this code, the supports shall be designed and installed for the seismic forces in accordance with this code.

G2404.9 (301.14) Rodentproofing.
Buildings or structures and the walls enclosing habitable or occupiable rooms and spaces in which persons live, sleep or work, or in which feed, food or foodstuffs are stored, prepared, processed, served or sold, shall be constructed to protect against the entry of rodents.

G2404.9.1 (301.14.1) Foundation and exterior wall sealing.
Annular spaces around pipes, electric cables, conduits or other openings in the walls shall be protected against the passage of rodents by closing such opening with cement mortar, concrete masonry, silicone caulking or noncorrosive metal.

G2404.10 (307.1) Evaporators and cooling coils.
Condensate drainage systems shall be provided for equipment and appliances containing evaporators and cooling coils in accordance with the International Mechanical Code.

G2404.11 (307.2) Fuel-burning appliances.
Liquid combustion byproducts of condensing appliances shall be collected and discharged to an approved plumbing fixture or disposal area in accordance with the manufacturer’s instructions. Condensate piping shall be of approved corrosion-resistant material and shall be not smaller than the drain connection on the appliance. Such piping shall maintain a minimum slope in the direction of discharge of not less than one-eighth unit vertical in 12 units horizontal (1-percent slope).

G2404.10 G2404.12 (307.5) Auxiliary drain pan.
Category IV condensing appliances shall be provided with an auxiliary drain pan where damage to any building component will occur as a result of stoppage in the condensate drainage system. Such pan shall be installed in accordance with the applicable provisions of Section M1411.

Exception: An auxiliary drain pan shall not be required for appliances that automatically shut down operation in the event of a stoppage in the condensate drainage system.
G2404.11 G2404.13 (307.6) Condensate pumps. Condensate pumps located in uninhabitable spaces, such as attics and crawl spaces, shall be connected to the appliance or equipment served such that when the pump fails, the appliance or equipment will be prevented from operating. Pumps shall be installed in accordance with the manufacturer’s instructions.

SECTION G2405 (302)
STRUCTURAL SAFETY

G2405.1 (302.1) Structural safety. The building shall not be weakened by the installation of any gas piping. In the process of installing or repairing any gas piping, the finished floors, walls, ceilings, tile work or any other part of the building or premises which is required to be changed or replaced shall be left in a safe structural condition in accordance with the requirements of this code.

G2405.1.1 (302.3) Cutting, notching and boring in wood members. The cutting, notching and boring of wood members shall comply with Sections G2405.1.1.1 through G2405.1.1.3.

G2405.1.1.1 (302.3.2) Joist notching and boring. Notching at the ends of joists shall not exceed one-fourth the joist depth. Holes bored in joists shall not be within 2 inches (51 mm) of the top and bottom of the joist and their diameters shall not exceed one-third the depth of the member. Notches in the top or bottom of the joist shall not exceed one-sixth the depth and shall not be located in the middle one-third of the span.

G2405.1.1.2 (302.3.3) Stud cutting and notching. In exterior walls and bearing partitions, any wood stud is permitted to be cut or notched to a depth not exceeding 25 percent of its width. Cutting or notching of studs to a depth not greater than 40 percent of the width of the stud is permitted in nonload-bearing partitions supporting no loads other than the weight of the partition.

G2405.1.1.3 (302.3.4) Bored holes. The diameter of bored holes in wood studs shall not exceed 40 percent of the stud depth. The diameter of bored holes in wood studs shall not exceed 60 percent of the stud depth in nonbearing partitions. The diameter of bored holes in wood studs shall not exceed 60 percent of the stud depth in any wall where each stud is doubled, provided that not more than two such successive doubled studs are so bored. The edge of the bored hole shall be not closer than 5/8 inch (15.9 mm) to the edge of the stud. Bored holes shall not be located at the same section of stud as a cut or notch.

G2405.2 (302.4) Alterations to trusses. Truss members and components shall not be cut, drilled, notched, spliced or otherwise altered in any way without the written concurrence and approval of a registered design professional. Alterations resulting in the addition of loads to any member, such as HVAC equipment and water heaters, shall not be permitted without verification that the truss is capable of supporting such additional loading.
G2405.3 (302.3.1) **Engineered wood products.**
Cuts, notches and holes bored in trusses, structural composite lumber, structural glued-laminated members and I-joists are prohibited except where permitted by the manufacturer’s recommendations or where the effects of such alterations are specifically considered in the design of the member by a registered design professional.

G2405.4 (302.5) **Cutting, notching and boring holes in structural steel framing.**
The cutting, notching and boring of holes in structural steel framing members shall be as prescribed by the registered design professional.

G2405.5 (302.6) **Cutting, notching and boring holes in cold-formed steel framing.**
Flanges and lips of load-bearing, cold-formed steel framing members shall not be cut or notched. Holes in webs of load-bearing, cold-formed steel framing members shall be permitted along the centerline of the web of the framing member and shall not exceed the dimensional limitations, penetration spacing or minimum hole edge distance as prescribed by the registered design professional. Cutting, notching and boring holes of steel floor/roof decking shall be as prescribed by the registered design professional.

G2405.6 (302.7) **Cutting, notching and boring holes in nonstructural cold-formed steel wall framing.**
Flanges and lips of nonstructural cold-formed steel wall studs shall be permitted along the centerline of the web of the framing member, shall not exceed 1½ inches (38 mm) in width or 4 inches (102 mm) in length, and the holes shall not be spaced less than 24 inches (610 mm) center to center from another hole or less than 10 inches (254 mm) from the bearing end.

SECTION G2406 (303)
APPLIANCE LOCATION

G2406.1 (303.1) **General.**
Appliances shall be located as required by this section, specific requirements elsewhere in this code and the conditions of the equipment and appliance listing. See Section M1305 for appliance access requirements.

G2406.2 (303.3) **Prohibited locations.**
Appliances shall not be located in sleeping rooms, bathrooms, toilet rooms, closets used for storage, or surgical rooms, or in a space that opens only into such rooms or spaces, except where the installation complies with one of the following:

1. The appliance is a direct-vent appliance installed in accordance with the conditions of the listing and the manufacturer’s instructions.

2. Vented room heaters, wall furnaces, vented decorative appliances, vented gas fireplaces, vented gas fireplace heaters and decorative appliances for installation in vented solid fuel-burning fireplaces are installed in rooms that meet the required volume criteria of Section G2407.5.

3. A single wall-mounted unvented room heater is installed in a bathroom and such unvented room heater is equipped as specified in Section G2445.6 and has an input

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rating not greater than 6,000 Btu/h (1.76 kW). The bathroom shall meet the required volume criteria of Section G2407.5.

4. A single wall-mounted unvented room heater is installed in a bedroom and such unvented room heater is equipped as specified in Section G2445.6 and has an input rating not greater than 10,000 Btu/h (2.93 kW). The bedroom shall meet the required volume criteria of Section G2407.5.

5. The appliance is installed in a room or space that opens only into a bedroom or bathroom, and such room or space is used for no other purpose and is provided with a solid weather-striped door equipped with an approved self-closing device. All combustion air shall be taken directly from the outdoors in accordance with Section G2407.6.

G2406.3 (303.6) Outdoor locations.
Appliances installed in outdoor locations shall be either listed for outdoor installation or provided with protection from outdoor environmental factors that influence the operability, durability and safety of the appliance.

G2406.4 (303.7) Pit locations.
Appliances installed in pits or excavations shall not come in direct contact with the surrounding soil. The sides of the pit or excavation shall be held back a minimum of 12 inches (305 mm) from the appliance. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry, such concrete or masonry shall extend a minimum of 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse.

G2406.5 (303.8) Drainage.
Below-grade installations shall be provided with a natural drain or an automatic lift or sump pump.

G2406.6 (303.4) Protection from vehicle impact damage.
Appliances shall not be installed in a location subject to vehicle impact damage except where protected by an approved means. Protection is not required for appliances located out of the vehicle’s normal travel path.

G2406.7 (303.5) Indoor locations.
Furnaces and boilers installed in closets and alcoves shall be listed for such installation.

SECTION G2407 (304)
COMBUSTION, VENTILATION AND DILUTION AIR

G2407.1 (304.1) General.
Air for combustion, ventilation and dilution of flue gases for appliances installed in buildings shall be provided by application of one of the methods prescribed in Sections G2407.5 through G2407.9. Where the requirements of Section G2407.5 are not met, outdoor air shall be introduced in accordance with one of the methods prescribed in Sections G2407.6 through G2407.9. Direct-vent appliances, gas appliances of other than natural draft design, vented gas appliances not designated as Category I and appliances equipped with power burners, shall be

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provided with combustion, ventilation and dilution air in accordance with the appliance manufacturer’s instructions.

**Exception:** Type 1 clothes dryers that are provided with makeup air in accordance with Section G2439.5.

G2407.2 (304.2) Appliance location. Appliances shall be located so as not to interfere with proper circulation of combustion, ventilation and dilution air.

G2407.3 (304.3) Draft hood/regulator location. Where used, a draft hood or a barometric draft regulator shall be installed in the same room or enclosure as the appliance served to prevent any difference in pressure between the hood or regulator and the combustion air supply.

G2407.4 (304.4) Makeup air provisions. Where exhaust fans, clothes dryers and kitchen ventilation systems interfere with the operation of appliances, makeup air shall be provided.

G2407.5 (304.5) Indoor combustion air. The required volume of indoor air shall be determined in accordance with Section G2407.5.1 or G2407.5.2, except that where the air infiltration rate is known to be less than 0.40 air changes per hour (ACH), Section G2407.5.2 shall be used. The total required volume shall be the sum of the required volume calculated for all appliances located within the space. Rooms communicating directly with the space in which the appliances are installed through openings not furnished with doors, and through combustion air openings sized and located in accordance with Section G2407.5.3, are considered to be part of the required volume.

G2407.5.1 (304.5.1) Standard method. The minimum required volume shall be 50 cubic feet per 1,000 Btu/h (4.8 m³/kW) of the appliance input rating.

G2407.5.2 (304.5.2) Known air-infiltration-rate method. Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows:

For appliances other than fan-assisted, calculate volume using Equation 24-1.

\[ \text{Required Volume}_{\text{other}} \geq \frac{21 \text{ ft}^3}{\text{ACH} \times 1,000 \text{ Btu/h}} \times I_{\text{other}} \]  

(Equation 24-1)

For fan-assisted appliances, calculate volume using Equation 24-2.

\[ \text{Required Volume}_{\text{fan}} \geq \frac{15 \text{ ft}^3}{\text{ACH} \times 1,000 \text{ Btu/hr}} \times I_{\text{fan}} \]  

(Equation 24-2)
where:

\[ I_{\text{other}} = \text{All appliances other than fan assisted (input in } Btu/h) \]

\[ I_{\text{fan}} = \text{Fan-assisted appliance (input in } Btu/h) \]

\[ ACH = \text{Air change per hour (percent of volume of space exchanged per hour, expressed as a decimal).} \]

For purposes of this calculation, an infiltration rate greater than 0.60 ACH shall not be used in Equations 24-1 and 24-2.

**G2407.5.3 (304.5.3) Indoor opening size and location.**

Openings used to connect indoor spaces shall be sized and located in accordance with Sections G2407.5.3.1 and G2407.5.3.2 (see Figure G2407.5.3).

**FIGURE G2407.5.3 (304.5.3)**

ALL AIR FROM INSIDE THE BUILDING
(see Section G2407.5.3)

**G2407.5.3.1 (304.5.3.1) Combining spaces on the same story.**

Each opening shall have a minimum free area of 1 square inch per 1,000 Btu/h (2,200 mm²/kW) of the total input rating of all appliances in the space, but not less than 100 square inches (0.64 m²). One opening shall commence within 12 inches (305 mm) of the top and one opening shall commence within 12 inches (305 mm) of the bottom of the enclosure. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

**G2407.5.3.2 (304.5.3.2) Combining spaces in different stories.**

The volumes of spaces in different stories shall be considered as communicating spaces where such spaces are connected by one or more openings in doors or floors having a total minimum free area of 2 square inches per 1,000 Btu/h (4,402 mm²/kW) of total input rating of all appliances.
G2407.6 (304.6) Outdoor combustion air.
Outdoor combustion air shall be provided through opening(s) to the outdoors in accordance with Section G2407.6.1 or G2407.6.2. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

G2407.6.1 (304.6.1) Two-permanent-openings method.
Two permanent openings, one commencing within 12 inches (305 mm) of the top and one commencing within 12 inches (305 mm) of the bottom of the enclosure, shall be provided. The openings shall communicate directly or by ducts with the outdoors or spaces that freely communicate with the outdoors.

Where directly communicating with the outdoors, or where communicating with the outdoors through vertical ducts, each opening shall have a minimum free area of 1 square inch per 4,000 Btu/h (550 mm²/kW) of total input rating of all appliances in the enclosure [see Figures G2407.6.1(1) and G2407.6.1(2)].

Where communicating with the outdoors through horizontal ducts, each opening shall have a minimum free area of not less than 1 square inch per 2,000 Btu/h (1,100 mm²/kW) of total input rating of all appliances in the enclosure [see Figure G2407.6.1(3)].

FIGURE G2407.6.1(1) [304.6.1(1)]
ALL AIR FROM OUTDOORS—INLET AIR FROM VENTILATED CRAWL SPACE AND OUTLET AIR TO VENTILATED ATTIC
FIGURE G2407.6.1(2) [304.6.1(2)]
ALL AIR FROM OUTDOORS THROUGH VENTILATED ATTIC (see Section G2407.6.1)
FIGURE G2407.6.1(3) [304.6.1(3)]
ALL AIR FROM OUTDOORS (see Section G2407.6.1)

G2407.6.2 (304.6.2) One-permanent-opening method.
One permanent opening, commencing within 12 inches (305 mm) of the top of the enclosure, shall be provided. The appliance shall have clearances of at least 1 inch (25 mm) from the sides and back and 6 inches (152 mm) from the front of the appliance. The opening shall directly communicate with the outdoors or through a vertical or horizontal duct to the outdoors, or spaces that freely communicate with the outdoors (see Figure G2407.6.2) and shall have a minimum free area of 1 square inch per 3,000 Btu/h (734 mm²/kW) of the total input rating of all appliances located in the enclosure and not less than the sum of the areas of all vent connectors in the space.
G2407.7 (304.7) Combination indoor and outdoor combustion air. 
The use of a combination of indoor and outdoor combustion air shall be in accordance with Sections G2407.7.1 through G2407.7.3.

G2407.7.1 (304.7.1) Indoor openings. 
Where used, openings connecting the interior spaces shall comply with Section G2407.5.3.

G2407.7.2 (304.7.2) Outdoor opening location. 
Outdoor opening(s) shall be located in accordance with Section G2407.6.

G2407.7.3 (304.7.3) Outdoor opening(s) size. 
The outdoor opening(s) size shall be calculated in accordance with the following:

1. The ratio of interior spaces shall be the available volume of all communicating spaces divided by the required volume.

2. The outdoor size reduction factor shall be one minus the ratio of interior spaces.

3. The minimum size of outdoor opening(s) shall be the full size of outdoor opening(s) calculated in accordance with Section G2407.6, multiplied by the reduction factor. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

G2407.8 (304.8) Engineered installations. 
Engineered combustion air installations shall provide an adequate supply of combustion, ventilation and dilution air and shall be approved.
G2407.9 (304.9) Mechanical combustion air supply.
Where all combustion air is provided by a mechanical air supply system, the combustion air shall be supplied from the outdoors at a rate not less than 0.35 cubic feet per minute per 1,000 $Btu/h$ (0.034 m$^3$/min per kW) of total input rating of all appliances located within the space.

G2407.9.1 (304.9.1) Makeup air.
Where exhaust fans are installed, makeup air shall be provided to replace the exhausted air.

G2407.9.2 (304.9.2) Appliance interlock.
Each of the appliances served shall be interlocked with the mechanical air supply system to prevent main burner operation when the mechanical air supply system is not in operation.

G2407.9.3 (304.9.3) Combined combustion air and ventilation air system.
Where combustion air is provided by the building’s mechanical ventilation system, the system shall provide the specified combustion air rate in addition to the required ventilation air.

G2407.10 (304.10) Louvers and grilles.
The required size of openings for combustion, ventilation and dilution air shall be based on the net free area of each opening. Where the free area through a design of louver, grille or screen is known, it shall be used in calculating the size opening required to provide the free area specified. Where the design and free area of louvers and grilles are not known, it shall be assumed that wood louvers will have 25-percent free area and metal louvers and grilles will have 75-percent free area. Screens shall have a mesh size not smaller than $\frac{1}{4}$ inch (6.4 mm).

Nonmotorized louvers and grilles shall be fixed in the open position. Motorized louvers shall be interlocked with the appliance so that they are proven to be in the full open position prior to main burner ignition and during main burner operation. Means shall be provided to prevent the main burner from igniting if the louvers fail to open during burner start-up and to shut down the main burner if the louvers close during operation.

G2407.11 (304.11) Combustion air ducts.
Combustion air ducts shall comply with all of the following:

1. Ducts shall be constructed of galvanized steel complying with Chapter 16 or of a material having equivalent corrosion resistance, strength and rigidity.

   **Exception:** Within dwellings units, unobstructed stud and joist spaces shall not be prohibited from conveying combustion air, provided that not more than one required fireblock is removed.

2. Ducts shall terminate in an unobstructed space allowing free movement of combustion air to the appliances.

3. Ducts shall serve a single enclosure.

4. Ducts shall not serve both upper and lower combustion air openings where both such openings are used. The separation between ducts serving upper and lower combustion air openings shall be maintained to the source of combustion air.
5. Ducts shall not be screened where terminating in an attic space.

6. Horizontal upper combustion air ducts shall not slope downward toward the source of combustion air.

7. The remaining space surrounding a chimney liner, gas vent, special gas vent or plastic piping installed within a masonry, metal or factory-built chimney shall not be used to supply combustion air.

   **Exception:** Direct-vent gas-fired appliances designed for installation in a solid fuel-burning fireplace where installed in accordance with the manufacturer’s instructions.

8. Combustion air intake openings located on the exterior of a building shall have the lowest side of such openings located not less than 12 inches (305 mm) vertically from the adjoining finished ground level.

**G2407.12 (304.12) Protection from fumes and gases.**
Where corrosive or flammable process fumes or gases, other than products of combustion, are present, means for the disposal of such fumes or gases shall be provided. Such fumes or gases include carbon monoxide, hydrogen sulfide, ammonia, chlorine and halogenated hydrocarbons.

In barbershops, beauty shops and other facilities where chemicals that generate corrosive or flammable products, such as aerosol sprays, are routinely used, nondirect vent-type appliances shall be located in a mechanical room separated or partitioned off from other areas with provisions for combustion air and dilution air from the outdoors. Direct-vent appliances shall be installed in accordance with the appliance manufacturer’s instructions.

**SECTION G2408**

**(305) INSTALLATION**

**G2408.1 (305.1) General.**
Equipment and appliances shall be installed as required by the terms of their approval, in accordance with the conditions of listing, the manufacturer’s instructions and this code. Manufacturer’s installation instructions shall be available on the job site at the time of inspection. Where a code provision is less restrictive than the conditions of the listing of the equipment or appliance or the manufacturer’s installation instructions, the conditions of the listing and the manufacturer’s installation instructions shall apply.

Unlisted appliances approved in accordance with Section G2404.3 shall be limited to uses recommended by the manufacturer and shall be installed in accordance with the manufacturer’s instructions, the provisions of this code and the requirements determined by the code official.

**G2408.2 (305.3) Elevation of ignition source.**
Equipment and appliances having an ignition source shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor in hazardous locations and public garages, private garages, repair garages, motor fuel-dispensing facilities and parking garages. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

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Exception: Elevation of the ignition source is not required for appliances that are listed as flammable-vapor-ignition resistant.

G2408.2.1 (305.3.1) Installation in residential garages.
In residential garages where appliances are installed in a separate, enclosed space having access only from outside of the garage, such appliances shall be permitted to be installed at floor level, provided that the required combustion air is taken from the exterior of the garage.

G2408.3 (305.5) Private garages.
Appliances located in private garages shall be installed with a minimum clearance of 6 feet (1829 mm) above the floor.

Exception: The requirements of this section shall not apply where the appliances are protected from motor vehicle impact and installed in accordance with Section G2408.2 and G2406.4.

G2408.4 (305.7) Clearances from grade. Under-floor and exterior grade installations.
Equipment and appliances installed at grade level shall be supported on a level concrete slab or other approved material extending not less than 3 inches (76 mm) above adjoining grade or shall be suspended not less than 6 inches (152 mm) above adjoining grade. Such supports shall be installed in accordance with the manufacturer’s instructions.

G2408.4.1 (305.7.1) Exterior grade installations.
Equipment and appliances installed above grade level shall be supported on a solid base or on approved material that is a minimum of 2 inches (51 mm) thick.

G2408.4.2 (305.7.2) Under-floor installation.
Suspended equipment shall be a minimum of 6 inches (152 m) above the adjoining grade.

G2408.4.3 (305.7.3) Crawl space supports.
A support shall be provided at each corner of the unit not less than 8 inches by 8 inches (204 mm by 204 mm). The unit shall be supported a minimum of 2 inches (51 mm) above grade. When constructed of brick, the bricks shall be mortared together. All units stacked shall be mortared together. Fabricated units, formed concrete, or other approved materials shall be permitted.

G2408.4.4 (303.7) Pit Locations.
Appliances installed in pits shall be installed in accordance with Section G2406.4.

G2408.4.5 (305.7.4) Drainage.
Below-grade installations shall be provided with a natural drain or an automatic lift or sump pump. For pit requirements, see Section G2406.4.

G2408.5 (305.8) Clearances to combustible construction.
Heat-producing equipment and appliances shall be installed to maintain the required clearances to combustible construction as specified in the listing and manufacturer’s instructions. Such clearances shall be reduced only in accordance with Section G2409. Clearances to combustibles shall include such considerations as door swing, drawer pull, overhead projections.
or shelving and window swing. Devices, such as door stops or limits and closers, shall not be used to provide the required clearances.

**G2408.6 (305.12) Avoid strain on gas piping.**

devices shall be supported and connected to the piping so as not to exert undue strain on the connections.

**SECTION G2409 (308)**

**CLEARANCE REDUCTION**

**G2409.1 (308.1) Scope.**

This section shall govern the reduction in required clearances to combustible materials, including gypsum board, and combustible assemblies for chimneys, vents, appliances, devices and equipment. Clearance requirements for air-conditioning equipment and central heating boilers and furnaces shall comply with Sections G2409.3 and G2409.4.

**G2409.2 (308.2) Reduction table.**

The allowable clearance reduction shall be based on one of the methods specified in Table G2409.2 or shall utilize a reduced clearance protective assembly listed and labeled in accordance with UL 1618. Where required clearances are not listed in Table G2409.2, the reduced clearances shall be determined by linear interpolation between the distances listed in the table. Reduced clearances shall not be derived by extrapolation below the range of the table. The reduction of the required clearances to combustibles for listed and labeled appliances and equipment shall be in accordance with the requirements of this section, except that such clearances shall not be reduced where reduction is specifically prohibited by the terms of the appliance or equipment listing [see Figures G2409.2(1) through 2409.2(3)].

**NOTES:**

"A" equals the clearance without protection.

"B" equals the reduced clearance permitted in accordance with Table G2409.2. The protection applied to the construction using combustible material shall extend far enough in each direction to make "C" equal to "A."

**FIGURE G2409.2(1) [308.2(1)]**

**EXTENT OF PROTECTION NECESSARY TO REDUCE CLEARANCES FROM GAS EQUIPMENT OR VENT CONNECTORS**

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FIGURE G2409.2(2) [308.2(2)]
WALL PROTECTOR CLEARANCE REDUCTION SYSTEM

For SI: 1 inch = 25.4 mm.
TABLE G2409.2 (308.2) REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION

<table>
<thead>
<tr>
<th>TYPE OF PROTECTION APPLIED TO AND COVERING ALL SURFACES OF</th>
<th>WHERE THE REQUIRED CLEARANCE WITH NO PROTECTION FROM APPLIANCE, VENT CONNECTOR, OR SINGLE-WALL METAL PIPE IS: (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36</td>
</tr>
<tr>
<td>Allowable clearances with specified protection (inches)</td>
<td></td>
</tr>
<tr>
<td>Use Column 1 for clearances above appliance or horizontal connector. Use Column 2 for clearances from appliance, vertical connector and single-wall metal pipe.</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
<table>
<thead>
<tr>
<th>COMBUSTIBLE MATERIAL WITHIN THE DISTANCE SPECIFIED AS THE REQUIRED CLEARANCE WITH NO PROTECTION [see Figures G2409.2(1), G2409.2(2), and G2409.2(3)]</th>
<th>Above Col. 1</th>
<th>Sides and rear Col. 2</th>
<th>Above Col. 1</th>
<th>Sides and rear Col. 2</th>
<th>Above Col. 1</th>
<th>Sides and rear Col. 2</th>
<th>Above Col. 1</th>
<th>Sides and rear Col. 2</th>
<th>Above Col. 1</th>
<th>Sides and rear Col. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 3 $\frac{1}{2}$-inch-thick masonry wall without ventilated airspace</td>
<td>—</td>
<td>24</td>
<td>—</td>
<td>12</td>
<td>—</td>
<td>9</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>2. 1 $\frac{1}{2}$-inch insulation board over 1-inch glass fiber or mineral wool batts</td>
<td>24</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3. 0.024-inch (nominal 24 gage) sheet metal over 1-inch glass fiber or mineral wool batts reinforced with wire on rear face with ventilated airspace</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4. 3 $\frac{1}{2}$-inch-thick masonry wall with ventilated airspace</td>
<td>—</td>
<td>12</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>5. 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
6. 1/2-inch-thick insulation board with ventilated airspace

<table>
<thead>
<tr>
<th></th>
<th>18</th>
<th>12</th>
<th>9</th>
<th>6</th>
<th>6</th>
<th>4</th>
<th>5</th>
<th>3</th>
<th>3</th>
<th>3</th>
</tr>
</thead>
</table>

7. 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace over 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace

<table>
<thead>
<tr>
<th></th>
<th>18</th>
<th>12</th>
<th>9</th>
<th>6</th>
<th>6</th>
<th>4</th>
<th>5</th>
<th>3</th>
<th>3</th>
<th>3</th>
</tr>
</thead>
</table>

8. 1-inch glass fiber or mineral wool batts sandwiched between two sheets 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace

<table>
<thead>
<tr>
<th></th>
<th>18</th>
<th>12</th>
<th>9</th>
<th>6</th>
<th>6</th>
<th>4</th>
<th>5</th>
<th>3</th>
<th>3</th>
<th>3</th>
</tr>
</thead>
</table>

For SI: 1 inch = 25.4 mm, °C = [(°F - 32)/1.8], 1 pound per cubic foot = 16.02 kg/m³, 1 Btu per inch per square foot per hour per °F = 0.144 W/m² · K.

a. Reduction of clearances from combustible materials shall not interfere with combustion air, draft hood clearance and relief, and accessibility of servicing.
b. All clearances shall be measured from the outer surface of the combustible material to the nearest point on the surface of the appliance, disregarding any intervening protection applied to the combustible material.
c. Spacers and ties shall be of noncombustible material. A spacer or tie shall not be used directly opposite an appliance or connector.
d. For all clearance reduction systems using a ventilated airspace, adequate provision for air circulation shall be provided as described [see Figures G2409.2(2) and G2409.2(3)].
e. There shall be at least 1 inch between clearance reduction systems and combustible walls and ceilings for reduction systems using ventilated airspace.
f. Where a wall protector is mounted on a single flat wall away from corners, it shall have an air gap of not less than 1 inch. To provide air circulation, the bottom and top edges, or only the side and top edges, or all edges shall be left open.
g. Mineral wool batts (blanket or board) shall have a density of not less than 8 pounds per cubic foot and a melting point of not less than 1500°F.
h. Insulation material used as part of a clearance reduction system shall have a thermal conductivity of 1.0 Btu per inch per square foot per hour per °F or less.
i. There shall be not less than 1 inch between the appliance and the protector. The clearance between the appliance and the combustible surface shall not be reduced below that allowed in this table.
j. All clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.
k. Listed single-wall connectors shall be installed in accordance with the manufacturer’s instructions.

G2409.3 (308.3) Clearances for indoor air-conditioning appliances.
Clearance requirements for indoor air-conditioning appliances shall comply with Sections G2409.3.1 through G2409.3.4.
G2409.3.1 (308.3.1) Appliances clearances.
Air-conditioning appliances shall be installed with clearances in accordance with the manufacturer’s instructions.

G2409.3.2 (308.3.2) Clearance reduction.
Air-conditioning appliances shall be permitted to be installed with reduced clearances to combustible material, provided that the combustible material or appliance is protected as described in Table G2409.2 and such reduction is allowed by the manufacturer’s instructions.

G2409.3.3 (308.3.3) Plenum clearances.
Where the furnace plenum is adjacent to plaster on metal lath or noncombustible material attached to combustible material, the clearance shall be measured to the surface of the plaster or other noncombustible finish where the clearance specified is 2 inches (51 mm) or less.

G2409.3.4 (308.3.4) Clearance from supply ducts.
Supply air ducts connecting to listed central heating furnaces shall have the same minimum clearance to combustibles as required for the furnace supply plenum for a distance of not less than 3 feet (914 mm) from the supply plenum. Clearance is not required beyond the 3-foot (914 mm) distance.

G2409.4 (308.4) Central heating boilers and furnaces.
Clearance requirements for central-heating boilers and furnaces shall comply with Sections G2409.4.1 through G2409.4.5. The clearance to these appliances shall not interfere with combustion air; draft hood clearance and relief; and accessibility for servicing.

G2409.4.1 (308.4.1) Appliances clearances.
Central-heating furnaces and low-pressure boilers shall be installed with clearances in accordance with the manufacturer’s instructions.

G2409.4.2 (308.4.2) Clearance reduction.
Central-heating furnaces and low-pressure boilers shall be permitted to be installed with reduced clearances to combustible material provided that the combustible material or appliance is protected as described in Table G2409.2 and such reduction is allowed by the manufacturer’s instructions.

G2409.4.3 (308.4.4) Plenum clearances.
Where the furnace plenum is adjacent to plaster on metal lath or noncombustible material attached to combustible material, the clearance shall be measured to the surface of the plaster or other noncombustible finish where the clearance specified is 2 inches (51 mm) or less.

G2409.4.4 (308.4.5) Clearance from supply ducts.
Supply air ducts connecting to listed central heating furnaces shall have the same minimum clearance to combustibles as required for the furnace supply plenum for a distance of not less than 3 feet (914 mm) from the supply plenum. Clearance is not required beyond the 3-foot (914 mm) distance.
SECTION G2410 (309)  
ELECTRICAL  
G2410.1 (309.1) Grounding.  
Gas piping shall not be used as a grounding electrode.  

G2410.2 (309.2) Connections.  
Electrical connections between appliances and the building wiring, including the grounding of the appliances, shall conform to Chapters 34 through 43 the North Carolina Electrical Code.  

SECTION G2411 (310)  
ELECTRICAL BONDING  
G2411.1 (310.1) Pipe and tubing other than CSST.  
Each above-ground portion of a gas piping system other than corrugated stainless steel tubing (CSST) that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping other than CSST shall be considered to be bonded where it is connected to appliances that are connected to the equipment grounding conductor of the circuit supplying that appliance.  

G2411.1.1 (310.1.1) CSST.  
Corrugated stainless steel tubing (CSST) gas piping systems and piping systems containing one or more segments of CSST shall be bonded to the electrical service grounding electrode system or, where provided, the lightning protection electrode system.  

Exception: CSST with an arc-resistant jacket tested in accordance with ANSI LC 1, and listed by an approved agency for installation without the direct bonding, as prescribed in this section, shall be installed in accordance with Section G2411.1 and the manufacturer’s installation instructions.  

G2411.1.1.1 (310.1.1.1) Point of connection.  
The bonding jumper shall connect to a metallic pipe, pipe fitting or CSST fitting.  

G2411.1.1.2 (310.1.1.2) Size and material of jumper.  
The bonding jumper shall be not smaller than 6 AWG copper wire of equivalent.  

G2411.1.1.3 (310.1.1.3) Bonding jumper length.  
The length of the bonding jumper between the connection to a gas piping system and the connection to a grounding electrode system shall not exceed 75 feet (22 860 mm). Any additional grounding electrodes used shall be bonded to the electrical service grounding electrode system or, where provided, the lightning protection grounding electrode system.
G2411.1.1.4 (310.1.1.4) Bonding connections.
Bonding connections shall be in accordance with NFPA 70.

G2411.1.1.5 (310.1.1.5) Connection devices.
Devices used for making the bonding connections shall be listed for the application in accordance with UL 467.

SECTION G2412 (401)
GENERAL

G2412.1 (401.1) Scope.
This section shall govern the design, installation, modification and maintenance of piping systems. The applicability of this code to piping systems extends from the point of delivery to the connections with the appliances and includes the design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance of such piping systems.

G2412.1.1 (401.1.1) Utility piping systems located within buildings.
Utility service piping located within buildings shall be installed in accordance with the structural safety and fire protection provisions of this code.

G2412.2 (401.2) Liquefied petroleum gas storage.
The storage system for liquefied petroleum gas shall be designed and installed in accordance with the International Fire Code and NFPA 58.
The enforcement of the location of undiluted liquefied petroleum gas containers shall be the responsibility of the North Carolina Department of Agriculture and Consumer Services in accordance with Article 5 of Chapter 119 of the North Carolina General Statutes.

G2412.3 (401.3) Modifications to existing systems.
In modifying or adding to existing piping systems, sizes shall be maintained in accordance with this chapter.

G2412.4 (401.4) Additional appliances.
Where an additional appliance is to be served, the existing piping shall be checked to determine if it has adequate capacity for all appliances served. If inadequate, the existing system shall be enlarged as required or separate piping of adequate capacity shall be provided.

G2412.5 (401.5) Identification.
For other than steel pipe, exposed piping shall be identified by a yellow label marked “Gas” in black letters. The marking shall be spaced at intervals not exceeding 5 feet (1524 mm). The marking shall not be required on pipe located in the same room as the appliance served. Exposed piping shall be identified by a yellow label marked “Gas” in black letters. The marking shall be spaced at intervals not exceeding 5 feet (1524 mm). All piping and tubing systems, greater than 0.5-pounds per square inch (3.45 kPa) service pressure, shall be identified by a yellow label with black letters indicating the piping system pressure. The system shall be marked at the beginning, all ends and at intervals not exceeding 5 feet (1524 mm) along its exposed length.
Exceptions:

1. Gas lines extending from the undiluted liquefied petroleum gas storage tanks to the building are not required to be labeled.

2. Black steel piping, 0.5-pounds per square inch (3.45 kPa) or less, located at dwelling units shall not be required to be labeled.

G2412.6 (401.6) Interconnections.
Where two or more meters are installed on the same premises but supply separate consumers, the piping systems shall not be interconnected on the outlet side of the meters.

G2412.7 (401.7) Piping meter identification.
Piping from multiple meter installations shall be marked with an approved a permanent identification by the installer so that the piping system supplied by each meter is readily identifiable.

G2412.8 (401.8) Minimum sizes.
All pipe utilized for the installation, extension and alteration of any piping system shall be sized to supply the full number of outlets for the intended purpose and shall be sized in accordance with Section G2413.

G2412.9 (401.9) Identification. Meter location.
Each length of pipe and tubing and each pipe fitting, utilized in a fuel gas system, shall bear the identification of the manufacturer.
When required, a meter shall be provided for the building or residence to be served. The location shall be such that the meter can be read, serviced or changed. The location, space requirements, dimensions and proper clearances shall be acceptable to the local gas company.

G2412.10 (401.10) Third-party testing and certification. Deleted.
Piping, tubing and fittings shall comply with the applicable referenced standards, specifications and performance criteria of this code and shall be identified in accordance with Section G2412.9. Piping, tubing and fittings shall either be tested by an approved third-party testing agency or certified by an approved third-party certification agency.

SECTION G2413 (402)
PIPE SIZING

G2413.1 (402.1) General considerations.
Piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand and supply gas to each appliance inlet at not less than the minimum supply pressure required by the appliance.

G2413.2 (402.2) Maximum gas demand.
The volumetric flow rate of gas to be provided shall be the sum of the maximum input of the appliances served.
The total connected hourly load shall be used as the basis for pipe sizing, assuming that all appliances could be operating at full capacity simultaneously. Where a diversity of load can be established, pipe sizing shall be permitted to be based on such loads.

The volumetric flow rate of gas to be provided shall be adjusted for altitude where the installation is above 2,000 feet (610 m) in elevation. The volume of gas to be provided, in cubic feet per hour, (MBtu for undiluted propane) shall be determined directly from the manufacturer's input ratings of the appliances served. Where an input rating is not indicated, the gas supplier, appliance manufacturer or a qualified agency shall be contacted. The total connected hourly load shall be used as the basis for pipe sizing, assuming that all appliances could be operating at full capacity simultaneously. Where a diversity of load can be established, pipe sizing shall be permitted to be based on such loads.

### G2413.3 (402.3) Sizing.

Gas piping shall be sized in accordance with one of the following:

1. **Pipe** sizing tables or sizing equations in accordance with Section G2413.4.

2. The sizing tables included in a listed piping system's manufacturer's installation instructions.

3. Other approved engineering methods.

### G2413.4 (402.4) Sizing tables and equations.

Where Tables G2413.4(1) through G2413.4(21) are used to size piping or tubing, the pipe length shall be determined in accordance with Section G2413.4.1, G2413.4.2 or G2413.4.3.

Where Equations 24-3 and 24-4 are used to size piping or tubing, the pipe or tubing shall have smooth inside walls and the pipe length shall be determined in accordance with Section G2413.4.1, G2413.4.2 or G2413.4.3.

1. Low-pressure gas equation [Less than \(1 \frac{1}{2}\) pounds per square inch (psi) (10.3 kPa)]:

   \[
   D = \frac{Q^{0.381}}{19.17 \left( \frac{\Delta H}{C_r \times L} \right)^{0.206}}
   \]

   *(Equation 24-3)*

2. High-pressure gas equation [1.5 psi (10.3 kPa) and above]:

   \[
   D = \frac{Q^{0.381}}{18.93 \left[ \frac{(P_1^2 - P_2^2) \times Y^{0.206}}{C_r \times L} \right]}
   \]

   *(Equation 24-4)*

where:

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\[D\] = Inside diameter of pipe, inches (mm).
\[Q\] = Input rate of appliance(s), cubic feet per hour at 60°F (16°C) and 30-inch mercury column.
\[P_1\] = Upstream pressure, psia \((P_1 + 14.7)\).
\[P_2\] = Downstream pressure, psia \((P_2 + 14.7)\).
\[L\] = Equivalent length of pipe, feet.
\[DH\] = Pressure drop, inch water column (27.7 inch water column = 1 psi).

**TABLE G2413.4 (402.4)**

**Cr AND Y VALUES FOR NATURAL GAS AND UNDILUTED PROPANE AT STANDARD CONDITIONS**

<table>
<thead>
<tr>
<th>GAS</th>
<th>EQUATION FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(C_r)</td>
</tr>
<tr>
<td>Natural gas</td>
<td>0.6094</td>
</tr>
<tr>
<td>Undiluted propane</td>
<td>1.2462</td>
</tr>
</tbody>
</table>

For SI: 1 cubic foot = 0.028 m³, 1 foot = 305 mm, 1-inch water column = 0.249 kPa, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.293 W.

**TABLE G2413.4(1) [402.4(2)]**

**SCHEDULE 40 METALLIC PIPE**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Natural</th>
<th>Inlet Pressure</th>
<th>Less than 2 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pressure Drop</td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specific Gravity</td>
<td>0.60</td>
</tr>
</tbody>
</table>

**PIPE SIZE (inches)**

<table>
<thead>
<tr>
<th>Nominal</th>
<th>(\frac{1}{2})</th>
<th>(\frac{3}{4})</th>
<th>1</th>
<th>(\frac{1}{4})</th>
<th>(\frac{3}{4})</th>
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<th>(\frac{1}{2})</th>
<th>(\frac{5}{4})</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual ID</td>
<td>0.622</td>
<td>0.824</td>
<td>1.049</td>
<td>1.380</td>
<td>1.610</td>
<td>2.067</td>
<td>2.469</td>
<td>3.068</td>
<td>4.026</td>
<td>5.047</td>
<td>6.065</td>
<td>7.981</td>
<td>10.020</td>
<td>11.938</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Capacity in Cubic Feet of Gas per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>172 360 678 1,390 2,090 4,020 6,400 11,300 23,100 41,800 67,600 139,000 252,000 399,000</td>
</tr>
<tr>
<td>20</td>
<td>118 247 466 957 1,430 2,760 4,400 7,780 15,900 28,700 46,500 95,500 173,000 275,000</td>
</tr>
<tr>
<td>30</td>
<td>95 199 374 768 1,150 2,220 3,530 6,250 12,700 23,000 37,300 76,700 139,000 220,000</td>
</tr>
<tr>
<td>40</td>
<td>81 170 320 657 985 1,900 3,020 5,350 10,900 19,700 31,900 65,600 119,000 189,000</td>
</tr>
<tr>
<td>50</td>
<td>72 151 284 583 873 1,680 2,680 4,740 9,660 17,500 28,300 58,200 106,000 167,000</td>
</tr>
<tr>
<td>60</td>
<td>65 137 257 528 791 1,520 2,430 4,290 8,760 15,800 25,600 52,700 95,700 152,000</td>
</tr>
<tr>
<td>70</td>
<td>60 126 237 486 728 1,400 2,230 3,950 8,050 14,600 23,600 48,500 88,100 139,000</td>
</tr>
<tr>
<td>80</td>
<td>56 117 220 452 677 1,300 2,080 3,670 7,490 13,600 22,000 45,100 81,900 130,000</td>
</tr>
<tr>
<td>90</td>
<td>52 110 207 424 635 1,220 1,950 3,450 7,030 12,700 20,600 42,300 76,900 122,000</td>
</tr>
<tr>
<td>100</td>
<td>50 104 195 400 600 1,160 1,840 3,260 6,640 12,000 19,500 40,000 72,600 115,000</td>
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<td>125</td>
<td>44 92 173 355 532 1,020 1,630 2,890 5,890 10,600 17,200 35,400 64,300 102,000</td>
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</table>
## TABLE G2413.4.2 (402.4(5))

### SCHEDULE 40 METALLIC PIPE

<table>
<thead>
<tr>
<th>Gas</th>
<th>Natural</th>
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<tbody>
<tr>
<td>Inlet Pressure</td>
<td>2.0 psi</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>1.0 psi</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.60</td>
</tr>
</tbody>
</table>

### PIPE SIZE (inches)

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<th>1</th>
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<th>1/2</th>
<th>2</th>
<th>2/2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual ID</td>
<td>0.622</td>
<td>0.824</td>
<td>1.049</td>
<td>1.380</td>
<td>1.610</td>
<td>2.067</td>
<td>2.469</td>
<td>3.068</td>
<td>4.026</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Capacity in Cubic Feet of Gas per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1,510, 3,040, 5,560, 11,400, 17,100, 32,900, 52,500, 92,800, 189,000</td>
</tr>
<tr>
<td>20</td>
<td>1,070, 2,150, 3,930, 8,070, 12,100, 23,300, 37,100, 65,600, 134,000</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**Notes:**
1. NA means a flow of less than 10 cfh.
2. All table entries have been rounded to three significant digits.
<table>
<thead>
<tr>
<th>Tube Size</th>
<th>Gas Pressure (kPa)</th>
<th>Gas Pressure (psi)</th>
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</thead>
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<td>129</td>
</tr>
<tr>
<td>40</td>
<td>753</td>
<td>110</td>
</tr>
<tr>
<td>50</td>
<td>673</td>
<td>100</td>
</tr>
<tr>
<td>60</td>
<td>615</td>
<td>92</td>
</tr>
<tr>
<td>70</td>
<td>569</td>
<td>85</td>
</tr>
<tr>
<td>80</td>
<td>532</td>
<td>80</td>
</tr>
<tr>
<td>90</td>
<td>502</td>
<td>75</td>
</tr>
<tr>
<td>100</td>
<td>462</td>
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<td>200</td>
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<td>232</td>
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<tr>
<td>400</td>
<td>216</td>
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</tr>
<tr>
<td>450</td>
<td>203</td>
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</tr>
<tr>
<td>500</td>
<td>192</td>
<td>8</td>
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<tr>
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<td>3</td>
</tr>
<tr>
<td>1,200</td>
<td>119</td>
<td>3</td>
</tr>
<tr>
<td>1,300</td>
<td>114</td>
<td>3</td>
</tr>
<tr>
<td>1,400</td>
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<td>102</td>
<td>3</td>
</tr>
<tr>
<td>1,700</td>
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<td>2</td>
</tr>
<tr>
<td>1,800</td>
<td>96</td>
<td>2</td>
</tr>
<tr>
<td>1,900</td>
<td>93</td>
<td>2</td>
</tr>
<tr>
<td>2,000</td>
<td>91</td>
<td>2</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: All table entries have been rounded to three significant digits.

**TABLE G2413.4(3) [402.4(9)]**

**SEMRIGID COPPER TUBING**

<table>
<thead>
<tr>
<th>Tube Size (inches)</th>
<th>Gas</th>
<th>Inlet Pressure</th>
<th>Pressure Drop</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Natural</td>
<td>Less than 2 psi</td>
<td>0.5 in. w.c.</td>
<td>0.60</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Nominal Length (ft)</th>
<th>Capacity in Cubic Feet of Gas per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K &amp; L 1/4 3/8 1/2 5/8 3/4 1 1/4 1/2 2</td>
</tr>
<tr>
<td></td>
<td>Outside 0.375 0.500 0.625 0.750 0.875 1.125 1.375 1.625 2.125</td>
</tr>
<tr>
<td></td>
<td>Inside 0.305 0.402 0.527 0.652 0.745 0.995 1.245 1.481 1.959</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:

2018 North Carolina Residential Code
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. NA means a flow of less than 10 cfh.
3. All table entries have been rounded to three significant digits.

## TABLE G2413.4(4) [402.4(12)]
### SEMIRIGID COPPER TUBING

<table>
<thead>
<tr>
<th>Gas</th>
<th>Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>2.0 psi</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>1.0 psi</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nominal</th>
<th>K &amp; L 1/4</th>
<th>3/8</th>
<th>1/2</th>
<th>5/8</th>
<th>3/4</th>
<th>1</th>
<th>1/4</th>
<th>1/2</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside</td>
<td>0.375 0.500</td>
<td>0.625</td>
<td>0.750</td>
<td>0.875</td>
<td>1.125</td>
<td>1.375</td>
<td>1.625</td>
<td>2.125</td>
<td></td>
</tr>
<tr>
<td>Inside</td>
<td>0.305 0.402</td>
<td>0.527</td>
<td>0.652</td>
<td>0.745</td>
<td>0.995</td>
<td>1.245</td>
<td>1.481</td>
<td>1.959</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Capacity in Cubic Feet of Gas per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>245 506 1.030 1.800 2.550 5.450 9.820 15.500 17.900 22.000</td>
</tr>
<tr>
<td>20</td>
<td>169 348 708 1.240 1.760 3.750 6.750 10.600 22.000</td>
</tr>
<tr>
<td>30</td>
<td>135 279 568 0.93 1.140 3.010 5.420 8.550 17.800</td>
</tr>
<tr>
<td>40</td>
<td>116 239 486 0.850 1.210 2.580 4.640 7.310 15.200</td>
</tr>
<tr>
<td>50</td>
<td>103 212 431 0.754 1.070 2.280 4.110 6.480 13.500</td>
</tr>
<tr>
<td>60</td>
<td>93 192 391 0.683 0.969 2.070 3.730 5.870 12.200</td>
</tr>
<tr>
<td>70</td>
<td>86 177 359 0.628 0.891 1.900 3.430 5.400 11.300</td>
</tr>
<tr>
<td>80</td>
<td>80 164 334 0.584 0.829 1.770 3.190 5.030 10.500</td>
</tr>
<tr>
<td>90</td>
<td>75 154 314 0.548 0.778 1.660 2.990 4.720 9.820</td>
</tr>
<tr>
<td>100</td>
<td>71 146 296 0.518 0.735 1.570 2.830 4.450 9.280</td>
</tr>
<tr>
<td>125</td>
<td>63 129 263 0.459 0.651 1.390 2.500 3.950 8.220</td>
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<tr>
<td>150</td>
<td>57 117 238 0.416 0.590 1.260 2.270 3.580 7.450</td>
</tr>
<tr>
<td>175</td>
<td>52 108 219 0.383 0.543 1.160 2.090 3.290 6.850</td>
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<tr>
<td>200</td>
<td>49 100 204 0.356 0.505 1.080 1.940 3.060 6.380</td>
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<tr>
<td>250</td>
<td>43 89 181 0.315 0.448 0.956 1.720 2.710 5.650</td>
</tr>
<tr>
<td>300</td>
<td>39 80 164 0.286 0.406 0.866 1.560 2.460 5.120</td>
</tr>
<tr>
<td>350</td>
<td>36 74 150 0.263 0.373 0.797 1.430 2.260 4.710</td>
</tr>
<tr>
<td>400</td>
<td>33 69 140 0.245 0.347 0.741 1.330 2.100 4.380</td>
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<td>450</td>
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<tr>
<td>600</td>
<td>27 55 112 0.196 0.279 0.595 1.070 1.690 3.520</td>
</tr>
<tr>
<td>650</td>
<td>26 53 108 0.188 0.267 0.570 1.030 1.620 3.370</td>
</tr>
<tr>
<td>700</td>
<td>25 51 103 0.181 0.256 0.548 0.986 1.550 3.240</td>
</tr>
<tr>
<td>750</td>
<td>24 49 100 0.174 0.247 0.528 0.950 1.500 3.120</td>
</tr>
<tr>
<td>800</td>
<td>23 47 96 0.168 0.239 0.510 0.917 1.450 3.010</td>
</tr>
<tr>
<td>850</td>
<td>22 46 93 0.163 0.231 0.493 0.888 1.400 2.920</td>
</tr>
<tr>
<td>900</td>
<td>22 44 90 0.158 0.224 0.478 0.861 1.360 2.830</td>
</tr>
<tr>
<td>950</td>
<td>21 43 88 0.153 0.217 0.464 0.836 1.320 2.740</td>
</tr>
<tr>
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<td>20 42 85 0.149 0.211 0.452 0.813 1.280 2.670</td>
</tr>
<tr>
<td>1,100</td>
<td>19 40 81 0.142 0.201 0.429 0.772 1.220 2.540</td>
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2018 North Carolina Residential Code
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<td>Capacity in Cubic Feet of Gas per Hour</td>
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</table>

Notes:
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. All table entries have been rounded to three significant digits.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

2018 North Carolina Residential Code
1. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: \[ L = 1.3n \text{ ft} \]
   where \( L \) is additional length (feet) of tubing and \( n \) is the number of additional fittings or bends.

2. EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

3. All table entries have been rounded to three significant digits.

### TABLE G2413.4(6) [402.4(18)]
CORRUGATED STAINLESS STEEL TUBING (CSST)

<table>
<thead>
<tr>
<th>Capacity in Cubic Feet of Gas Per Hour</th>
<th>Natural</th>
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<tr>
<td>Gas</td>
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</tr>
<tr>
<td>Inlet Pressure</td>
<td>2.0 psi</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>1.0 psi</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.60</td>
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#### TUBE SIZE (EHD)

<table>
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<th>18</th>
<th>19</th>
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<th>46</th>
<th>48</th>
<th>60</th>
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<tbody>
<tr>
<td>Length (ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,

\[ 1 \text{ British thermal unit per hour} = 0.2931 \text{ W}, \] \[ 1 \text{ cubic foot per hour} = 0.0283 \text{ m}^3/\text{h}, 1 \text{ degree} = 0.01745 \text{ rad}. \]

#### Notes:

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds \( \frac{3}{4} \) psi, DO NOT USE THIS TABLE. Consult with the regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator can vary with flow rate.

2. CAUTION: Capacities shown in the table might exceed maximum capacity for a selected regulator. Consult with the regulator or tubing manufacturer for guidance.

3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: \[ L = 1.3n \text{ ft} \]
   where \( L \) is additional length (feet) of tubing and \( n \) is the number of additional fittings or bends.

4. EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

5. All table entries have been rounded to three significant digits.
### Gas Natural

**Inlet Pressure** Less than 2 psi

**Pressure Drop** 0.5 in. w.c.

**Specific Gravity** 0.60

<table>
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<tr>
<th>PIPE SIZE (inches)</th>
<th>Nominal OD</th>
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<th>1</th>
<th>1/4</th>
<th>1/2</th>
<th>2</th>
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<td>SDR 11</td>
<td>SDR 11</td>
<td>SDR 10</td>
<td>SDR 11</td>
<td>SDR 11</td>
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<tr>
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<td><strong>Length (ft)</strong></td>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m$^3$/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.

---

### TABLE G2413.4(8) [402.4(22)]

**POLYETHYLENE PLASTIC PIPE**

<table>
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<th>Nominal OD</th>
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<th>3/4</th>
<th>1</th>
<th>1/4</th>
<th>1/2</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Designation</strong></td>
<td>SDR 9</td>
<td>SDR 11</td>
<td>SDR 11</td>
<td>SDR 10</td>
<td>SDR 11</td>
<td>SDR 11</td>
<td></td>
</tr>
<tr>
<td><strong>Actual ID</strong></td>
<td>0.660</td>
<td>0.860</td>
<td>1.077</td>
<td>1.328</td>
<td>1.554</td>
<td>1.943</td>
<td></td>
</tr>
<tr>
<td><strong>Length (ft)</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
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<td>3,720</td>
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2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Inlet Pressure</th>
<th>Pressure Drop</th>
<th>Specific Gravity</th>
</tr>
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<tbody>
<tr>
<td>10.0 psi</td>
<td>1.0 psi</td>
<td>1.50</td>
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</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.
### INTENDED USE

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<td>2.469</td>
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#### PIPE SIZE (Inches)

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<td>2,000</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 inch water column = 0.2488 kPa.

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.

---

2018 North Carolina Residential Code
### Table G2413.4(10) [402.4(26)]
**Schedule 40 Metallic Pipe**

<table>
<thead>
<tr>
<th>INTENDED USE</th>
<th>Pipe sizing between first stage (high-pressure regulator) and second stage (low-pressure regulator).</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>PIPE SIZE (inches)</th>
<th>Nominal</th>
<th>1/4</th>
<th>3/4</th>
<th>1</th>
<th>1 1/4</th>
<th>1 1/2</th>
<th>2</th>
<th>2 1/2</th>
<th>3</th>
<th>4</th>
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<td>1.380</td>
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<td>2.067</td>
<td>2.469</td>
<td>3.068</td>
<td>4.026</td>
<td></td>
</tr>
<tr>
<td>Capacity in Thousands of Btu per Hour</td>
<td>5,890</td>
<td>12,300</td>
<td>23,200</td>
<td>47,600</td>
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<td>137,000</td>
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<td>387,000</td>
<td>789,000</td>
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</table>

### Table 2413.4.10(10) [402.4(26)]
**Gas Undiluted Propane**

| Inlet Pressure | 10.0 psi |
| Pressure Drop  | 3.0 psi |
| Specific Gravity | 1.50 |

---

2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.

### TABLE G2413.4(11) [402.4(27)]
**SCHEDULE 40 METALLIC PIPE**

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<tr>
<th>Inlet Pressure</th>
<th>Pressure Drop</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 psi</td>
<td>1.0 psi</td>
<td>1.50</td>
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</table>

#### INTENDED USE
Pipe sizing between 2 psig service and line pressure regulator.

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<th>1 1/2</th>
<th>2</th>
<th>2 1/2</th>
<th>3</th>
<th>4</th>
</tr>
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<td></td>
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<tr>
<td><strong>Actual ID</strong></td>
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<td><strong>Length (ft)</strong></td>
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<td></td>
</tr>
<tr>
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<td>10,500</td>
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<td>4,150</td>
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<td>23,900</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.

## TABLE G2413.4(12) [402.4(28)]
**SCHEDULE 40 METALLIC PIPE**

<table>
<thead>
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<th>Gas</th>
<th>Undiluted Propane</th>
</tr>
</thead>
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<td><strong>Inlet Pressure</strong></td>
<td>11.0 in. w.c.</td>
</tr>
<tr>
<td><strong>Pressure Drop</strong></td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>1.50</td>
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</table>

<table>
<thead>
<tr>
<th>INTENDED USE</th>
<th>Pipe sizing between single- or second-stage (low pressure) regulator and appliance.</th>
</tr>
</thead>
<tbody>
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<td><strong>Capacity in Thousands of Btu per Hour</strong></td>
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<td>291</td>
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2018 North Carolina Residential Code
### TABLE G2413.4(13) [402.4(29)]
**SEMIRIGID COPPER TUBING**

<table>
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<tr>
<th>Gas</th>
<th>Undiluted Propane</th>
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<tbody>
<tr>
<td><strong>Inlet Pressure</strong></td>
<td>10.0 psi</td>
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<tr>
<td><strong>Pressure Drop</strong></td>
<td>1.0 psi</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>1.50</td>
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#### INTENDED USE

<table>
<thead>
<tr>
<th>Nominal</th>
<th>Sizing between first stage (high-pressure regulator) and second stage (low-pressure regulator).</th>
</tr>
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<td><strong>TUBE SIZE (inches)</strong></td>
<td>K &amp; L</td>
</tr>
<tr>
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</tr>
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</tr>
<tr>
<td><strong>Inside</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Capacity in Thousands of Btu per Hour</th>
</tr>
</thead>
<tbody>
<tr>
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<td>513</td>
</tr>
<tr>
<td>20</td>
<td>352</td>
</tr>
<tr>
<td>30</td>
<td>283</td>
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<td>40</td>
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<td>215</td>
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<tr>
<td>60</td>
<td>194</td>
</tr>
<tr>
<td>70</td>
<td>179</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 inch water column = 0.2488 kPa,

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.
| TUBE SIZE (inches) | 80 | 90 | 100 | 125 | 150 | 175 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 | 850 | 900 | 950 | 1,000 | 1,050 | 1,100 | 1,150 | 1,200 | 1,250 | 1,300 | 1,350 | 1,400 | 1,450 | 1,500 | 1,550 | 1,600 | 1,650 | 1,700 | 1,750 | 1,800 | 1,850 | 1,900 | 1,950 | 2,000 |
|-------------------|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Inlet Pressure    | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. | 11.0 in. w.c. |
| Pressure Drop     | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. | 0.5 in. w.c. |
| Specific Gravity  | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. All table entries have been rounded to three significant digits.

TABLE G2413.4(14) [402.4(30)]
SEМИRIGID COPPER TUBING

<table>
<thead>
<tr>
<th>INTENDED USE</th>
<th>Sizing between single- or second-stage (low-pressure regulator) and appliance.</th>
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</thead>
<tbody>
<tr>
<td>TUBE SIZE (inches)</td>
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</tr>
<tr>
<td>Nominal Length (ft)</td>
<td>1/8</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Outside</td>
<td>0.375</td>
</tr>
<tr>
<td>Inside</td>
<td>0.305</td>
</tr>
<tr>
<td>Capacity in Thousands of Btu per Hour</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>45</td>
</tr>
<tr>
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<tr>
<td>2,000</td>
<td>NA</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. NA means a flow of less than 10,000 Btu/hr.
3. All table entries have been rounded to three significant digits.

### TABLE G2413.4(15) [402.4(31)]
**SEMRIGID COPPER TUBING**

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<tr>
<td>Pressure Drop</td>
<td>1.0 psi</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.50</td>
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</tbody>
</table>

#### INTENDED USE
Tube sizing between 2 psig service and line pressure regulator.

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<th>5/8</th>
<th>3/4</th>
<th>1</th>
<th>1/4</th>
<th>1/2</th>
<th>2</th>
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<td>0.625</td>
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<td>1.375</td>
<td>1.625</td>
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<tr>
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<td></td>
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<td>605</td>
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<td>248</td>
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<td>775</td>
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</tr>
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<td>94</td>
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<td>192</td>
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<td>26</td>
<td>53</td>
<td>60</td>
<td>107</td>
<td>126</td>
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<td>241</td>
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<td>502</td>
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<td>70</td>
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<td>15</td>
<td>23</td>
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<td>52</td>
<td>94</td>
<td>109</td>
<td>178</td>
<td>208</td>
<td>307</td>
<td>438</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. All table entries have been rounded to three significant digits.

**TABLE G2413.4(16) [402.4(32)]**
**CORRUGATED STAINLESS STEEL TUBING (CSST)**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Undiluted Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>11.0 in. w.c.</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.50</td>
</tr>
</tbody>
</table>
### Designation

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>90</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>50</td>
<td>80</td>
<td>120</td>
<td>140</td>
<td>80</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>120</td>
<td>170</td>
<td>220</td>
<td>120</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>130</td>
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</tr>
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<td>150</td>
<td>170</td>
<td>220</td>
<td>280</td>
<td>170</td>
<td>280</td>
</tr>
</tbody>
</table>

**Notes:**
1. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: 

   \[
   L = 1.3n \text{ where } L \text{ is the additional length (feet) of tubing and } n \text{ is the number of additional fittings or bends.}
   \]
2. EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
3. All table entries have been rounded to three significant digits.

### TABLE G2413.4(17) [402.4(33)]
**CORRUGATED STAINLESS STEEL TUBING (CSST)**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Undiluted Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>2.0 psi</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>1.0 psi</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.50</td>
</tr>
</tbody>
</table>

### INTENDED USE: SIZING BETWEEN 2 PSI SERVICE AND THE LINE PRESSURE REGULATOR.

**TUBE SIZE (EHD)**

<table>
<thead>
<tr>
<th>Flow Designation</th>
<th>13</th>
<th>15</th>
<th>18</th>
<th>19</th>
<th>23</th>
<th>25</th>
<th>30</th>
<th>31</th>
<th>37</th>
<th>39</th>
<th>46</th>
<th>48</th>
<th>60</th>
<th>62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity in Thousands of Btu per Hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (ft)</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>300</td>
<td>400</td>
<td>500</td>
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<tr>
<td>100</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:
1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds \( \frac{1}{2} \) psi (based on 13 in. w.c. outlet pressure), DO NOT USE THIS TABLE. Consult with the regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator can vary with flow rate.

2. CAUTION: Capacities shown in the table might exceed maximum capacity for a selected regulator. Consult with the regulator or tubing manufacturer for guidance.

3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: \( L = 1.3n \) where \( L \) is additional length (feet) of tubing and \( n \) is the number of additional fittings or bends.

4. EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

5. All table entries have been rounded to three significant digits.

### TABLE G2413.4(18) [402.4(34)]
CORRUGATED STAINLESS STEEL TUBING (CSST)

<table>
<thead>
<tr>
<th>Flow Designation</th>
<th>Capacity in Thousands of Btu per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (ft)</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>826</td>
</tr>
<tr>
<td>25</td>
<td>509</td>
</tr>
<tr>
<td>30</td>
<td>461</td>
</tr>
<tr>
<td>40</td>
<td>396</td>
</tr>
<tr>
<td>50</td>
<td>352</td>
</tr>
<tr>
<td>75</td>
<td>284</td>
</tr>
<tr>
<td>80</td>
<td>275</td>
</tr>
<tr>
<td>100</td>
<td>243</td>
</tr>
<tr>
<td>150</td>
<td>196</td>
</tr>
<tr>
<td>200</td>
<td>169</td>
</tr>
<tr>
<td>250</td>
<td>150</td>
</tr>
<tr>
<td>300</td>
<td>136</td>
</tr>
<tr>
<td>400</td>
<td>117</td>
</tr>
<tr>
<td>500</td>
<td>104</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:
1. Table does not include effect of pressure drop across line regulator. Where regulator loss exceeds 1 psi, DO NOT USE THIS TABLE. Consult with the regulator manufacturer for pressure drops and capacity factors. Pressure drop across regulator can vary with the flow rate.

2. CAUTION: Capacities shown in the table might exceed maximum capacity of selected regulator. Consult with the tubing manufacturer for guidance.

3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: \( L = 1.3n \) where \( L \) is additional length (feet) of tubing and \( n \) is the number of additional fittings or bends.

4. EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

5. All table entries have been rounded to three significant digits.
### TABLE G2413.4(19) [402.4(35)]
**POLYETHYLENE PLASTIC PIPE**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Undiluted Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>11.0 in. w.c.</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.50</td>
</tr>
</tbody>
</table>

**INTENDED USE**

PE pipe sizing between integral 2-stage regulator at tank or second stage (low-pressure regulator) and building.

<table>
<thead>
<tr>
<th>PIPE SIZE (inches)</th>
<th>Nominal OD</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1/4</th>
<th>1</th>
<th>1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Designation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>SDR 9</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SDR 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SDR 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SDR 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SDR 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SDR 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual ID</td>
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<td>0.860</td>
<td>1.077</td>
<td>1.328</td>
<td>1.554</td>
<td>1.943</td>
<td></td>
</tr>
<tr>
<td>Length (ft)</td>
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<td>340</td>
<td>680</td>
<td>1,230</td>
<td>2,130</td>
<td>3,210</td>
<td>5,770</td>
</tr>
<tr>
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<td>1,770</td>
<td>3,180</td>
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<td>1,520</td>
<td>2,730</td>
</tr>
<tr>
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<td>978</td>
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<td>452</td>
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<td>119</td>
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<td>563</td>
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<td>87</td>
<td>157</td>
<td>271</td>
<td>409</td>
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</tr>
<tr>
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<td>41</td>
<td>82</td>
<td>148</td>
<td>256</td>
<td>387</td>
<td>695</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m$^3$/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.

### TABLE G2413.4(20) [402.4(36)]
**POLYETHYLENE PLASTIC PIPE**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Undiluted Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>2.0 psi</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>1.0 psi</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.50</td>
</tr>
</tbody>
</table>

**INTENDED USE**

PE pipe sizing between 2 psig service regulator and line pressure regulator.

2018 North Carolina Residential Code
<table>
<thead>
<tr>
<th>Nominal OD</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1 1/4</th>
<th>1 1/2</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation</td>
<td>SDR 9</td>
<td>SDR 11</td>
<td>SDR 11</td>
<td>SDR 10</td>
<td>SDR 11</td>
<td>SDR 11</td>
</tr>
<tr>
<td>Actual ID</td>
<td>0.660</td>
<td>0.860</td>
<td>1.077</td>
<td>1.328</td>
<td>1.554</td>
<td>1.943</td>
</tr>
<tr>
<td>Length (ft)</td>
<td>Capacity in Thousands of Btu per Hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3,130</td>
<td>6,260</td>
<td>11,300</td>
<td>19,600</td>
<td>29,500</td>
<td>53,100</td>
</tr>
<tr>
<td>20</td>
<td>2,150</td>
<td>4,300</td>
<td>7,760</td>
<td>13,400</td>
<td>20,300</td>
<td>36,500</td>
</tr>
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<td>6,230</td>
<td>10,800</td>
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<td>29,300</td>
</tr>
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<td>5,330</td>
<td>9,240</td>
<td>14,000</td>
<td>25,100</td>
</tr>
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<td>1,310</td>
<td>2,620</td>
<td>4,730</td>
<td>8,190</td>
<td>12,400</td>
<td>22,000</td>
</tr>
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<td>60</td>
<td>1,190</td>
<td>2,370</td>
<td>4,280</td>
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<td>20,100</td>
</tr>
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<td>3,670</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m$^3$/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.
## POLYETHYLENE PLASTIC TUBING

<table>
<thead>
<tr>
<th>Gas</th>
<th>Undiluted Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>11.0 in. w.c.</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.50</td>
</tr>
</tbody>
</table>

**INTENDED USE:** PE pipe sizing between first stage and second stage regulator.

### TABLE G2413.4(22) [402.4(38)]

**POLYETHYLENE PLASTIC TUBING**

<table>
<thead>
<tr>
<th>Plastic Tubing Size (CTS) (inch)</th>
<th>Nominal OD</th>
<th>1/2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
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<td>SDR 7</td>
<td>SDR 11</td>
<td></td>
</tr>
<tr>
<td>Actual ID</td>
<td>0.445</td>
<td>0.927</td>
<td></td>
</tr>
<tr>
<td>Length (ft)</td>
<td>Capacity in Cubic Feet of Gas per Hour</td>
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<td></td>
</tr>
<tr>
<td>10</td>
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<td>500</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**Note:** All table entries have been rounded to three significant digits.
### PLASTIC TUBING SIZE (inches)

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<th>Nominal OD</th>
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<th>1/4</th>
<th>1/2</th>
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<td>SDR 11</td>
<td>SDR 10</td>
<td>SDR 11</td>
<td>SDR 11</td>
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<td>Capacity in Thousands of Btu per Hour</td>
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<td></td>
</tr>
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<td>7.648</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W.

#### TABLE G2413.4(23) [402.4(39)]

**POLYETHYLENE PLASTIC TUBING**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Undiluted Propane</th>
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</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>10.0 psi</td>
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<td>Pressure Drop</td>
<td>1.0 psi</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.50</td>
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</table>

**INTENDED USE:** PE pipe sizing between first stage and second stage regulator.

<table>
<thead>
<tr>
<th>Nominal OD</th>
<th>1/2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation</td>
<td>SDR 7</td>
<td>SDR 11.5</td>
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<tr>
<td>Actual ID</td>
<td>0.445</td>
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</table>

2018 North Carolina Residential Code
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<tr>
<th>Length (ft)</th>
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<td>900</td>
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</tr>
<tr>
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<tr>
<td>1,500</td>
<td>92</td>
</tr>
<tr>
<td>2,000</td>
<td>79</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W.

**G2413.4.1 (402.4.1) Longest length method.**
The pipe size of each section of gas piping shall be determined using the longest length of piping from the point of delivery to the most remote outlet and the load of the section.

**G2413.4.2 (402.4.2) Branch length method.**
Pipe shall be sized as follows:

1. *Pipe* size of each section of the longest pipe run from the point of delivery to the most remote outlet shall be determined using the longest run of piping and the load of the section.

2. The pipe size of each section of branch piping not previously sized shall be determined using the length of piping from the point of delivery to the most remote outlet in each branch and the load of the section.

**G2413.4.3 (402.4.3) Hybrid pressure.**
The pipe size for each section of higher pressure gas piping shall be determined using the longest length of piping from the point of delivery to the most remote line pressure regulator.
The pipe size from the line pressure regulator to each outlet shall be determined using the length of piping from the regulator to the most remote outlet served by the regulator.

G2413.5 (402.5) Allowable pressure drop.
The design pressure loss in any piping system under maximum probable flow conditions, from the point of delivery to the inlet connection of the appliance, shall be such that the supply pressure at the appliance is greater than or equal to the minimum pressure required by the appliance.

G2413.6 (402.6) Maximum design operating pressure.
The maximum design operating pressure for piping systems located inside buildings shall not exceed 5 pounds per square inch gauge (psig) (34 kPa gauge) except where one or more of the following conditions are met:

1. The piping system is welded.
2. The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.
3. The piping is a temporary installation for buildings under construction.

G2413.6.1 (402.6.1) Liquefied petroleum gas systems.
LP-gas systems designed to operate below -5°F (-21°C) or with butane or a propane-butane mix shall be designed to either accommodate liquid LP-gas or prevent LP-gas vapor from condensing into a liquid.

SECTION G2414 (403)
PIPING MATERIALS

G2414.1 (403.1) General.
Materials used for piping systems shall comply with the requirements of this chapter or shall be approved.

G2414.2 (403.2) Used materials.
Pipe, fittings, valves or other materials shall not be used again unless they are free of foreign materials and have been ascertained to be adequate for the service intended.

G2414.3 (403.3) Other materials.
Material not covered by the standards specifications listed herein shall be investigated and tested to determine that it is safe and suitable for the proposed service, and, in addition, shall be recommended for that service by the manufacturer and shall be approved by the code official.

G2414.4 (403.4) Metallic pipe.
Metallic pipe shall comply with Sections G2414.4.1 and G2414.4.2.

G2414.4.1 (403.4.1) Cast iron.
Cast-iron pipe shall not be used.
G2414.4.2 (403.4.2) Steel.
Steel and wrought-iron pipe shall be at least of standard weight (Schedule 40) and shall comply with one of the following standards:

1. ASME B 36.10, 10M.
2. ASTM A 53/A 53M.
3. ASTM A 106.

G2414.5 (403.5) Metallic tubing.
Seamless copper, aluminum alloy and steel tubing shall not be used with gases corrosive to such materials.

G2414.5.1 (403.5.1) Steel tubing.
Steel tubing shall comply with ASTM A 254.

G2414.5.2 (403.5.2) Copper copper alloy tubing.
Copper tubing shall comply with Standard Type K or L of ASTM B 88 or ASTM B 280.

Copper and copper alloy tubing shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas (0.7 milligrams per 100 liters).

G2414.5.3 (403.5.3) Corrugated stainless steel tubing.
Corrugated stainless steel tubing shall be listed in accordance with ANSI LC 1/CSA 6.26.

G2414.6 (403.6) Plastic pipe, tubing and fittings.
Polyethylene plastic pipe, tubing and fittings used to supply fuel gas shall conform to ASTM D 2513. Such pipe shall be marked “Gas” and “ASTM D 2513.”

Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and conform to the 2008 edition of ASTM D 2513. Such pipe shall be marked “Gas” and “ASTM D 2513.”

Polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) plastic pipe, tubing and fittings shall not be used to supply fuel gas.

G2414.6.1 (403.6.1) Anodeless risers.
Plastic pipe, tubing and anodeless risers shall comply with the following:

1. Factory-assembled anodeless risers shall be recommended by the manufacturer for the gas used and shall be leak tested by the manufacturer in accordance with written procedures.

2. Service head adapters and field-assembled anodeless risers incorporating service head adapters shall be recommended by the manufacturer for the gas used, and shall be designed and certified to meet the requirements of Category I of ASTM D 2513, and U.S. Department of Transportation, Code of Federal Regulations, Title 49, Part 192.281(e). The manufacturer shall provide the user with qualified installation
instructions as prescribed by the U.S. Department of Transportation, Code of Federal Regulations, Title 49, Part 192.283(b).

**G2414.6.2 (403.6.2) LP-gas systems.**
The use of plastic pipe, tubing and fittings in undiluted liquefied petroleum gas piping systems shall be in accordance with NFPA 58.

**G2414.6.3 (403.6.3) Regulator vent piping.**
Plastic pipe and fittings used to connect regulator vents to remote vent terminations shall be of PVC conforming to ANSI/UL 651. PVC vent piping shall not be installed indoors.

**G2414.7 (403.7) Workmanship and defects.**
Pipe, tubing and fittings shall be clear and free from cutting burrs and defects in structure or threading, and shall be thoroughly brushed, and chip and scale blown.

Defects in pipe or tubing or fittings shall not be repaired. Defective pipe, tubing or fittings shall be replaced. (See Section G2417.1.2.)

**G2414.8 (403.8) Protective coating.**
Where in contact with material or atmosphere exerting a corrosive action, metallic piping and fittings coated with a corrosion-resistant material shall be used. External or internal coatings or linings used on piping or components shall not be considered as adding strength. See Section G2415.6 for corrosion protection through an exterior wall, and Section G2415.11 for specific underground installations.

**G2414.9 (403.9) Metallic pipe threads.**
Metallic pipe and fitting threads shall be taper pipe threads and shall comply with ASME B 1.20.1.

**G2414.9.1 (403.9.1) Damaged threads.**
Pipe with threads that are stripped, chipped, corroded or otherwise damaged shall not be used. Where a weld opens during the operation of cutting or threading, that portion of the pipe shall not be used.

**G2414.9.2 (403.9.2) Number of threads.**
Field threading of metallic pipe shall be in accordance with Table G2414.9.2.

| TABLE G2414.9.2 (403.9.2) |
|---------------------------|-----------------|------------------|
| SPECIFICATIONS FOR THREADING METALLIC PIPE |
| IRON PIPE SIZE (inches) | APPROXIMATE LENGTH OF THREADED PORTION (inches) | APPROXIMATE NO. OF THREADS TO BE CUT |
| 1/2 | 3/4 | 10 |
| 3/4 | 3/4 | 10 |
| 1 | 7/8 | 10 |
For SI: 1 inch = 25.4 mm.

**G2414.9.3 (403.9.3) Thread joint compounds.**
Thread joint compounds shall be resistant to the action of liquefied petroleum gas or to any other chemical constituents of the gases to be conducted through the piping.

**G2414.10 (403.10) Metallic piping joints and fittings.**
The type of piping joint used shall be suitable for the pressure-temperature conditions and shall be selected giving consideration to joint tightness and mechanical strength under the service conditions. The joint shall be able to sustain the maximum end force caused by the internal pressure and any additional forces due to temperature expansion or contraction, vibration, fatigue, or to the weight of the pipe and its contents.

**G2414.10.1 (403.10.1) Pipe joints.**
Pipe joints shall be threaded, flanged, brazed or welded. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys shall not contain more than 0.05-percent phosphorus.
Pipe joints shall be threaded, flanged, brazed, or welded, or made with press-connect fittings complying with ANSI LC-4. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys shall not contain more than 0.05-percent phosphorus.

**G2414.10.2 (403.10.2) Tubing joints.**
Tubing joints shall be made with approved gas tubing fittings or be brazed with a material having a melting point in excess of 1,000°F (538°C) or made with press-connect fittings complying with ANSI LC-4. Brazing alloys shall not contain more than 0.05-percent phosphorus.

**G2414.10.3 (403.10.3) Flared joints.**
Flared joints shall be used only in systems constructed from nonferrous pipe and tubing where experience or tests have demonstrated that the joint is suitable for the conditions and where provisions are made in the design to prevent separation of the joints.

**G2414.10.4 (403.10.4) Metallic fittings.**
Metallic fittings, shall comply with the following:

1. Fittings used with steel or wrought-iron pipe shall be steel, copper alloy, malleable iron or cast iron.
2. Fittings used with copper or copper alloy pipe shall be copper or copper alloy.
3. Cast-iron bushings shall be prohibited.
4. Special fittings. Fittings such as couplings, proprietary-type joints, saddle tees, gland-type compression fittings, and flared, flareless and compression-type tubing fittings
shall be: used within the fitting manufacturer’s pressure-temperature recommendations; used within the service conditions anticipated with respect to vibration, fatigue, thermal expansion and contraction; and shall be approved.

5. Where pipe fittings are drilled and tapped in the field, the operation shall be in accordance with all of the following:

5.1. The operation shall be performed on systems having operating pressures of 5 psi (34.5 kPa) or less.

5.2. The operation shall be performed by the gas supplier or the gas supplier’s designated representative.

5.3. The drilling and tapping operation shall be performed in accordance with written procedures prepared by the gas supplier.

5.4. The fittings shall be located outdoors.

5.5. The tapped fitting assembly shall be inspected and proven to be free of leakage.

G2414.11 (403.11) Plastic piping, joints and fittings.
Plastic pipe, tubing and fittings shall be joined in accordance with the manufacturers’ instructions. Such joints shall comply with the following:

1. The joints shall be designed and installed so that the longitudinal pull-out resistance of the joints will be at least equal to the tensile strength of the plastic piping material.

2. Heat-fusion joints shall be made in accordance with qualified procedures that have been established and proven by test to produce gas-tight joints at least as strong as the pipe or tubing being joined. Joints shall be made with the joining method recommended by the pipe manufacturer. Heat fusion fittings shall be marked “ASTM D 2513.”

3. Where compression-type mechanical joints are used, the gasket material in the fitting shall be compatible with the plastic piping and with the gas distributed by the system. An internal tubular rigid stiffener shall be used in conjunction with the fitting. The stiffener shall be flush with the end of the pipe or tubing and shall extend at least to the outside end of the compression fitting when installed. The stiffener shall be free of rough or sharp edges and shall not be a force fit in the plastic. Split tubular stiffeners shall not be used.

4. Plastic piping joints and fittings for use in liquefied petroleum gas piping systems shall be in accordance with NFPA 58.

SECTION G2415 (404)
PIPING SYSTEM INSTALLATION
G2415.1 (404.1) Installation of materials.
Materials used shall be installed in strict accordance with the standards under which the materials are accepted and approved. In the absence of such installation procedures, the manufacturer’s instructions shall be followed. Where the requirements of referenced standards or manufacturer’s instructions do not conform to minimum provisions of this code, the provisions of this code shall apply.

G2415.2 (404.2) CSST.
CSST piping systems shall be installed in accordance with the terms of their approval, the conditions of listing, the manufacturer’s instructions and this code.

G2415.3 (404.3) Prohibited locations.
Piping shall not be installed in or through a ducted supply, return or exhaust, or a clothes chute, chimney or gas vent, dumbwaiter or elevator shaft. Piping installed downstream of the point of delivery shall not extend through any townhouse unit other than the unit served by such piping.

G2415.4 (404.4) Piping in solid partitions and walls.
Concealed piping shall not be located in solid partitions and solid walls, unless installed in a chase or casing.

G2415.5 (404.5) Fittings in concealed locations.
Fittings installed in concealed locations shall be limited to the following types:

1. Threaded elbows, tees and couplings.
2. Brazed fittings.
3. Welded fittings.
4. Fittings listed to ANSI LC-1/CSA 6.26 or ANSI LC-4.

G2415.6 (404.6) Underground penetrations prohibited. Piping through foundation wall.
Gas piping shall not penetrate building foundation walls at any point below grade. Gas piping shall enter and exit a building at a point above grade and the annular space between the pipe and the wall shall be sealed.
Underground piping, where installed below grade through the outer foundation or basement wall of a building, shall be encased in a protective pipe sleeve, or shall be protected by an approved device or method. The annular space between the gas piping and the sleeve and between the sleeve and the wall shall be sealed.

G2415.7 (404.7) Protection against physical damage.
Where piping will be concealed within light-frame construction assemblies, the piping shall be protected against penetration by fasteners in accordance with Sections G2415.7.1 through G2415.7.3.

Exception: Black steel piping and galvanized steel piping shall not be required to be protected.

G2415.7.1 (404.7.1) Piping through bored holes or notches.
Where piping is installed through holes or notches in framing members and the piping is
located less than 1\(\frac{1}{2}\) inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the pipe shall be protected by shield plates that cover the width of the pipe and the framing member and that extend not less than 4 inches (51 mm) to each side of the framing member(s). Where the framing member that the piping passes through is a bottom plate, bottom track, top plate or top track, the shield plates shall cover the framing member and extend not less than 4 inches (51 mm) above the bottom framing member(s) and not less than 4 inches (51 mm) below the top framing member(s).

G2415.7.2 (404.7.2) Piping installed in other locations.
Where the piping is located within a framing member (i.e. steel studs) and is less than 1\(\frac{1}{2}\) inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the piping shall be protected by shield plates that cover the width and length of the piping. Where the piping is located outside of a framing member and is located less than 1\(\frac{1}{2}\) inches (38 mm) from the nearest edge of the face of the framing member to which the membrane will be attached, the piping shall be protected by shield plates that cover the width and length of the piping.

2415.7.3 (404.7.3) Shield plates.
Shield plates shall be of steel material having a thickness of not less than 0.0575 inch (1.463 mm) (No. 16 gage).

G2415.8 (404.8) Piping in solid floors.
Piping in solid floors shall be laid in channels in the floor and covered in a manner that will allow access to the piping with a minimum amount of damage to the building. Where such piping is subject to exposure to excessive moisture or corrosive substances, the piping shall be protected in an approved manner. As an alternative to installation in channels, the piping shall be installed in a conduit of Schedule 40 steel, wrought iron, PVC or ABS pipe in accordance with Section G2415.6.1 or G2415.6.2.

G2415.8.1 (404.8.1) Conduit with one end terminating outdoors.
The conduit shall extend into an occupiable portion of the building and, at the point where the conduit terminates in the building, the space between the conduit and the gas piping shall be sealed to prevent the possible entrance of any gas leakage. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor. If the end sealing is capable of withstanding the full pressure of the gas pipe, the conduit shall be designed for the same pressure as the pipe. Such conduit shall extend not less than 4 inches (102 mm) outside the building, shall be vented above grade to the outdoors and shall be installed to prevent the entrance of water and insects.

G2415.8.2 (404.8.2) Conduit with both ends terminating indoors.
Where the conduit originates and terminates within the same building, the conduit shall originate and terminate in an accessible portion of the building and shall not be sealed. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor.
G2415.9 (404.9) Above-ground piping outdoors.
Piping installed outdoors shall be elevated not less than \(3\frac{1}{2}\) inches (152 mm) above ground and where installed across roof surfaces, shall be elevated not less than \(3\frac{1}{2}\) inches (152 mm) above the roof surface. Piping installed above ground, outdoors, and installed across the surface of roofs shall be securely supported and located where it will be protected from physical damage. Where passing through an outside wall, the piping shall also be protected against corrosion by coating or wrapping with an inert material. Where piping is encased in a protective pipe sleeve, the annular space between the piping and the sleeve shall be sealed.

Ferrous metal exposed in exterior locations shall be protected from corrosion with one coat of exterior paint. Zinc coatings (galvanized) shall be deemed adequate protection for gas piping above ground.

G2415.10 (404.10) Isolation.
Metallic piping and metallic tubing that conveys fuel gas from an LP-gas storage container shall be provided with an approved dielectric fitting to electrically isolate the underground portion of the pipe or tube from the above ground portion that enters a building. Such dielectric fitting or dielectric regulator shall be installed above ground outdoors.

G2415.11 (404.11) Protection against corrosion underground.
Metallic pipe or tubing exposed to corrosive action, such as soil condition or moisture, shall be protected in an approved manner. Zinc coatings (galvanizing) shall not be deemed adequate protection for gas piping underground. Where dissimilar metals are joined underground, an insulating coupling or fitting shall be used. Piping shall not be laid in contact with cinders.

G2415.11.1 (404.11.1) Prohibited use.
Uncoated threaded or socket-welded joints shall not be used in piping in contact with soil or where internal or external crevice corrosion is known to occur.

G2415.11.2 (404.11.2) Protective coatings and wrapping.
Pipe protective coatings and wrappings shall be approved for the application and shall be factory applied.

Exception: Where installed in accordance with the manufacturer’s instructions, field application of coatings and wrappings shall be permitted for pipe nipples, fittings and locations where the factory coating or wrapping has been damaged or necessarily removed at joints.

G2415.12 (404.12) Minimum burial depth.
Underground piping systems shall be installed a minimum depth of 12 inches (305 mm) below grade, except as provided for in Section G2415.12.1 and G2415.12.2.

G2415.12.1 (404.12.1) Individual outside appliances.
Individual lines to outdoor lights, grills or other appliances shall be installed not less than 8 inches (203 mm) below finished grade, provided that such installation is approved and is installed in locations not susceptible to physical damage.

G2415.12.2 (404.12.2) Alternate to burial depth.
Metal piping shall be provided with a protective conduit of wrought iron, plastic pipe, or steel pipe, and topped with a 3 inch (76 mm) thick by 6 inch (152 mm) wide concrete barrier. See Section G2415.17 for plastic gas pipe requirements and limitations.

G2415.13 (404.13) Trenches.
The trench shall be graded so that the pipe has a firm, substantially continuous bearing on the bottom of the trench.

_Piping_ installed underground beneath buildings is prohibited except where the _piping_ is encased in a conduit of wrought iron, plastic pipe, steel pipe or other _approved_ conduit material designed to withstand the superimposed loads. The conduit shall be protected from corrosion in accordance with Section G2415.11 and shall be installed in accordance with Section G2415.14.1 or G2415.14.2.

The conduit shall extend into an occupiable portion of the building and, at the point where the conduit terminates in the building, the space between the conduit and the _gas piping_ shall be sealed to prevent the possible entrance of any gas leakage. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor. Where the end sealing is capable of withstanding the full pressure of the gas pipe, the conduit shall be designed for the same pressure as the pipe. Such conduit shall extend not less than 4 inches (102 mm) outside the building, shall be vented above grade to the outdoors and shall be installed so as to prevent the entrance of water and insects.

G2415.14.2 (404.14.2) Conduit with both ends terminating indoors.
Where the conduit originates and terminates within the same building, the conduit shall originate and terminate in an accessible portion of the building and shall not be sealed. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor.

G2415.15 (404.15) Outlet closures.
_Gas outlets_ that do not connect to _appliances_ shall be capped gas tight.

_Exception:_ Listed and labeled flush-mounted-type quick-disconnect devices and listed and labeled _gas convenience outlets_ shall be installed in accordance with the manufacturer’s instructions.

G2415.16 (404.16) Location of outlets.
The unthreaded portion of _piping outlets_ shall extend not less than 1 inch (25 mm) through finished ceilings and walls and where extending through floors, outdoor patios and slabs, shall not be less than 2 inches (51 mm) above them. The _outlet fitting_ or _piping_ shall be securely supported. _Outlets_ shall not be placed behind doors. _Outlets_ shall be located in the room or space where the _appliance_ is installed.

_Exception:_ Listed and labeled flush-mounted-type quick-disconnect devices and listed and labeled _gas convenience outlets_ shall be installed in accordance with the manufacturer’s instructions.
G2415.17 (404.17) Plastic pipe.
The installation of plastic pipe shall comply with Sections G2415.17.1 through G2415.17.3.

G2415.17.1 (404.17.1) Limitations.
Plastic pipe shall be installed outdoors underground only. Plastic pipe shall not be used within or under any building or slab or be operated at pressures greater than 100 psig (689 kPa) for natural gas or 30 psig (207 kPa) for LP-gas.

Exceptions:
1. Plastic pipe shall be permitted to terminate above ground outside of buildings where installed in premanufactured anodeless risers or service head adapter risers that are installed in accordance with the manufacturer’s instructions.

2. Plastic pipe shall be permitted to terminate with a wall head adapter within buildings where the plastic pipe is inserted in a piping material for fuel gas use in buildings.

3. Plastic pipe shall be permitted under outdoor patio, walkway and driveway slabs provided that the burial depth complies with Section G2415.10.

G2415.17.2 (404.17.2) Connections.
Connections outdoors and underground between metallic and plastic piping shall be made only with transition fittings conforming to ASTM D 2513 Category I or ASTM F 1973.

G2415.17.3 (404.17.3) Tracer.
A yellow insulated copper tracer wire or other approved conductor shall be installed adjacent to underground nonmetallic piping. Access shall be provided to the tracer wire or the tracer wire shall terminate above ground at each end of the nonmetallic piping. The tracer wire size shall not be less than 18 AWG and the insulation type shall be suitable for direct burial.

G2415.18 (404.18) Pipe cleaning.
The use of a flammable or combustible gas to clean or remove debris from a piping system shall be prohibited.

G2415.19 (404.19) Prohibited devices.
A device shall not be placed inside the piping or fittings that will reduce the cross-sectional area or otherwise obstruct the free flow of gas.

Exceptions:
1. Approved gas filters.

2. An approved fitting or device where the gas piping system has been sized to accommodate the pressure drop of the fitting or device.

G2415.20 (404.20) Testing of piping.
Before any system of piping is put in service or concealed, it shall be tested to ensure that it is gas tight. Testing, inspection and purging of piping systems shall comply with Section G2417.
SECTION G2416 (405)  
PIPING BENDS AND CHANGES IN DIRECTION

G2416.1 (405.1) General.  
Changes in direction of pipe shall be permitted to be made by the use of fittings, factory bends or field bends.

G2416.2 (405.2) Metallic pipe.  
Metallic pipe bends shall comply with the following:

1. Bends shall be made only with bending tools and procedures intended for that purpose.
2. All bends shall be smooth and free from buckling, cracks or other evidence of mechanical damage.
3. The longitudinal weld of the pipe shall be near the neutral axis of the bend.
4. Pipe shall not be bent through an arc of more than 90 degrees (1.6 rad).
5. The inside radius of a bend shall be not less than six times the outside diameter of the pipe.

G2416.3 (405.3) Plastic pipe.  
Plastic pipe bends shall comply with the following:

1. The pipe shall not be damaged and the internal diameter of the pipe shall not be effectively reduced.
2. Joints shall not be located in pipe bends.
3. The radius of the inner curve of such bends shall not be less than 25 times the inside diameter of the pipe.
4. Where the piping manufacturer specifies the use of special bending tools or procedures, such tools or procedures shall be used.

SECTION G2417 (406)  
INSPECTION, TESTING AND PURGING

G2417.1 (406.1) General.  
Prior to acceptance and initial operation, all piping installations shall be visually inspected and pressure tested to determine that the materials, design, fabrication and installation practices comply with the requirements of this code.  
(See NC GS 143-139.3 for alternate inspection of liquefied propane gas piping systems for residential structures.)

2018 North Carolina Residential Code
G2417.1.1 (406.1.1) Inspections.  
Inspection shall consist of visual examination, during or after manufacture, fabrication, assembly or pressure tests.

G2417.1.2 (406.1.2) Repairs and additions.  
In the event repairs or additions are made after the pressure test, the affected piping shall be tested.

    Minor repairs and additions are not required to be pressure tested provided that the work is inspected and connections are tested with a noncorrosive leak-detecting fluid or other approved leak-detecting methods.

G2417.1.3 (406.1.3) New branches.  
Where new branches are installed to new appliances, only the newly installed branches shall be required to be pressure tested. Connections between the new piping and the existing piping shall be tested with a noncorrosive leak-detecting fluid or other approved leak-detecting methods.

G2417.1.4 (406.1.4) Section testing.  
A piping system shall be permitted to be tested as a complete unit or in sections. Under no circumstances shall a valve in a line be used as a bulkhead between gas in one section of the piping system and test medium in an adjacent section, except where a double block and bleed valve system is installed. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve closing mechanism, is designed to safely withstand the test pressure.

G2417.1.5 (406.1.5) Regulators and valve assemblies.  
Regulator and valve assemblies fabricated independently of the piping system in which they are to be installed shall be permitted to be tested with inert gas or air at the time of fabrication.

G2417.1.6 (406.1.6) Pipe clearing.  
Prior to testing, the interior of the pipe shall be cleared of all foreign material.

G2417.2 (406.2) Test medium.  
The test medium shall be air, nitrogen, carbon dioxide or an inert gas. Oxygen shall not be used.

G2417.3 (406.3) Test preparation.  
Pipe joints, including welds, shall be left exposed for examination during the test.

    Exception: Covered or concealed pipe end joints that have been previously tested in accordance with this code.

G2417.3.1 (406.3.1) Expansion joints.  
Expansion joints shall be provided with temporary restraints, if required, for the additional thrust load under test.
G2417.3.2 (406.3.2) Appliance and equipment isolation.
Appliances and equipment that are not to be included in the test shall be either disconnected from the piping or isolated by blanks, blind flanges or caps.

G2417.3.3 (406.3.3) Appliance and equipment disconnection.
Where the piping system is connected to appliances or equipment designed for operating pressures of less than the test pressure, such appliances or equipment shall be isolated from the piping system by disconnecting them and capping the outlet(s).

G2417.3.4 (406.3.4) Valve isolation.
Where the piping system is connected to appliances or equipment designed for operating pressures equal to or greater than the test pressure, such appliances or equipment shall be isolated from the piping system by closing the individual appliance or equipment shutoff valve(s).

G2417.3.5 (406.3.5) Testing precautions.
Testing of piping systems shall be performed in a manner that protects the safety of employees and the public during the test.

G2417.4 (406.4) Test pressure measurement.
Test pressure shall be measured with a manometer or with a pressure-measuring device designed and calibrated to read, record, or indicate a pressure loss caused by leakage during the pressure test period. The source of pressure shall be isolated before the pressure tests are made. Mechanical gauges used to measure test pressures shall have a range such that the highest end of the scale is not greater than five times the test pressure.

G2417.4.1 (406.4.1) Test pressure.
The test pressure to be used shall be not less than \( \frac{3}{2} \) times the proposed maximum working pressure, but not less than 3 psig (20 kPa gauge) 10 psig (69 kPa gauge), irrespective of design pressure. Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe.

**Exception:** Fuel piping system that are being tested with manifolds, regulator or other pressure regulating appliance in place at the time of the test shall be tested no less than \( \frac{11}{2} \) times the proposed maximum working pressure, but not less than 3 psig (20 kPa gauge), irrespective of design pressure.

G2417.4.2 (406.4.2) Test duration.
The test duration shall be not less than 10 minutes.

G2417.4.2.1 (406.4.3) Test gauges.
Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 pounds per square inch (psi) (69 kPa) or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.

2. Tests requiring a pressure of greater than 10 psi (69 kPa) but less than or equal to 100 psi (689 kPa) shall utilize a testing gauge having increments of 1 psi (6.9 kPa)
G2417.5 (406.5) Detection of leaks and defects.
The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak unless such reduction can be readily attributed to some other cause.

G2417.5.1 (406.5.1) Detection methods.
The leakage shall be located by means of an approved gas detector, a noncorrosive leak detection fluid or other approved leak detection methods.

Matches, candles, open flames or other methods that could provide a source of ignition shall not be used.

G2417.5.2 (406.5.2) Corrections.
Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested.

G2417.6 (406.6) Piping system and equipment leakage check.
Leakage checking of systems and equipment shall be in accordance with Sections G2417.6.1 through G2417.6.4.

G2417.6.1 (406.6.1) Test gases.
Leak checks using fuel gas shall be permitted in piping systems that have been pressure tested in accordance with Section G2417.

G2417.6.2 (406.6.2) Before turning gas on.
During the process of turning gas on into a system of new gas piping, the entire system shall be inspected to determine that there are no open fittings or ends and that all valves at unused outlets are closed and plugged or capped.

G2417.6.3 (406.6.3) Leak check.
Immediately after the gas is turned on into a new system or into a system that has been initially restored after an interruption of service, the piping system shall be checked for leakage. Where leakage is indicated, the gas supply shall be shut off until the necessary repairs have been made.

G2417.6.4 (406.6.4) Placing appliances and equipment in operation.
Appliances and equipment shall not be placed in operation until after the piping system has been checked for leakage in accordance with Section G2417.6.3, the piping system has been purged in accordance with Section G2417.7 and the connections to the appliances have been checked for leakage.

G2417.7 (406.7) Purging.
The purging of piping shall be in accordance with Sections G2417.7.1 through 2417.7.3.
G2417.7.1 (406.7.1) Piping systems required to be purged outdoors.
The purging of piping systems shall be in accordance with the provisions of Sections G2417.7.1.1 through G2417.7.1.4 where the piping system meets either of the following:

1. The design operating gas pressure is greater than 2 psig (13.79 kPa).

2. The piping being purged contains one or more sections of pipe or tubing meeting the size and length criteria of Table G2417.7.1.1.

G2417.7.1.1 (406.7.1.1) Removal from service.
Where existing gas piping is opened, the section that is opened shall be isolated from the gas supply and the line pressure vented to the outdoors in accordance with Section G2417.7.1.3. Where gas piping meeting the criteria of Table G2417.7.1.1 is removed from service, the residual fuel gas in the piping shall be displaced with an inert gas.

G2417.7.1.1.1 (406.7.1.1.1) Piping added to facilitate purging.
Any piping added to facilitate purging to the outdoors shall be limited to the piping materials allowed and installed per Section G2414, or, if constantly attended, the temporary use of flexible hose complying with ANSI/UL 21 standard shall be used in accordance with NFPA 58.

Exception: If the line pressure cannot be vented to the outdoors; the building and all affected spaces shall be evacuated of personnel not involved with purging the gas lines, quantities of flammable gas shall not exceed 25 percent of the lower explosive limit (1.0-percent fuel/air mixture for natural gas or 0.6-percent fuel/air mixture for LP-gas) as measured by a combustible gas detector, all ignition sources shall be eliminated, and adequate ventilation to prevent accumulation of flammable gases shall be provided.

TABLE G2417.7.1.1 (406.7.1.1)
SIZE AND LENGTH OF PIPING

<table>
<thead>
<tr>
<th>NOMINAL PIPE SIZE (inches)</th>
<th>LENGTH OF PIPING (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 2 / &lt; 3</td>
<td>&gt; 50</td>
</tr>
<tr>
<td>≥ 3 / &lt; 4</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>≥ 4 / &lt; 6</td>
<td>&gt; 15</td>
</tr>
<tr>
<td>≥ 6 / &lt; 8</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>≥ 8</td>
<td>Any length</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. CSST EHD size of 62 is equivalent to nominal 2-inch pipe or tubing size.

G2417.7.1.2 (406.7.1.2) Placing in operation.
Where gas piping containing air and meeting the criteria of Table G2417.7.1.1 is placed in operation, the air in the piping shall first be displaced with an inert gas. The inert gas shall then be displaced with fuel gas in accordance with Section G2417.7.1.3.
G2417.7.1.3 (406.7.1.3) Outdoor discharge of purged gases.
The open end of a piping system being pressure vented or purged shall discharge directly to an outdoor location. Purging operations shall comply with all of the following requirements:

1. The point of discharge shall be controlled with a shutoff valve.

2. The point of discharge shall be located not less than 10 feet (3048 mm) from sources of ignition, not less than 10 feet (3048 mm) from building openings and not less than 25 feet (7620 mm) from mechanical air intake openings.

3. During discharge, the open point of discharge shall be continuously attended and monitored with a combustible gas indicator that complies with Section G2417.7.1.4.

4. Purging operations introducing fuel gas shall be stopped when 90 percent fuel gas by volume is detected within the pipe.

5. Persons not involved in the purging operations shall be evacuated from all areas within 10 feet (3048 mm) of the point of discharge.

G2417.7.1.4 (406.7.1.4) Combustible gas indicator.
Combustible gas indicators shall be listed and shall be calibrated in accordance with the manufacturer’s instructions. Combustible gas indicators shall numerically display a volume scale from zero percent to 100 percent in 1 percent or smaller increments.

G2417.7.2 (406.7.2) Piping systems allowed to be purged indoors or outdoors.
The purging of piping systems shall be in accordance with the provisions of Section G2417.7.2.1 where the piping system meets both of the following:

1. The design operating gas pressure is 2 psig (13.79 kPa) or less.

2. The piping being purged is constructed entirely from pipe or tubing not meeting the size and length criteria of Table G2417.7.1.1.

G2417.7.2.1 (406.7.2.1) Purging procedure.
The piping system shall be purged in accordance with one or more of the following:

1. The piping shall be purged with fuel gas and shall discharge to the outdoors.

2. The piping shall be purged with fuel gas and shall discharge to the indoors or outdoors through an appliance burner not located in a combustion chamber. Such burner shall be provided with a continuous source of ignition.

3. The piping shall be purged with fuel gas and shall discharge to the indoors or outdoors through a burner that has a continuous source of ignition and that is designed for such purpose.
4. The piping shall be purged with fuel gas that is discharged to the indoors or outdoors, and the point of discharge shall be monitored with a listed combustible gas detector in accordance with Section G2417.7.2.2. Purging shall be stopped when fuel gas is detected.

5. The piping shall be purged by the gas supplier in accordance with written procedures. Deleted.

G2417.7.2.2 (406.7.2.2) Combustible gas detector.
Combustible gas detectors shall be listed and shall be calibrated or tested in accordance with the manufacturer’s instructions. Combustible gas detectors shall be capable of indicating the presence of fuel gas.

G2417.7.3 (406.7.3) Purging appliances and equipment.
After the piping system has been placed in operation, appliances and equipment shall be purged before being placed into operation.

G2417.7.4 (406.7.4) Personnel training.
Personnel performing purging operation shall be trained according to the hazards associated with purging and shall not rely on odor when monitoring the concentration of combustible gas.

SECTION G2418 (407)
PIPING SUPPORT

G2418.1 (407.1) General.
Piping shall be provided with support in accordance with Section G2418.2.

G2418.2 (407.2) Design and installation.
Piping shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, metal hangers or building structural components suitable for the size of piping, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. Piping shall be anchored to prevent undue strains on connected appliances and shall not be supported by other piping. Pipe hangers and supports shall conform to the requirements of MSS SP-58 and shall be spaced in accordance with Section G2424. Supports, hangers and anchors shall be installed so as not to interfere with the free expansion and contraction of the piping between anchors. All parts of the supporting equipment shall be designed and installed so that they will not be disengaged by movement of the supported piping.

SECTION G2419 (408)
DRIPS AND SLOPED PIPING

G2419.1 (408.1) Slopes. Deleted.
Piping for other than dry gas conditions shall be sloped not less than $\frac{1}{4}$ inch in 15 feet (6.4 mm in 4572 mm) to prevent traps.
G2419.2 (408.2) Drips. Deleted.
Where wet gas exists, a drip shall be provided at any point in the line of pipe where condensate could collect. A drip shall also be provided at the outlet of the meter and shall be installed so as to constitute a trap wherein an accumulation of condensate will shut off the flow of gas before the condensate will run back into the meter.

G2419.3 (408.3) Location of drips. Deleted.
Drips shall be provided with ready access to permit cleaning or emptying. A drip shall not be located where the condensate is subject to freezing.

G2419.4 (408.4) Sediment trap.
Where a sediment trap is not incorporated as part of the appliance, a sediment trap shall be installed downstream of the appliance shutoff valve as close to the inlet of the appliance as practical. The sediment trap shall be either a tee fitting having a capped nipple of any length installed vertically in the bottommost opening of the tee as illustrated in Figure G2419.4 or other device approved as an effective sediment trap. Illuminating appliances, ranges, clothes dryers, log lighters, gas logs, decorative vented appliances for installation in vented fireplaces, gas fireplaces and outdoor grills need not be so equipped. The sediment trap required by a MP regulator can act as the Section G2419.4 required sediment trap, (See Section G2421.2 Item 5), if it is located within 6 feet (nom.) of appliance.

TO GAS SUPPLY IF BRANCH CONNECTS TO APPLIANCE OR TO APPLIANCE IF BRANCH CONNECTS TO GAS SUPPLY

FIGURE G2419.4 (408.4)
METHOD OF INSTALLING A TEE FITTING SEDIMENT TRAP

SECTION G2420 (409)
SHUTOFF VALVES

G2420.1 (409.1) General.
Piping systems shall be provided with shutoff valves in accordance with this section.

G2420.1.1 (409.1.1) Valve approval.
Shutoff valves shall be of an approved type; shall be constructed of materials compatible with the piping; and shall comply with the standard that is applicable for the pressure and application, in accordance with Table G2420.1.1.

<table>
<thead>
<tr>
<th>VALVE STANDARDS</th>
<th>APPLIANCE SHUTOFF VALVE APPLICATION UP TO 1/2 psig PRESSURE</th>
<th>OTHER VALVE APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI Z21.15</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>ASME B 16.44</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ASME B 16.33</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

For SI: 1 pound per square inch gauge = 6.895 kPa.
a. If labeled 2G.
b. If labeled 5G.

G2420.1.2 (409.1.2) Prohibited locations.
Shutoff valves shall be prohibited in concealed locations and furnace plenums.

G2420.1.3 (409.1.3) Access to shutoff valves.
Shutoff valves shall be located in places so as to provide access for operation and shall be installed so as to be protected from damage.

G2420.2 (409.2) Meter valve. Deleted.
Every meter shall be equipped with a shutoff valve located on the supply side of the meter.

G2420.3 (409.3.2) Individual buildings.
In a common system serving more than one building, shutoff valves shall be installed outdoors at each building.

G2420.4 (409.4) MP regulator valves.
A listed shutoff valve shall be installed immediately ahead of each MP regulator.

G2420.5 (409.5) Appliance shutoff valve.
Each appliance shall be provided with a shutoff valve in accordance with Section G2420.5.1, G2420.5.2 or G2420.5.3.
G2420.5.1 (409.5.1) Located within same room.
The shutoff valve shall be located in the same room as the appliance. The shutoff valve shall be within 6 feet (1829 mm) of the appliance, and shall be installed upstream of the union, connector or quick disconnect device it serves. Such shutoff valves shall be provided with access. Appliance shutoff valves located in the firebox of a fireplace shall be installed in accordance with the appliance manufacturer’s instructions.

This section shall not prohibit the use or the installation of gas shutoff valves in the firebox of fireplaces serving listed gas appliances.

G2420.5.2 (409.5.2) Vented decorative appliances and room heaters.
Shutoff valves for vented decorative appliances, room heaters and decorative appliances for installation in vented fireplaces shall be permitted to be installed in an area remote from the appliances where such valves are provided with ready access. Such valves shall be permanently identified and shall not serve another appliance. The piping from the shutoff valve to within 6 feet (1829 mm) of the appliance shall be designed, sized and installed in accordance with Sections G2412 through G2419.

G2420.5.3 (409.5.3) Located at manifold. Deleted.
Where the appliance shutoff valve is installed at a manifold, such shutoff valve shall be located within 50 feet (15 240 mm) of the appliance served and shall be readily accessible and permanently identified. The piping from the manifold to within 6 feet (1829 mm) of the appliance shall be designed, sized and installed in accordance with Sections G2412 through G2419.

SECTION G2421 (410)
FLOW CONTROLS

G2421.1 (410.1) Pressure regulators.
A line pressure regulator shall be installed where the appliance is designed to operate at a lower pressure than the supply pressure. Line gas pressure regulators shall be listed as complying with ANSI Z21.80. Access shall be provided to pressure regulators. Pressure regulators shall be protected from physical damage. Regulators installed on the exterior of the building shall be approved for outdoor installation.

G2421.2 (410.2) MP regulators.
MP pressure regulators shall comply with the following:

1. The MP regulator shall be approved and shall be suitable for the inlet and outlet gas pressures for the application.

2. The MP regulator shall maintain a reduced outlet pressure under lock-up (no-flow) conditions.

3. The capacity of the MP regulator, determined by published ratings of its manufacturer, shall be adequate to supply the appliances served.
4. The MP pressure regulator shall be provided with access. Where located indoors, the regulator shall be vented to the outdoors or shall be equipped with a leak-limiting device, in either case complying with Section G2421.3.

5. A tee fitting with one opening capped or plugged shall be installed between the MP regulator and its upstream shutoff valve. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument and to serve as a sediment trap.

6. A tee fitting with one opening capped or plugged shall be installed not less than 10 pipe diameters downstream of the MP regulator outlet. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument. A means to test pressure shall be installed not less than 10 pipe diameters downstream of the MP regulator outlet. Such fitting shall be positioned to allow connection of a pressure-measuring instrument.

7. Where connected to rigid piping, a union shall be installed within 1 foot (304 mm) of either side of the MP regulator.

   **Exception:** Where other than rigid piping is connected to the MP regulator, the union is not required.

G2421.3 (410.3) Venting of regulators.

*Pressure regulators* that require a vent shall be vented directly to the outdoors. The vent shall be designed to prevent the entry of insects, water and foreign objects.

   a. Regulator vent outlets serving propane piping shall be located 3 feet (914 mm) horizontally from openings and operable openings that are below the vent, and 5 feet (1524 mm) in any direction from direct vent appliance intakes and mechanical ventilation intakes or 1 foot (305 mm) below openings and operable openings, and 3 feet (914 mm) below direct vent and mechanical vent intakes.

   b. Regulator vent outlets serving natural gas piping shall be located 3 feet (914 mm) horizontally from operable openings above the vent, and 5 feet (1524 mm) horizontally from direct vent appliance intakes and mechanical ventilation air intakes located above the vent, or 1 foot (305 mm) above openings and operable openings, and 3 feet (914 mm) above direct vent and mechanical vent intakes.

   **Exception:** A vent to the outdoors is not required for regulators equipped with and labeled for utilization with an approved vent-limiting device installed in accordance with the manufacturer’s instructions.

G2421.3.1 (410.3.1) Vent piping.

Vent piping for relief vents and breather vents shall be constructed of materials allowed for gas piping in accordance with Section G2414. Vent piping shall be not smaller than the vent connection on the pressure regulating device. Vent piping serving relief vents and combination relief and breather vents shall be run independently to the outdoors and shall serve only a single device vent. Vent piping serving only breather vents is permitted to be connected in a manifold arrangement where sized in accordance with an approved design that minimizes backpressure in the event of diaphragm rupture. Regulator vent piping shall not exceed the length specified in the regulator manufacturer’s installation instructions.
G2421.4 (410.4) Excess flow valves.
Where automatic excess flow valves are installed, they shall be listed for the application and shall be sized and installed in accordance with the manufacturer’s instructions.

G2421.5 (410.5) Flashback arrestor check valve.
Where fuel gas is used with oxygen in any hot work operation, a listed protective device that serves as a combination flashback arrestor and backflow check valve shall be installed at an approved location on both the fuel gas and oxygen supply lines. Where the pressure of the piped fuel gas supply is insufficient to ensure such safe operation, approved equipment shall be installed between the gas meter and the appliance that increases pressure to the level required for such safe operation.

G2421.6 (416) Overpressure protection devices.

G2421.6.1 (416.1) Where required.
Where the serving gas supplier delivers gas at a pressure greater than 2 psi for piping systems serving appliances designed to operate at a gas pressure of 14 inches w.c. or less, overpressure protection devices shall be installed. Piping systems serving equipment designed to operate at inlet pressures greater than 14 inches w.c. shall be equipped with overpressure protection devices as required by the appliance manufacturer’s installation instructions.

G2421.6.2 (416.2) Pressure limitation requirements.
The requirements for pressure limitation shall be in accordance with Sections G2421.6.2.1 through G2421.6.2.5.

G2421.6.2.1 (416.2.1) Pressure under 14 inches w.c.
Where piping systems serving appliances designed to operate with a gas supply pressure of 14 inches w.c. or less are required to be equipped with overpressure protection by Section 416.1, each overpressure protection device shall be adjusted to limit the gas pressure to each connected appliance to 2 psi or less upon a failure of the line pressure regulator.

G2421.6.2.2 (416.2.2) Pressure over 14 inches w.c.
Where piping systems serving appliances designed to operate with a gas supply pressure greater than 14 inches w.c. are required to be equipped with overpressure protection by Section G2421.6.1, each overpressure protection device shall be adjusted to limit the gas pressure to each connected appliance as required by the appliance manufacturer’s installation instructions.

G2421.6.2.3 (416.2.3) Device capability.
Each overpressure protection device installed to meet the requirements of this section shall be capable of limiting the pressure to its connected appliance(s) as required by this Section G2421.6.2.1, independently of any other pressure control equipment in the piping system.

G2421.6.2.4 (416.2.4) Failure detection.
Each gas piping system for which an overpressure protection device is required by Section G2421.6 shall be designed and installed so that a failure of the primary pressure control device(s) is detectable.
G2421.6.2.5 (416.2.5) Relief valve.
Where a pressure relief valve is used to meet the requirements of Section G2421.6, it shall have a flow capacity such that the pressure in the protected system is maintained at or below the limits specified in Section G2421.6.2.1 under all of the following conditions:

1. The line pressure regulator for which the relief valve is providing overpressure protection has failed wide open.

2. The gas pressure at the inlet of the line pressure regulator for which the relief valve is providing overpressure protection is not less than the regulator’s normal operating inlet pressure.

G2421.6.3 (416.3) Devices.
Pressure-relieving or pressure-limiting devices shall be one of the following:

1. Pressure relief valve.


3. Series regulator installed upstream from the line regulator and set to continuously limit the pressure on the inlet of the line regulator to the maximum values specified by Section G2421.6.2.1.

4. Automatic shutoff device installed in series with the line pressure regulator and set to shut off when the pressure on the downstream piping system reaches the maximum values specified by Section G2421.6.2.1. This device shall be designed so that it will remain closed until manually reset.

The devices specified in this section shall be installed either as an integral part of the service or line pressure regulator or as separate units. Where separate pressure-relieving or pressure-limiting devices are installed, they shall comply with Sections G2421.6.3.1 through G2421.6.3.6.

G2421.6.3.1 (416.3.1) Construction and installation.
Pressure-relieving and pressure-limiting devices shall be constructed of materials so that the operation of the devices will not be impaired by corrosion of external parts by the atmosphere or of internal parts by the gas. Pressure-relieving and pressure-limiting devices shall be designed and installed so that they can be operated to determine whether the valve is free. The devices shall be designed and installed so that they can be tested to determine the pressure at which they will operate and examined for leakage when in the closed position.

G2421.6.3.2 (416.3.2) External control piping.
External control piping shall be designed and installed so that damage to the control piping of one device will not render both the regulator and the overpressure protection device inoperative.

G2421.6.3.3 (416.3.3) Setting.
Each pressure-relieving or pressure-limiting device shall be set so that the gas pressure supplied to the connected appliances does not exceed the limits specified in Section G2421.6.2.1.

**G2421.6.3.4 (416.3.4) Unauthorized operation.**
Where unauthorized operation of any shutoff valve could render a pressure relieving valve or pressure-limiting device inoperative, one of the following shall be accomplished:

1. The valve shall be locked in the open position. Authorized personnel shall be instructed in the importance of leaving the shutoff valve open and of being present while the shutoff valve is closed so that it can be locked in the open position before leaving the premises.

2. Duplicate relief valves shall be installed, each having adequate capacity to protect the system, and the isolating valves and three-way valves shall be arranged so that only one relief valve can be rendered inoperative at a time.

**G2421.6.3.5 (416.3.5) Vents.**
The discharge stacks, vents and outlet parts of all pressure-relieving and pressure-limiting devices shall be located so that gas is safely discharged to the outdoors. Discharge stacks and vents shall be designed to prevent the entry of water, insects and other foreign material that could cause blockage. The discharge stack or vent line shall be not less than the same size as the outlet of the pressure-relieving device.

**G2421.6.3.6 (416.3.6) Size of fittings, pipe and openings.**
The fittings, pipe and openings located between the system to be protected and the pressure-relieving device shall be sized to prevent hammering of the valve and to prevent impairment of relief capacity.

**SECTION G2422 (411)**

**APPLIANCE CONNECTIONS**

**G2422.1 (411.1) Connecting appliances.**
Appliances shall be connected to the piping system by one of the following:

1. Rigid metallic pipe and fittings.

2. Corrugated stainless steel tubing (CSST) where installed in accordance with the manufacturer’s instructions.

3. Listed and labeled appliance connectors in compliance with ANSI Z21.24 and installed in accordance with the manufacturer’s instructions and located entirely in the same room as the appliance.

4. Listed and labeled quick-disconnect devices used in conjunction with listed and labeled appliance connectors.
5. Listed and labeled convenience outlets used in conjunction with listed and labeled appliance connectors.

6. Listed and labeled outdoor appliance connectors in compliance with ANSI Z21.75/CSA 6.27 and installed in accordance with the manufacturer’s instructions.

7. Listed outdoor gas hose connectors in compliance with ANSI Z21.54 used to connect portable outdoor appliances. The gas hose connection shall be made only in the outdoor area where the appliance is used, and shall be to the gas piping supply at an appliance shutoff valve, a listed quick-disconnect device or listed gas convenience outlet.

**G2422.1.1 (411.1.2) Protection from damage.**
Connectors and tubing shall be installed so as to be protected against physical damage.

**G2422.1.2 (411.1.3) Connector installation.**
Appliance fuel connectors shall be installed in accordance with the manufacturer’s instructions and Sections G2422.1.2.1 through G2422.1.2.4.

**G2422.1.2.1 (411.1.3.1) Maximum length.**
Connectors shall have an overall length not to exceed 6 feet (1829 mm). Measurement shall be made along the centerline of the connector. Only one connector shall be used for each appliance.

**Exception:** Rigid metallic piping used to connect an appliance to the piping system shall be permitted to have a total length greater than 6 feet (1829 mm) provided that the connecting pipe is sized as part of the piping system in accordance with Section G2413 and the location of the appliance shutoff valve complies with Section G2420.5.

**G2422.1.2.2 (411.1.3.2) Minimum size.**
Connectors shall have the capacity for the total demand of the connected appliance.

**G2422.1.2.3 (411.1.3.3) Prohibited locations and penetrations.**
Connectors shall not be concealed within, or extended through, walls, floors, partitions, ceilings or appliance housings.

**Exceptions:**

1. Connectors constructed of materials allowed for piping systems in accordance with Section G2414 shall be permitted to pass through walls, floors, partitions and ceilings where installed in accordance with Section G2420.5.2 or G2420.5.3.

2. Rigid steel pipe connectors shall be permitted to extend through openings in appliance housings.

3. Fireplace inserts that are factory equipped with grommets, sleeves or other means of protection in accordance with the listing of the appliance.
4. Semirigid tubing and listed connectors shall be permitted to extend through an opening in an appliance housing, cabinet or casing where the tubing or connector is protected against damage.

G2422.1.2.4 (411.1.3.4) Shutoff valve.
A shutoff valve not less than the nominal size of the connector shall be installed ahead of the connector in accordance with Section G2420.5.

G2422.1.3 (411.1.5) Connection of gas engine-powered air conditioners.
Internal combustion engines shall not be rigidly connected to the gas supply piping.

G2422.1.4 (411.1.6) Unions.
A union fitting shall be provided for appliances connected by rigid metallic pipe. Such unions shall be accessible and located within 6 feet (1829 mm) of the appliance.

G2422.1.5 (411.1.4) Movable appliances.
Where appliances are equipped with casters or are otherwise subject to periodic movement or relocation for purposes such as routine cleaning and maintenance, such appliances shall be connected to the supply system piping by means of an appliance connector listed as complying with ANSI Z21.69 or by means of Item 1 of Section G2422.1. Such flexible connectors shall be installed and protected against physical damage in accordance with the manufacturer’s instructions.

G2422.2 (411.3) Suspended low-intensity infrared tube heaters.
Suspended low-intensity infrared tube heaters shall be connected to the building piping system with a connector listed for the application complying with ANSI Z21.24/CGA 6.10. The connector shall be installed as specified by the tube heater manufacturer’s instructions.

SECTION G2423 (413)
COMPRESSED NATURAL GAS MOTOR VEHICLE FUEL-DISPENSING FACILITIES

G2423.1 (413.1) General.
Motor fuel-dispensing facilities for CNG fuel shall be in accordance with Section 413 of the International Fuel Gas Code.

SECTION G2424 (415)
PIPING SUPPORT INTERVALS

G2424.1 (415.1) Interval of support.
Piping shall be supported at intervals not exceeding the spacing specified in Table G2424.1. Spacing of supports for CSST shall be in accordance with the CSST manufacturer’s instructions.

Exception: Fuel gas piping from grade-mounted propane tanks, < 2000 Gallon WC, extending from the tank into the ground, or into the building with less than 4 feet of pipe shall not require additional support.
TABLE G2424.1 (415.1)
SUPPORT OF PIPING

<table>
<thead>
<tr>
<th>STEEL PIPE, NOMINAL SIZE OF PIPE (inches)</th>
<th>SPACING OF SUPPORTS (feet)</th>
<th>NOMINAL SIZE OF TUBING SMOOTH-WALL (inch O.D.)</th>
<th>SPACING OF SUPPORTS (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>6</td>
<td>1/2</td>
<td>4</td>
</tr>
<tr>
<td>3/4 or 1</td>
<td>8</td>
<td>5/8 or 3/4</td>
<td>6</td>
</tr>
<tr>
<td>1 1/4 or larger (horizontal)</td>
<td>10</td>
<td>7/8 or 1</td>
<td>8</td>
</tr>
<tr>
<td>1 1/4 or larger (vertical)</td>
<td>Every floor level</td>
<td>1 or larger (vertical)</td>
<td>Every floor level</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

SECTION G2425 (501)
GENERAL

G2425.1 (501.1) Scope.
This section shall govern the installation, maintenance, repair and approval of factory-built chimneys, chimney liners, vents and connectors and the utilization of masonry chimneys serving gas-fired appliances.

G2425.2 (501.2) General.
Every appliance shall discharge the products of combustion to the outdoors, except for appliances exempted by Section G2425.8.

G2425.3 (501.3) Masonry chimneys.
Masonry chimneys shall be constructed in accordance with Section G2427.5 and Chapter 10.

G2425.4 (501.4) Minimum size of chimney or vent.
Chimneys and vents shall be sized in accordance with Sections G2427 and G2428. Examples of methodologies are shown in Appendix B.

G2425.5 (501.5) Abandoned inlet openings.
Abandoned inlet openings in chimneys and vents shall be closed by an approved method.

G2425.6 (501.6) Positive pressure.
Where an appliance equipped with a mechanical forced draft system creates a positive pressure in the venting system, the venting system shall be designed for positive pressure applications.

G2425.7 (501.7) Connection to fireplace.
Connection of appliances to chimney flues serving fireplaces shall be in accordance with Sections G2425.7.1 through G2425.7.3.
G2425.7.1 (501.7.1) Closure and access.
A noncombustible seal shall be provided below the point of connection to prevent entry of room air into the flue. Means shall be provided for access to the flue for inspection and cleaning.

G2425.7.2 (501.7.2) Connection to factory-built fireplace flue.
An appliance shall not be connected to a flue serving a factory-built fireplace unless the appliance is specifically listed for such installation. The connection shall be made in accordance with the appliance manufacturer’s installation instructions.

G2425.7.3 (501.7.3) Connection to masonry fireplace flue.
A connector shall extend from the appliance to the flue serving a masonry fireplace such that the flue gases are exhausted directly into the flue. The connector shall be accessible or removable for inspection and cleaning of both the connector and the flue. Listed direct connection devices shall be installed in accordance with their listing.

G2425.8 (501.8) Appliances not required to be vented.
The following appliances shall not be required to be vented:

1. Ranges.
2. Built-in domestic cooking units listed and marked for optional venting.
3. Hot plates and laundry stoves.
4. Type 1 clothes dryers (Type 1 clothes dryers shall be exhausted in accordance with the requirements of Section G2439).
5. Refrigerators.
6. Counter appliances.
7. Room heaters listed for unvented use.

Where the appliances listed in Items 5 through 7 above are installed so that the aggregate input rating exceeds 20 Btu per hour per cubic foot (207 W/m$^3$) of volume of the room or space in which such appliances are installed, one or more shall be provided with venting systems or other approved means for conveying the vent gases to the outdoor atmosphere so that the aggregate input rating of the remaining unvented appliances does not exceed 20 Btu per hour per cubic foot (207 W/m$^3$). Where the room or space in which the appliance is installed is directly connected to another room or space by a doorway, archway or other opening of comparable size that cannot be closed, the volume of such adjacent room or space shall be permitted to be included in the calculations.

G2425.9 (501.9) Chimney entrance.
Connectors shall connect to a masonry chimney flue at a point not less than 12 inches (305 mm) above the lowest portion of the interior of the chimney flue.
G2425.10 (501.10) Connections to exhauster. 
Appliance connections to a chimney or vent equipped with a power exhauster shall be made on the inlet side of the exhauster. Joints on the positive pressure side of the exhauster shall be sealed to prevent flue-gas leakage as specified by the manufacturer's installation instructions for the exhauster.

G2425.11 (501.11) Masonry chimneys. 
Masonry chimneys utilized to vent appliances shall be located, constructed and sized as specified in the manufacturer's installation instructions for the appliances being vented and Section G2427.

G2425.12 (501.12) Residential and low-heat appliances flue lining systems. 
Flue lining systems for use with residential-type and low-heat appliances shall be limited to the following:

1. Clay flue lining complying with the requirements of ASTM C 315 or equivalent. Clay flue lining shall be installed in accordance with Chapter 10.

2. Listed chimney lining systems complying with UL 1777.

3. Other approved materials that will resist, without cracking, softening or corrosion, flue gases and condensate at temperatures up to 1,800°F (982°C).

G2425.13 (501.13) Category I appliance flue lining systems. 
Flue lining systems for use with Category I appliances shall be limited to the following:

1. Flue lining systems complying with Section G2425.12.

2. Chimney lining systems listed and labeled for use with gas appliances with draft hoods and other Category I gas appliances listed and labeled for use with Type B vents.

The design, sizing and installation of vents for Category II, III and IV appliances shall be in accordance with the appliance manufacturer's instructions.

G2425.15 (501.15) Existing chimneys and vents. 
Where an appliance is permanently disconnected from an existing chimney or vent, or where an appliance is connected to an existing chimney or vent during the process of a new installation, the chimney or vent shall comply with Sections G2425.15.1 through G2425.15.4.

G2425.15.1 (501.15.1) Size. 
The chimney or vent shall be resized as necessary to control flue gas condensation in the interior of the chimney or vent and to provide the appliance or appliances served with the required draft. For Category I appliances, the resizing shall be in accordance with Section G2426.

G2425.15.2 (501.15.2) Flue passageways. 
The flue gas passageway shall be free of obstructions and combustible deposits and shall be cleaned if previously used for venting a solid or liquid fuel-burning appliance or fireplace. The flue liner, chimney inner wall or vent inner wall shall be continuous and shall be free of
cracks, gaps, perforations, or other damage or deterioration that would allow the escape of combustion products, including gases, moisture and creosote.

G2425.15.3 (501.15.3) Cleanout. 

*Masonry chimney* flues shall be provided with a cleanout opening having a minimum height of 6 inches (152 mm). The upper edge of the opening shall be located not less than 6 inches (152 mm) below the lowest *chimney* inlet opening. The cleanout shall be provided with a tight-fitting, noncombustible cover.

G2425.15.4 (501.15.4) Clearances. 

Chimneys and vents shall have airspace clearance to combustibles in accordance with Chapter 10 and the chimney or vent manufacturer’s installation instructions.

Exception: *Masonry chimneys* without the required air-space clearances shall be permitted to be used if lined or relined with a chimney lining system listed for use in chimneys with reduced clearances in accordance with UL 1777. The chimney clearance shall be not less than that permitted by the terms of the chimney liner listing and the manufacturer’s instructions.

G2425.15.4.1 (501.15.4.1) Fireblocking. 

Noncombustible fireblocking shall be provided in accordance with Chapter 10.

SECTION G2426 (502) 

VENTS 

G2426.1 (502.1) General.

Vents, except as provided in Section G2427.7, shall be listed and labeled. Type B and BW vents shall be tested in accordance with UL 441. Type L vents shall be tested in accordance with UL 641. Vents for Category II and III *appliances* shall be tested in accordance with UL 1738. Plastic vents for Category IV *appliances* shall not be required to be listed and labeled where such vents are as specified by the *appliance* manufacturer and are installed in accordance with the *appliance* manufacturer’s instructions.

G2426.2 (502.2) Connectors required.

Connectors shall be used to connect *appliances* to the vertical *chimney* or vent, except where the *chimney* or vent is attached directly to the *appliance*. Vent connector size, material, construction and installation shall be in accordance with Section G2427.

G2426.3 (502.3) Vent application.

The application of vents shall be in accordance with Table G2427.4.

G2426.4 (502.4) Insulation shield.

Where *type B, BW and L* vents pass through insulated assemblies, an insulation shield constructed of steel having a minimum thickness of 0.0187 inch (0.4712 mm) (No. 26 gage) shall be installed to provide clearance between the vent and the insulation material. The clearance shall not be less than the clearance to combustibles specified by the vent manufacturer’s installation instructions. Where vents pass through attic space, the shield shall terminate not less than 2 inches (51 mm) above the insulation materials and shall be secured in
place to prevent displacement. Insulation shields provided as part of a listed vent system shall be installed in accordance with the manufacturer’s instructions.

**G2426.5 (502.5) Installation.**
Vent systems shall be sized, installed and terminated in accordance with the vent and appliance manufacturer’s installation instructions and Section G2427.

**G2426.6 (502.6) Support of vents.**
All portions of vents shall be adequately supported for the design and weight of the materials employed.

**G2426.7 (502.7) Protection against physical damage.**
In concealed locations, where a vent is installed through holes or notches in studs, joists, rafters or similar members less than $1 \frac{1}{2}$ inches (38 mm) from the nearest edge of the member, the vent shall be protected by shield plates. Protective steel shield plates having a minimum thickness of 0.0575-inch (1.463 mm) (16 gage) shall cover the area of the vent where the member is notched or bored and shall extend a minimum of 4 inches (102 mm) above sole plates, below top plates and to each side of a stud, joist or rafter.

**G2426.7.1 (502.7.1) Door swing.**
Appliance and equipment vent terminals shall be located such that doors cannot swing within 12 inches (305 mm) horizontally of the vent terminal. Door stops or closures shall not be installed to obtain this clearance.

**SECTION G2427 (503)**
VENTING OF APPLIANCES

**G2427.1 (503.1) General.**
The venting of appliances shall be in accordance with Sections G2427.2 through G2427.16.

**G2427.2 (503.2) Venting systems required.**
Except as permitted in Sections G2427.2.1, G2427.2.2 and G2425.8, all appliances shall be connected to venting systems.

**G2427.2.1 (503.2.3) Direct-vent appliances.**
Listed direct-vent appliances shall be installed in accordance with the manufacturer’s instructions and Section G2427.8, Item 3.

**G2427.2.2 (503.2.4) Appliances with integral vents.**
Appliances incorporating integral venting means shall be installed in accordance with the manufacturer’s instructions and Section G2427.8, Items 1 and 2.

**G2427.3 (503.3) Design and construction.**
Venting systems shall be designed and constructed so as to convey all flue and vent gases to the outdoors.
G2427.3.1 (503.3.1) Appliance draft requirements.
A venting system shall satisfy the draft requirements of the appliance in accordance with the manufacturer’s instructions.

G2427.3.2 (503.3.2) Design and construction.
Appliances required to be vented shall be connected to a venting system designed and installed in accordance with the provisions of Sections G2427.4 through G2427.16.

G2427.3.3 (503.3.3) Mechanical draft systems.
Mechanical draft systems shall comply with the following:

1. Mechanical draft systems shall be listed and shall be installed in accordance with the manufacturer’s instructions for both the appliance and the mechanical draft system.

2. Appliances requiring venting shall be permitted to be vented by means of mechanical draft systems of either forced or induced draft design.

3. Forced draft systems and all portions of induced draft systems under positive pressure during operation shall be designed and installed so as to prevent leakage of flue or vent gases into a building.

4. Vent connectors serving appliances vented by natural draft shall not be connected into any portion of mechanical draft systems operating under positive pressure.

5. Where a mechanical draft system is employed, provisions shall be made to prevent the flow of gas to the main burners when the draft system is not performing so as to satisfy the operating requirements of the appliance for safe performance.

6. The exit terminals of mechanical draft systems shall be not less than 7 feet (2134 mm) above finished ground level where located adjacent to public walkways and shall be located as specified in Section G2427.8, Items 1 and 2.

G2427.3.4 (503.3.5) Air ducts and furnace plenums.
Venting systems shall not extend into or pass through any fabricated air duct or furnace plenum.

G2427.3.5 (503.3.6) Above-ceiling air-handling spaces.
Where a venting system passes through an above-ceiling air-handling space or other nonducted portion of an air-handling system, the venting system shall conform to one of the following requirements:

1. The venting system shall be a listed special gas vent; other venting system serving a Category III or Category IV appliance; or other positive pressure vent, with joints sealed in accordance with the appliance or vent manufacturer’s instructions.

2. The venting system shall be installed such that fittings and joints between sections are not installed in the above-ceiling space.

3. The venting system shall be installed in a conduit or enclosure with sealed joints separating the interior of the conduit or enclosure from the ceiling space.
G2427.4 (503.4) Type of venting system to be used.
The type of venting system to be used shall be in accordance with Table G2427.4.

**TABLE G2427.4 (503.4)**
**TYPE OF VENTING SYSTEM TO BE USED**

<table>
<thead>
<tr>
<th>APPLIANCES</th>
<th>TYPE OF VENTING SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed Category I appliances</td>
<td>Type B gas vent (Section G2427.6)</td>
</tr>
<tr>
<td>Listed appliances equipped with draft</td>
<td>Chimney (Section G2427.5)</td>
</tr>
<tr>
<td>hood</td>
<td>Single-wall metal pipe (Section G2427.7)</td>
</tr>
<tr>
<td>Appliances listed for use with Type B gas</td>
<td>Listed chimney lining system for gas venting (Section</td>
</tr>
<tr>
<td>vent</td>
<td>G2427.5.2)</td>
</tr>
<tr>
<td></td>
<td>Special gas vent listed for these appliances (Section</td>
</tr>
<tr>
<td></td>
<td>G2427.4.2)</td>
</tr>
<tr>
<td>Listed vented wall furnaces</td>
<td>Type B-W gas vent (Sections G2427.6, G2436)</td>
</tr>
<tr>
<td>Category II appliances</td>
<td>As specified or furnished by manufacturers of listed</td>
</tr>
<tr>
<td></td>
<td>appliances (Sections G2427.4.1, G2427.4.2)</td>
</tr>
<tr>
<td>Category III appliances</td>
<td>As specified or furnished by manufacturers of listed</td>
</tr>
<tr>
<td></td>
<td>appliances (Sections G2427.4.1, G2427.4.2)</td>
</tr>
<tr>
<td>Category IV appliances</td>
<td>As specified or furnished by manufacturers of listed</td>
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<tr>
<td></td>
<td>appliances (Sections G2427.4.1, G2427.4.2)</td>
</tr>
<tr>
<td>Unlisted appliances</td>
<td>Chimney (Section G2427.5)</td>
</tr>
<tr>
<td>Decorative appliances in vented fireplaces</td>
<td>Chimney</td>
</tr>
<tr>
<td>Direct-vent appliances</td>
<td>See Section G2427.2.1</td>
</tr>
<tr>
<td>Appliances with integral vent</td>
<td>See Section G2427.2.2</td>
</tr>
</tbody>
</table>

G2427.4.1 (503.4.1) Plastic piping.
Where plastic piping is used to vent an appliance, the appliance shall be listed for use with such venting materials and the appliance manufacturer’s installation instructions shall identify the specific plastic piping material.

G2427.4.1.1 (503.4.1.1) (IFGS) Plastic vent joints.
Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer’s instructions. Where a primer is required, it shall be of a contrasting color or an ultraviolet primer in accordance with Section P2906.9.1.4.

G2427.4.2 (503.4.2) Special gas vent.
Special gas vent shall be listed and installed in accordance with the special gas vent manufacturer’s instructions.

G2427.5 (503.5) Masonry, metal and factory-built chimneys.
Masonry, metal and factory-built chimneys shall comply with Sections G2427.5.1 through G2427.5.9.

G2427.5.1 (503.5.1) Factory-built chimneys.
Factory-built chimneys shall be installed in accordance with the manufacturer’s instructions. Factory-built chimneys used to vent appliances that operate at a positive vent pressure shall be listed for such application.
G2427.5.2 (503.5.3) Masonry chimneys.
Masonry chimneys shall be built and installed in accordance with NFPA 211 and shall be lined with approved clay flue lining, a listed chimney lining system or other approved material that will resist corrosion, erosion, softening or cracking from vent gases at temperatures up to 1,800°F (982°C).

Exception: Masonry chimney flues serving listed gas appliances with draft hoods, Category I appliances and other gas appliances listed for use with Type B vents shall be permitted to be lined with a chimney lining system specifically listed for use only with such appliances. The liner shall be installed in accordance with the liner manufacturer’s instructions. A permanent identifying label shall be attached at the point where the connection is to be made to the liner. The label shall read: “This chimney liner is for appliances that burn gas only. Do not connect to solid or liquid fuel-burning appliances or incinerators.”

G2427.5.3 (503.5.4) Chimney termination.
Chimneys for residential-type or low-heat appliances shall extend not less than 3 feet (914 mm) above the highest point where they pass through a roof of a building and not less than 2 feet (610 mm) higher than any portion of a building within a horizontal distance of 10 feet (3048 mm). Chimneys for medium-heat appliances shall extend not less than 10 feet (3048 mm) higher than any portion of any building within 25 feet (7620 mm). Chimneys shall extend not less than 5 feet (1524 mm) above the highest connected appliance draft hood outlet or flue collar. Decorative shrouds shall not be installed at the termination of factory-built chimneys except where such shrouds are listed and labeled for use with the specific factory-built chimney system and are installed in accordance with the manufacturer’s instructions.

G2427.5.4 (503.5.5) Size of chimneys.
The effective area of a chimney venting system serving listed appliances with draft hoods, Category I appliances, and other appliances listed for use with Type B vents shall be determined in accordance with one of the following methods:

1. The provisions of Section G2428.

2. For sizing an individual chimney venting system for a single appliance with a draft hood, the effective areas of the vent connector and chimney flue shall be not less than the area of the appliance flue collar or draft hood outlet, nor greater than seven times the draft hood outlet area.

3. For sizing a chimney venting system connected to two appliances with draft hoods, the effective area of the chimney flue shall be not less than the area of the larger draft hood outlet plus 50 percent of the area of the smaller draft hood outlet, nor greater than seven times the smallest draft hood outlet area.

4. Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods.

5. Other approved engineering methods.
G2427.5.5 (503.5.6) Inspection of chimneys.
Before replacing an existing appliance or connecting a vent connector to a chimney, the chimney passageway shall be examined to ascertain that it is clear and free of obstructions and it shall be cleaned if previously used for venting solid or liquid fuel-burning appliances or fireplaces.

G2427.5.5.1 (503.5.6.1) Chimney lining.
Chimneys shall be lined in accordance with NFPA 211.

Exception: Where an existing chimney complies with Sections G2427.5.5 through G2427.5.5.3 and its sizing is in accordance with Section G2427.5.4, its continued use shall be allowed where the appliance vented by such chimney is replaced by an appliance of similar type, input rating and efficiency.

G2427.5.5.2 (503.5.6.2) Cleanouts.
Cleanouts shall be examined to determine if they will remain tightly closed when not in use.

G2427.5.5.3 (503.5.6.3) Unsafe chimneys.
Where inspection reveals that an existing chimney is not safe for the intended application, it shall be repaired, rebuilt, lined, relined or replaced with a vent or chimney to conform to NFPA 211 and it shall be suitable for the appliances to be vented.

G2427.5.6 (503.5.7) Chimneys serving appliances burning other fuels.
Chimneys serving appliances burning other fuels shall comply with Sections G2427.5.6.1 through G2427.5.6.4.

G2427.5.6.1 (503.5.7.1) Solid fuel-burning appliances.
An appliance shall not be connected to a chimney flue serving a separate appliance designed to burn solid fuel.

G2427.5.6.2 (503.5.7.2) Liquid fuel-burning appliances.
Where one chimney flue serves gas appliances and liquid fuel-burning appliances, the appliances shall be connected through separate openings or shall be connected through a single opening where joined by a suitable fitting located as close as practical to the chimney. Where two or more openings are provided into one chimney flue, they shall be at different levels. Where the appliances are automatically controlled, they shall be equipped with safety shutoff devices.

G2427.5.6.3 (503.5.7.3) Combination gas- and solid fuel-burning appliances.
A combination gas- and solid fuel-burning appliance shall be permitted to be connected to a single chimney flue where equipped with a manual reset device to shut off gas to the main burner in the event of sustained backdraft or flue gas spillage. The chimney flue shall be sized to properly vent the appliance.

G2427.5.6.4 (503.5.7.4) Combination gas- and oil fuel-burning appliances.
A listed combination gas- and oil fuel-burning appliance shall be permitted to be connected to a single chimney flue. The chimney flue shall be sized to properly vent the appliance.
G2427.5.7 (503.5.8) Support of chimneys.
All portions of chimneys shall be supported for the design and weight of the materials employed. Factory-built chimneys shall be supported and spaced in accordance with the manufacturer’s installation instructions.

G2427.5.8 (503.5.9) Cleanouts.
Where a chimney that formerly carried flue products from liquid or solid fuel-burning appliances is used with an appliance using fuel gas, an accessible cleanout shall be provided. The cleanout shall have a tight-fitting cover and be installed so its upper edge is at least 6 inches (152 mm) below the lower edge of the lowest chimney inlet opening.

G2427.5.9 (503.5.10) Space surrounding lining or vent.
The remaining space surrounding a chimney liner, gas vent, special gas vent or plastic piping installed within a masonry chimney shall not be used to vent another appliance. The insertion of another liner or vent within the chimney as provided in this code and the liner or vent manufacturer’s instructions shall not be prohibited.

The remaining space surrounding a chimney liner, gas vent, special gas vent or plastic piping installed within a masonry, metal or factory-built chimney shall not be used to supply combustion air. Such space shall not be prohibited from supplying combustion air to direct-vent appliances designed for installation in a solid fuel-burning fireplace and installed in accordance with the manufacturer’s instructions.

G2427.6 (503.6) Gas vents.
Gas vents shall comply with Sections G2427.6.1 through G2427.6.11. (See Section G2403, Definitions.)

G2427.6.1 (503.6.1) Installation, general.
Gas vents shall be installed in accordance with the manufacturer’s instructions.

G2427.6.2 (503.6.2) Type B-W vent capacity.
A Type B-W gas vent shall have a listed capacity not less than that of the listed vented wall furnace to which it is connected.

G2427.6.3 (503.6.4) Gas vent terminations.
A gas vent shall terminate in accordance with one of the following:

1. Gas vents that are 12 inches (305 mm) or less in size and located not less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate above the roof in accordance with Figure G2427.6.3.

2. Gas vents that are over 12 inches (305 mm) in size or are located less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate not less than 2 feet (610 mm) above the highest point where they pass through the roof and not less than 2 feet (610 mm) above any portion of a building within 10 feet (3048 mm) horizontally.

3. As provided for direct-vent systems in Section G2427.2.1.

4. As provided for appliances with integral vents in Section G2427.2.2.
5. As provided for mechanical draft systems in Section G2427.3.3.
A. TERMINATION 10 FT OR LESS FROM RIDGE, WALL, OR PARAPET

B. TERMINATION MORE THAN 10 FT FROM RIDGE, WALL, OR PARAPET

2018 North Carolina Residential Code
### ROOF SLOPE

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<th>H (minimum) ft</th>
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<td>Over <strong>20/12</strong> to <strong>21/12</strong></td>
<td>8.0</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm

**FIGURE G2427.6.3 (503.6.4)**

**TERMINATION LOCATIONS FOR GAS VENTS WITH LISTED CAPS 12 INCHES OR LESS IN SIZE AT LEAST 8 FEET FROM A VERTICAL WALL**

**G2427.6.3.1 (503.6.4.1) Decorative shrouds.**
Decorative shrouds shall not be installed at the termination of gas vents except where such shrouds are listed for use with the specific gas venting system and are installed in accordance with manufacturer’s instructions.

**G2427.6.4 (503.6.5) Minimum height.**
A Type B or L gas vent shall terminate at least 5 feet (1524 mm) in vertical height above the highest connected appliance draft hood or flue collar. A Type B-W gas vent shall terminate not less than 12 feet (3658 mm) in vertical height above the bottom of the wall furnace.

**G2427.6.5 (503.6.6) Roof terminations.**
Gas vents shall extend through the roof flashing, roof jack or roof thimble and terminate with a listed cap or listed roof assembly.
G2427.6.6 (503.6.7) Forced air inlets.  
Gas vents shall terminate not less than 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm).

G2427.6.7 (503.6.8) Exterior wall penetrations.  
A gas vent extending through an exterior wall shall not terminate adjacent to the wall or below eaves or parapets, except as provided in Sections G2427.2.1 and G2427.3.3.

G2427.6.8 (503.6.9) Size of gas vents.  
Venting systems shall be sized and constructed in accordance with Section G2428 or other approved engineering methods and the gas vent and appliance manufacturer’s installation instructions.

G2427.6.8.1 (503.6.9.1) Category I appliances.  
The sizing of natural draft venting systems serving one or more listed appliances equipped with a draft hood or appliances listed for use with Type B gas vent, installed in a single story of a building, shall be in accordance with one of the following methods:

1. The provisions of Section G2428.

2. For sizing an individual gas vent for a single, draft-hood-equipped appliance, the effective area of the vent connector and the gas vent shall be not less than the area of the appliance draft hood outlet, nor greater than seven times the draft hood outlet area.

3. For sizing a gas vent connected to two appliances with draft hoods, the effective area of the vent shall be not less than the area of the larger draft hood outlet plus 50 percent of the area of the smaller draft hood outlet, nor greater than seven times the smaller draft hood outlet area.

4. Approved engineering practices.

G2427.6.8.2 (503.6.9.2) Vent offsets.  
Type B and L vents sized in accordance with Item 2 or 3 of Section G2427.6.8.1 shall extend in a generally vertical direction with offsets not exceeding 45 degrees (0.79 rad), except that a vent system having not more than one 60-degree (1.04 rad) offset shall be permitted. Any angle greater than 45 degrees (0.79 rad) from the vertical is considered horizontal. The total horizontal distance of a vent plus the horizontal vent connector serving draft hood-equipped appliances shall be not greater than 75 percent of the vertical height of the vent.

G2427.6.8.3 (503.6.9.3) Category II, III and IV appliances.  
The sizing of gas vents for Category II, III and IV appliances shall be in accordance with the appliance manufacturer's instructions. The sizing of plastic pipe that is specified by the appliance manufacturer as a venting material for Category II, III and IV appliances, shall be in accordance with the appliance manufacturer's instructions.

G2427.6.8.4 (503.6.9.4) Mechanical draft.  
Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods.
G2427.6.9 (503.6.11) Support of gas vents.
Gas vents shall be supported and spaced in accordance with the manufacturer's installation instructions.

G2427.6.10 (503.6.12) Marking.
In those localities where solid and liquid fuels are used extensively, gas vents shall be permanently identified by a label attached to the wall or ceiling at a point where the vent connector enters the gas vent. The determination of where such localities exist shall be made by the code official. The label shall read:

“This gas vent is for appliances that burn gas. Do not connect to solid or liquid fuel-burning appliances or incinerators.”

G2427.6.11 (503.6.13) Fastener penetrations.
Screws, rivets and other fasteners shall not penetrate the inner wall of double-wall gas vents, except at the transition from an appliance draft hood outlet, a flue collar or a single-wall metal connector to a double-wall vent.

G2427.7 (503.7) Single-wall metal pipe.
Single-wall metal pipe vents shall comply with Sections G2427.7.1 through G2427.7.13.

G2427.7.1 (503.7.1) Construction.
Single-wall metal pipe shall be constructed of galvanized sheet steel not less than 0.0304 inch (0.7 mm) thick, or other approved, noncombustible, corrosion-resistant material.

G2427.7.2 (503.7.2) Cold climate.
Uninsulated single-wall metal pipe shall not be used outdoors for venting appliances in regions where the 99-percent winter design temperature is below 32°F (0°C).

G2427.7.3 (503.7.3) Termination.
Single-wall metal pipe shall terminate at least 5 feet (1524 mm) in vertical height above the highest connected appliance draft hood outlet or flue collar. Single-wall metal pipe shall extend at least 2 feet (610 mm) above the highest point where it passes through a roof of a building and at least 2 feet (610 mm) higher than any portion of a building within a horizontal distance of 10 feet (3048 mm). An approved cap or roof assembly shall be attached to the terminus of a single-wall metal pipe.

G2427.7.4 (503.7.4) Limitations of use.
Single-wall metal pipe shall be used only for runs directly from the space in which the appliance is located through the roof or exterior wall to the outdoor atmosphere.

G2427.7.5 (503.7.5) Roof penetrations.
A pipe passing through a roof shall extend without interruption through the roof flashing, roof jack or roof thimble. Where a single-wall metal pipe passes through a roof constructed of combustible material, a noncombustible, nonventilating thimble shall be used at the point of passage. The thimble shall extend not less than 18 inches (457 mm) above and 6 inches (152 mm) below the roof with the annular space open at the bottom and closed only at the top. The thimble shall be sized in accordance with Section G2427.7.7.

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**G2427.7.6 (503.7.6) Installation.**
Single-wall metal pipe shall not originate in any unoccupied attic or concealed space and shall not pass through any attic, inside wall, concealed space, or floor. The installation of a single-wall metal pipe through an exterior combustible wall shall comply with Section G2427.7.7.

**G2427.7.7 (503.7.7) Single-wall penetrations of combustible walls.**
Single-wall metal pipe shall not pass through a combustible exterior wall unless guarded at the point of passage by a ventilated metal thimble not smaller than the following:

1. For listed appliances with draft hoods and appliances listed for use with Type B gas vents, the thimble shall be not less than 4 inches (102 mm) larger in diameter than the metal pipe. Where there is a run of not less than 6 feet (1829 mm) of metal pipe in the open between the draft hood outlet and the thimble, the thimble shall be permitted to be not less than 2 inches (51 mm) larger in diameter than the metal pipe.

2. For unlisted appliances having draft hoods, the thimble shall be not less than 6 inches (152 mm) larger in diameter than the metal pipe.

3. For residential and low-heat appliances, the thimble shall be not less than 12 inches (305 mm) larger in diameter than the metal pipe.

**Exception:** In lieu of thimble protection, all combustible material in the wall shall be removed a sufficient distance from the metal pipe to provide the specified clearance from such metal pipe to combustible material. Any material used to close up such opening shall be noncombustible.

**G2427.7.8 (503.7.8) Clearances.**
Minimum clearances from single-wall metal pipe to combustible material shall be in accordance with Table G2427.10.5. The clearance from single-wall metal pipe to combustible material shall be permitted to be reduced where the combustible material is protected as specified for vent connectors in Table G2409.2.

**G2427.7.9 (503.7.9) Size of single-wall metal pipe.**
A venting system constructed of single-wall metal pipe shall be sized in accordance with one of the following methods and the appliance manufacturer’s instructions:

1. For a draft-hood-equipped appliance, in accordance with Section G2428.

2. For a venting system for a single appliance with a draft hood, the areas of the connector and the pipe each shall be not less than the area of the appliance flue collar or draft hood outlet, whichever is smaller. The vent area shall not be greater than seven times the draft hood outlet area.

3. Other approved engineering methods.

**G2427.7.10 (503.7.10) Pipe geometry.**
Any shaped single-wall metal pipe shall be permitted to be used, provided that its equivalent
effective area is equal to the effective area of the round pipe for which it is substituted, and provided that the minimum internal dimension of the pipe is not less than 2 inches (51 mm).

**G2427.7.11 (503.7.11) Termination capacity.**
The vent cap or a roof assembly shall have a venting capacity of not less than that of the pipe to which it is attached.

**G2427.7.12 (503.7.12) Support of single-wall metal pipe.**
All portions of single-wall metal pipe shall be supported for the design and weight of the material employed.

**G2427.7.13 (503.7.13) Marking.**
Single-wall metal pipe shall comply with the marking provisions of Section G2427.6.10.

**G2427.8 (503.8) Venting system termination location.**
The location of venting system terminations shall comply with the following (see Appendix C):

1. A mechanical *draft* venting system shall terminate not less than 3 feet (914 mm) above any forced-air inlet located within 10 feet (3048 mm).

**Exceptions:**

1. This provision shall not apply to the *combustion air* intake of a direct-vent *appliance*.

2. This provision shall not apply to the separation of the integral outdoor air inlet and flue gas discharge of listed outdoor *appliances*.

2. A mechanical *draft* venting system, excluding *direct-vent appliances*, shall terminate not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from, or 1 foot (305 mm) above any door, operable window or gravity air inlet into any building. The bottom of the vent terminal shall be located not less than 12 inches (305 mm) above finished ground level.

3. The vent terminal of a *direct-vent appliance* with an input of 10,000 *Btu* per hour (3 kW) or less shall be located not less than 6 inches (152 mm) from any air opening into a building. Such an *appliance* with an input over 10,000 *Btu* per hour (3 kW) but not over 50,000 *Btu* per hour (14.7 kW) shall be installed with a 9-inch (230 mm) vent termination *clearance*, and an *appliance* with an input over 50,000 *Btu* per hour (14.7 kW) shall have not less than a 12-inch (305 mm) vent termination *clearance*. The bottom of the vent terminal and the air intake shall be located not less than 12 inches (305 mm) above grade finished ground level.

4. Through-the-wall vents for Category II and IV *appliances* and noncategorized condensing *appliances* shall not terminate over public walkways or over an area where *condensate* or vapor could create a nuisance or hazard or could be detrimental to the operation of *regulators*, *relief valves* or other *equipment*. Where local experience indicates that *condensate* is a problem with Category I and III *appliances*, this provision shall also apply. Drains for *condensate* shall be installed in accordance with the appliance and vent manufacturer’s installation instructions.
5. Vent systems for Category IV appliances that terminate through an outside wall of a building and discharge flue gases perpendicular to the adjacent wall shall be located not less than 10 feet (3048 mm) horizontally from an operable opening in an adjacent building. This requirement shall not apply to vent terminals that are 2 feet (607 mm) or more above or 25 feet (7620 mm) or more below operable openings.

   **Exception:** If manufacturer’s installation instructions allow closer clearances, those instructions can be followed.

6. Externally mounted appliances. Vent systems for externally wall-mounted appliances shall be located as required by the manufacturer’s installation instructions.

**G2427.9 (503.9) Condensation drainage.**
Provisions shall be made to collect and dispose of condensate from venting systems serving Category II and IV appliances and noncategorized condensing appliances in accordance with Section G2427.8, Item 4. Where local experience indicates that condensation is a problem, provisions shall be made to drain off and dispose of condensate from venting systems serving Category I and III appliances in accordance with Section G2427.8, Item 4.

**G2427.10 (503.10) Vent connectors for Category I appliances.**
Vent connectors for Category I appliances shall comply with Sections G2427.10.1 through G2427.10.13.

**G2427.10.1 (503.10.1) Where required.**
A vent connector shall be used to connect an appliance to a gas vent, chimney or single-wall metal pipe, except where the gas vent, chimney or single-wall metal pipe is directly connected to the appliance.

**G2427.10.2 (503.10.2) Materials.**
Vent connectors shall be constructed in accordance with Sections G2427.10.2.1 through G2427.10.2.4.

**G2427.10.2.1 (503.10.2.1) General.**
A vent connector shall be made of noncombustible corrosion-resistant material capable of withstanding the vent gas temperature produced by the appliance and of sufficient thickness to withstand physical damage.

**G2427.10.2.2 (503.10.2.2) Vent connectors located in unconditioned areas.**
Where the vent connector used for an appliance having a draft hood or a Category I appliance is located in or passes through attics, crawl spaces or other unconditioned spaces, that portion of the vent connector shall be listed Type B, Type L or listed vent material having equivalent insulation properties.

   **Exception:** Single-wall metal pipe located within the exterior walls of the building in areas having a local 99-percent winter design temperature of 5°F (-15°C) or higher shall be permitted to be used in unconditioned spaces other than attics and crawl spaces.

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G2427.10.2.3 (503.10.2.3) Residential-type appliance connectors.
Where vent connectors for residential-type appliances are not installed in attics or other unconditioned spaces, connectors for listed appliances having draft hoods, appliances having draft hoods and equipped with listed conversion burners and Category I appliances shall be one of the following:

1. Type B or L vent material.
2. Galvanized sheet steel not less than 0.018 inch (0.46 mm) thick.
3. Aluminum (1100 or 3003 alloy or equivalent) sheet not less than 0.027 inch (0.69 mm) thick.
4. Stainless steel sheet not less than 0.012 inch (0.31 mm) thick.
5. Smooth interior wall metal pipe having resistance to heat and corrosion equal to or greater than that of Item 2, 3 or 4.
6. A listed vent connector.

*Vent connectors* shall not be covered with insulation.

**Exception:** Listed insulated *vent connectors* shall be installed in accordance with the manufacturer’s instructions.

G2427.10.2.4 (503.10.2.4) Low-heat appliance.
A vent connector for a nonresidential, low-heat appliance shall be a factory-built chimney section or steel pipe having resistance to heat and corrosion equivalent to that for the appropriate galvanized pipe as specified in Table G2427.10.2.4. Factory-built chimney sections shall be joined together in accordance with the chimney manufacturer’s instructions.

**TABLE G2427.10.2.4 (503.10.2.4)**
**MINIMUM THICKNESS FOR GALVANIZED STEEL VENT CONNECTORS FOR LOW-HEAT APPLIANCES**

<table>
<thead>
<tr>
<th>DIAMETER OF CONNECTOR (inches)</th>
<th>MINIMUM THICKNESS (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6</td>
<td>0.019</td>
</tr>
<tr>
<td>6 to less than 10</td>
<td>0.023</td>
</tr>
<tr>
<td>10 to 12 inclusive</td>
<td>0.029</td>
</tr>
<tr>
<td>14 to 16 inclusive</td>
<td>0.034</td>
</tr>
<tr>
<td>Over 16</td>
<td>0.056</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

G2427.10.3 (503.10.3) Size of vent connector.
*Vent connectors* shall be sized in accordance with Sections G2427.10.3.1 through G2427.3.5.
G2427.10.3.1 (503.10.3.1) Single draft hood and fan-assisted.
A vent connector for an appliance with a single draft hood or for a Category I fan-assisted combustion system appliance shall be sized and installed in accordance with Section G2428 or other approved engineering methods.

G2427.10.3.2 (503.10.3.2) Multiple draft hood.
For a single appliance having more than one draft hood outlet or flue collar, the manifold shall be constructed according to the instructions of the appliance manufacturer. Where there are no instructions, the manifold shall be designed and constructed in accordance with approved engineering practices. As an alternate method, the effective area of the manifold shall equal the combined area of the flue collars or draft hood outlets and the vent connectors shall have a minimum 1-foot (305 mm) rise.

G2427.10.3.3 (503.10.3.3) Multiple appliances.
Where two or more appliances are connected to a common vent or chimney, each vent connector shall be sized in accordance with Section G2428 or other approved engineering methods.

As an alternative method applicable only when all of the appliances are draft hood equipped, each vent connector shall have an effective area not less than the area of the draft hood outlet of the appliance to which it is connected.

G2427.10.3.4 (503.10.3.4) Common connector/ manifold.
Where two or more appliances are vented through a common vent connector or vent manifold, the common vent connector or vent manifold shall be located at the highest level consistent with available headroom and the required clearance to combustible materials and shall be sized in accordance with Section G2428 or other approved engineering methods.

As an alternate method applicable only where there are two draft hood-equipped appliances, the effective area of the common vent connector or vent manifold and all junction fittings shall be not less than the area of the larger vent connector plus 50 percent of the area of the smaller flue collar outlet.

G2427.10.3.5 (503.10.3.5) Size increase.
Where the size of a vent connector is increased to overcome installation limitations and obtain connector capacity equal to the appliance input, the size increase shall be made at the appliance draft hood outlet.

G2427.10.4 (503.10.4) Two or more appliances connected to a single vent or chimney.
Where two or more vent connectors enter a common gas vent, chimney flue, or single-wall metal pipe, the smaller connector shall enter at the highest level consistent with the available headroom or clearance to combustible material. Vent connectors serving Category I appliances shall not be connected to any portion of a mechanical draft system operating under positive static pressure, such as those serving Category III or IV appliances.

G2427.10.4.1 (503.10.4.1) Two or more openings.
Where two or more openings are provided into one chimney flue or vent, the openings
shall be at different levels, or the connectors shall be attached to the vertical portion of
the chimney or vent at an angle of 45 degrees (0.79 rad) or less relative to the vertical.

G2427.10.5 (503.10.5) Clearance.
Minimum clearances from vent connectors to combustible material shall be in accordance
with Table G2427.10.5.

Exception: The clearance between a vent connector and combustible material shall be
permitted to be reduced where the combustible material is protected as specified for
vent connectors in Table G2409.2.

TABLE G2427.10.5 (503.10.5)\textsuperscript{a}
CLEARANCES FOR CONNECTORS

<table>
<thead>
<tr>
<th>APPLIANCE</th>
<th>MINIMUM DISTANCE FROM COMBUSTIBLE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Listed Type B gas vent material</td>
</tr>
<tr>
<td>Listed appliances with draft hoods and appliances listed for use with Type B gas vents</td>
<td>As listed</td>
</tr>
<tr>
<td>Residential boilers and furnaces with listed gas conversion burner and with draft hood</td>
<td>6 inches</td>
</tr>
<tr>
<td>Residential appliances listed for use with Type L vents</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Listed gas-fired toilets</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Unlisted residential appliances with draft hood</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Residential and low-heat appliances other than above</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Medium-heat appliances</td>
<td>Not permitted</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
\textsuperscript{a} These clearances shall apply unless the manufacturer’s installation instructions for a listed appliance or connector specify different clearances, in which case the listed clearances shall apply.

G2427.10.6 (503.10.6) Joints.
Joints between sections of connector piping and connections to flue collars and draft hood outlets shall be fastened by one of the following methods:

1. Sheet metal screws.

2. Vent connectors of listed vent material assembled and connected to flue collars or draft hood outlets in accordance with the manufacturers’ instructions.

3. Other approved means.
**G2427.10.7 (503.10.7) Slope.**
A vent connector shall be installed without dips or sags and shall slope upward toward the vent or chimney at least $\frac{1}{4}$ inch per foot (21 mm/m).

*Exception:* Vent connectors attached to a mechanical draft system installed in accordance with the appliance and draft system manufacturers’ instructions.

**G2427.10.8 (503.10.8) Length of vent connector.**
The maximum horizontal length of a single-wall connector shall be 75 percent of the height of the chimney or vent except for engineered systems. The maximum horizontal length of a Type B double-wall connector shall be 100 percent of the height of the chimney or vent except for engineered systems.

**G2427.10.9 (503.10.9) Support.**
A vent connector shall be supported for the design and weight of the material employed to maintain clearances and prevent physical damage and separation of joints.

**G2427.10.10 (503.10.10) Chimney connection.**
Where entering a flue in a masonry or metal chimney, the vent connector shall be installed above the extreme bottom to avoid stoppage. Where a thimble or slip joint is used to facilitate removal of the connector, the connector shall be firmly attached to or inserted into the thimble or slip joint to prevent the connector from falling out. Means shall be employed to prevent the connector from entering so far as to restrict the space between its end and the opposite wall of the chimney flue (see Section G2425.9).

**G2427.10.11 (503.10.11) Inspection.**
The entire length of a vent connector shall be provided with ready access for inspection, cleaning and replacement.

**G2427.10.12 (503.10.12) Fireplaces.**
A vent connector shall not be connected to a chimney flue serving a fireplace unless the fireplace flue opening is permanently sealed.

**G2427.10.13 (503.10.13) Passage through ceilings, floors or walls.**
Single-wall metal pipe connectors shall not pass through any wall, floor or ceiling except as permitted by Section G2427.7.4.

**G2427.11 (503.11) Vent connectors for Category II, III and IV appliances.**
Vent connectors for Category II, III and IV appliances shall be as specified for the venting systems in accordance with Section G2427.4.

**G2427.12 (503.12) Draft hoods and draft controls.**
The installation of draft hoods and draft controls shall comply with Sections G2427.12.1 through G2427.12.7.

**G2427.12.1 (503.12.1) Appliances requiring draft hoods.**
Vented appliances shall be installed with draft hoods.
Exception: Dual oven-type combination ranges; direct-vent appliances; fan-assisted combustion system appliances; appliances requiring chimney draft for operation; single firebox boilers equipped with conversion burners with inputs greater than 400,000 Btu per hour (117 kW); appliances equipped with blast, power or pressure burners that are not listed for use with draft hoods; and appliances designed for forced venting.

G2427.12.2 (503.12.2) Installation.
A draft hood supplied with or forming a part of a listed vented appliance shall be installed without alteration, exactly as furnished and specified by the appliance manufacturer.

G2427.12.2.1 (503.12.2.1) Draft hood required.
If a draft hood is not supplied by the appliance manufacturer where one is required, a draft hood shall be installed, shall be of a listed or approved type and, in the absence of other instructions, shall be of the same size as the appliance flue collar. Where a draft hood is required with a conversion burner, it shall be of a listed or approved type.

G2427.12.2.2 (503.12.2.2) Special design draft hood.
Where it is determined that a draft hood of special design is needed or preferable for a particular installation, the installation shall be in accordance with the recommendations of the appliance manufacturer and shall be approved.

G2427.12.3 (503.12.3) Draft control devices.
Where a draft control device is part of the appliance or is supplied by the appliance manufacturer, it shall be installed in accordance with the manufacturer’s instructions. In the absence of manufacturer’s instructions, the device shall be attached to the flue collar of the appliance or as near to the appliance as practical.

G2427.12.4 (503.12.4) Additional devices.
Appliances requiring a controlled chimney draft shall be permitted to be equipped with a listed double-acting barometric-draft regulator installed and adjusted in accordance with the manufacturer’s instructions.

G2427.12.5 (503.12.5) Location.
Draft hoods and barometric draft regulators shall be installed in the same room or enclosure as the appliance in such a manner as to prevent any difference in pressure between the hood or regulator and the combustion air supply.

G2427.12.6 (503.12.6) Positioning.
Draft hoods and draft regulators shall be installed in the position for which they were designed with reference to the horizontal and vertical planes and shall be located so that the relief opening is not obstructed by any part of the appliance or adjacent construction. The appliance and its draft hood shall be located so that the relief opening is accessible for checking vent operation.

G2427.12.7 (503.12.7) Clearance.
A draft hood shall be located so its relief opening is not less than 6 inches (152 mm) from any surface except that of the appliance it serves and the venting system to which the draft hood is connected. Where a greater or lesser clearance is indicated on the appliance label, the clearance shall be not less than that specified on the label. Such clearances shall not be reduced.
G2427.13 (503.13) Manually operated dampers.
A manually operated damper shall not be placed in the vent connector for any appliance. Fixed baffles shall not be classified as manually operated dampers.

An automatically operated vent damper shall be of a listed type.

G2427.15 (503.15) Obstructions.
Devices that retard the flow of vent gases shall not be installed in a vent connector, chimney, or vent. The following shall not be considered as obstructions:

1. Draft regulators and safety controls specifically listed for installation in venting systems and installed in accordance with the manufacturer's instructions.

2. Approved draft regulators and safety controls that are designed and installed in accordance with approved engineering methods.

3. Listed heat reclaimers and automatically operated vent dampers installed in accordance with the manufacturer's instructions.

4. Approved economizers, heat reclaimers and recuperators installed in venting systems of appliances not required to be equipped with draft hoods, provided that the appliance manufacturer's instructions cover the installation of such a device in the venting system and performance in accordance with Sections G2427.3 and G2427.3.1 is obtained.

5. Vent dampers serving listed appliances installed in accordance with Sections G2428.2.1 and G2428.3.1 or other approved engineering methods.

G2427.16 (503.16) (IFGS) Outside wall penetrations.
Where vents, including those for direct-vent appliances, penetrate outside walls of buildings, the annular spaces around such penetrations shall be permanently sealed using approved materials to prevent entry of combustion products into the building.

SECTION G2428 (504)
SIZING OF CATEGORY I APPLIANCE VENTING SYSTEMS

G2428.1 (504.1) Definitions.
The following definitions apply to the tables in this section.

APPLIANCE CATEGORIZED VENT DIAMETER/AREA. The minimum vent area/diameter permissible for Category I appliances to maintain a nonpositive vent static pressure when tested in accordance with nationally recognized standards.

FAN-ASSISTED COMBUSTION SYSTEM. An appliance equipped with an integral mechanical means to either draw or force products of combustion through the combustion chamber or heat exchanger.
**FAN Min.** The minimum input rating of a Category I fan-assisted *appliance* attached to a vent or connector.

**FAN Max.** The maximum input rating of a Category I fan-assisted *appliance* attached to a vent or connector.

**NAT Max.** The maximum input rating of a Category I draft-hood-equipped *appliance* attached to a vent or connector.

**FAN + FAN.** The maximum combined *appliance* input rating of two or more Category I fan-assisted *appliances* attached to the common vent.

**FAN + NAT.** The maximum combined *appliance* input rating of one or more Category I fan-assisted *appliances* and one or more Category I draft-hood-equipped *appliances* attached to the common vent.

**NA.** Vent configuration is not permitted due to potential for *condensate* formation or pressurization of the venting system, or not applicable due to physical or geometric restraints.

**NAT + NAT.** The maximum combined *appliance* input rating of two or more Category I draft-hood-equipped *appliances* attached to the common vent.

**G2428.2 (504.2) Application of single appliance vent Tables G2428.2(1) and G2428.2(2).** The application of Tables G2428.2(1) and G2428.2(2) shall be subject to the requirements of Sections G2428.2.1 through G2428.2.17.

**TABLE G2428.2(1) [504.2(1)]
TYPE B DOUBLE-WALL GAS VENT**

<table>
<thead>
<tr>
<th>Number of Appliances</th>
<th>Single</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appliance Type</strong></td>
<td>Category I</td>
</tr>
<tr>
<td><strong>Appliance Vent Connection</strong></td>
<td>Connected directly to vent</td>
</tr>
</tbody>
</table>
TABLE G2428.2(1) [504.2(1)]—continued
TYPE B DOUBLE-WALL GAS VENT

<table>
<thead>
<tr>
<th>HEIGHT (H) (Foot)</th>
<th>LATERAL (L) (Foot)</th>
<th>VENT DIAMETER—(D) inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Min</td>
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Number of Appliances | Single |
Appliance Type       | Category I |
Appliance Vent Connection | Connected directly to vent |
### TABLE G2482.2(2) [504.2(2)]
#### TYPE B DOUBLE-WALL GAS VENT

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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.
### TABLE G2428.2(2) [504.2(2)]—continued

**TYPE B DOUBLE-WALL GAS VENT**

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<th>LATERAL (L) (feet)</th>
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(continued)

**Number of Appliances** | Single
---|---
**Appliance Type** | Category I
**Appliance Vent Connection** | Single-wall metal connector

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2018 North Carolina Residential Code


**Table: Vent Diameter**

<table>
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<tr>
<th>HEIGHT (H) (feet)</th>
<th>LATERAL (L) (feet)</th>
<th>VENT DIAMETER—(D) inches</th>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

**G2428.2.1 (504.2.1) Vent obstructions.**

These venting tables shall not be used where obstructions, as described in Section G2427.15, are installed in the venting system. The installation of vents serving listed *appliances* with vent dampers shall be in accordance with the *appliance* manufacturer’s instructions or in accordance with the following:

1. The maximum capacity of the vent system shall be determined using the “NAT Max” column.

2. The minimum capacity shall be determined as if the *appliance* were a fan-assisted *appliance*, using the “FAN Min” column to determine the minimum capacity of the vent system. Where the corresponding “FAN Min” is “NA,” the vent configuration shall not be permitted and an alternative venting configuration shall be utilized.

**G2428.2.2 (504.2.2) Minimum size.**

Where the vent size determined from the tables is smaller than the *appliance draft hood* outlet or *flue collar*, the smaller size shall be permitted to be used provided all of the following requirements are met:

1. The total vent height (H) is at least 10 feet (3048 mm).

2. Vents for *appliance draft hood* outlets or *flue collars* 12 inches (305 mm) in diameter or smaller are not reduced more than one table size.
3. Vents for appliance draft hood outlets or flue collars larger than 12 inches (305 mm) in diameter are not reduced more than two table sizes.

4. The maximum capacity listed in the tables for a fan-assisted appliance is reduced by 10 percent (0.90x maximum table capacity).

5. The draft hood outlet is greater than 4 inches (102 mm) in diameter. Do not connect a 3-inch-diameter (76 mm) vent to a 4-inch-diameter (102 mm) draft hood outlet. This provision shall not apply to fan-assisted appliances.

G2428.2.3 (504.2.3) Vent offsets.
Single-appliance venting configurations with zero (0) lateral lengths in Tables G2428.2(1) and G2428.2(2) shall not have elbows in the venting system. Single-appliance venting configurations with lateral lengths include two 90-degree (1.57 rad) elbows. For each additional elbow up to and including 45 degrees (0.79 rad), the maximum capacity listed in the venting tables shall be reduced by 5 percent. For each additional elbow greater than 45 degrees (0.79 rad) up to and including 90 degrees (1.57 rad), the maximum capacity listed in the venting tables shall be reduced by 10 percent. Where multiple offsets occur in a vent, the total lateral length of all offsets combined shall not exceed that specified in Tables G2428.2(1) and G2428.2(2).

G2428.2.4 (504.2.4) Zero lateral.
Zero (0) lateral (L) shall apply only to a straight vertical vent attached to a top outlet draft hood or flue collar.

G2428.2.5 (504.2.5) High-altitude installations.
Sealevel input ratings shall be used when determining maximum capacity for high-altitude installation. Actual input, derated for altitude, shall be used for determining minimum capacity for high-altitude installation.

G2428.2.6 (504.2.6) Multiple input rate appliances.
For appliances with more than one input rate, the minimum vent capacity (FAN Min) determined from the tables shall be less than the lowest appliance input rating, and the maximum vent capacity (FAN Max/NAT Max) determined from the tables shall be greater than the highest appliance rating input.

G2428.2.7 (504.2.7) Liner system sizing and connections.
Listed corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table G2428.2(1) or G2428.2(2) for Type B vents with the maximum capacity reduced by 20 percent (0.80 x maximum capacity) and the minimum capacity as shown in Table G2428.2(1) or G2428.2(2). Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with Section G2428.2.3. The 20-percent reduction for corrugated metallic chimney liner systems includes an allowance for one long-radius 90-degree (1.57 rad) turn at the bottom of the liner.

Connections between chimney liners and listed double-wall connectors shall be made with listed adapters designed for such purpose.

G2428.2.8 (504.2.8) Vent area and diameter.
Where the vertical vent has a larger diameter than the vent connector, the vertical vent
diameter shall be used to determine the minimum vent capacity, and the connector diameter shall be used to determine the maximum vent capacity. The flow area of the vertical vent shall not exceed seven times the flow area of the listed appliance categorized vent area, flue collar area, or draft hood outlet area unless designed in accordance with approved engineering methods.

G2428.2.9 (504.2.9) Chimney and vent locations.
Tables G2428.2(1) and G2428.2(2) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 feet (1524 mm) higher than required by Figure G2427.6.3 and where vents terminate in accordance with Section G2427.6.3, Item 2, the outdoor portion of the vent shall be enclosed as required by this section for vents not considered to be exposed to the outdoors or such venting system shall be engineered. A Type B vent shall not be considered to be exposed to the outdoors where it passes through an unventilated enclosure or chase insulated to a value of not less than R8.

G2428.2.10 (504.2.10) Corrugated vent connector size.
Corrugated vent connectors shall be not smaller than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter.

G2428.2.11 (504.2.11) Vent connector size limitation.
Vent connectors shall not be increased in size more than two sizes greater than the listed appliance categorized vent diameter, flue collar diameter or draft hood outlet diameter.

G2428.2.12 (504.2.12) Component commingling.
In a single run of vent or vent connector, different diameters and types of vent and connector components shall be permitted to be used, provided that all such sizes and types are permitted by the tables.

G2428.2.13 (504.2.13) Draft hood conversion accessories.
Draft hood conversion accessories for use with masonry chimneys venting listed Category I fan-assisted appliances shall be listed and installed in accordance with the manufacturer’s instructions for such listed accessories.

G2428.2.14 (504.2.14) Table interpolation.
Interpolation shall be permitted in calculating capacities for vent dimensions that fall between the table entries.

G2428.2.15 (504.2.15) Extrapolation prohibited.
Extrapolation beyond the table entries shall not be permitted.

G2428.2.16 (504.2.16) Engineering calculations.
For vent heights less than 6 feet (1829 mm) and greater than shown in the tables, engineering methods shall be used to calculate vent capacities.

G2428.2.17 (504.2.17) Height entries.
Where the actual height of a vent falls between entries in the height column of the applicable table in Tables G2428.2(1) and G2428.2(2), either interpolation shall be used or the lower
Appliance input rating shown in the table entries shall be used for FAN Max and NAT Max column values and the higher appliance input rating shall be used for the FAN MIN column values.

G2428.3 (504.3) Application of multiple appliance vent Tables G2428.3(1) through G2428.3(4).

The application of Tables G2428.3(1) through G2428.3(4) shall be subject to the requirements of Sections G2428.3.1 through G2428.3.23.

**TABLE G2428.3(1) [504.3(1)]**

**TYPE B DOUBLE-WALL VENT**

<table>
<thead>
<tr>
<th>Number of Appliances</th>
<th>Two or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliances Type</td>
<td>Category I</td>
</tr>
<tr>
<td>Appliances Vent Connection</td>
<td>Single-wall metal connector</td>
</tr>
</tbody>
</table>

### VENT CONNECTOR CAPACITY

<table>
<thead>
<tr>
<th>VENT HEIGHT (feet)</th>
<th>CONNECTOR RIDGE (feet)</th>
<th>TYPE B DOUBLE-WALL VENT AND CONNECTOR DIAMETER—(2) inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
<td>FAN</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
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<td>4</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

### COMMON VENT CAPACITY

<table>
<thead>
<tr>
<th>VENT HEIGHT (feet)</th>
<th>TYPE B DOUBLE-WALL COMMON VENT DIAMETER—(2) inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>93</td>
</tr>
<tr>
<td>8</td>
<td>101</td>
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<tr>
<td>10</td>
<td>110</td>
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<tr>
<td>12</td>
<td>129</td>
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<tr>
<td>14</td>
<td>156</td>
</tr>
<tr>
<td>16</td>
<td>183</td>
</tr>
<tr>
<td>18</td>
<td>210</td>
</tr>
<tr>
<td>20</td>
<td>237</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.
## TABLE G2428.3(2) [504.3(2)]

### TYPE B DOUBLE-WALL VENT

<table>
<thead>
<tr>
<th>VENT HEIGHT (H) (feet)</th>
<th>CONNECTOR RISE (R) (feet)</th>
<th>SINGLE-WALL METAL VENT CONNECTOR DIAMETER—(D) inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FAN</td>
<td>NAT</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
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<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### COMMON VENT CAPACITY

<table>
<thead>
<tr>
<th>VENT HEIGHT (H) (feet)</th>
<th>TYPE B DOUBLE-WALL COMMON VENT DIAMETER—(D) inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FAN + FAN</td>
</tr>
<tr>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

## TABLE G2428.3(3) [504.3(3)]

### MASONRY CHIMNEY

<table>
<thead>
<tr>
<th>Number of Appliances</th>
<th>Two or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliances Type</td>
<td>Category I</td>
</tr>
<tr>
<td>Appliances Vent Connection</td>
<td>Type B double-wall connector</td>
</tr>
</tbody>
</table>
### VENT CONNECTOR CAPACITY

<table>
<thead>
<tr>
<th>VENT HEIGHT (ft)</th>
<th>CONNECTOR RISE (ft)</th>
<th>TYPE C DOUBLE-WALL VENT CONNECTOR DIAMETER—(D) inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>8</td>
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</tr>
<tr>
<td>20</td>
<td>26</td>
<td>23</td>
</tr>
</tbody>
</table>

### COMMON VENT CAPACITY

<table>
<thead>
<tr>
<th>VENT HEIGHT (ft)</th>
<th>MINIMUM INTERNAL AREA OF MASONRY CHIMNEY FLUE (square inches)</th>
<th>COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTUH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>12</td>
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<tr>
<td>50</td>
<td>92</td>
<td>38</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm², 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

### TABLE G2428.3(4) [504.3(4)]

#### MASONRY CHIMNEY

<table>
<thead>
<tr>
<th>Number of Appliances</th>
<th>Two or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliances Type</td>
<td>Category I</td>
</tr>
<tr>
<td>Appliances Vent Connection</td>
<td>Single-wall connector</td>
</tr>
</tbody>
</table>
G2428.3.1 (504.3.1) Vent obstructions.
These venting tables shall not be used where obstructions, as described in Section G2427.15, are installed in the venting system. The installation of vents serving listed appliances with vent dampers shall be in accordance with the appliance manufacturer’s instructions or in accordance with the following:

1. The maximum capacity of the vent connector shall be determined using the NAT Max column.

2. The maximum capacity of the vertical vent or chimney shall be determined using the FAN+ NAT column when the second appliance is a fan-assisted appliance, or the NAT+ NAT column when the second appliance is equipped with a draft hood.

3. The minimum capacity shall be determined as if the appliance were a fan-assisted appliance.

3.1. The minimum capacity of the vent connector shall be determined using the FAN Min column.
3.2. The FAN+FAN column shall be used when the second appliance is a fan-assisted appliance, and the FAN+NAT column shall be used when the second appliance is equipped with a draft hood, to determine whether the vertical vent or chimney configuration is not permitted (NA). Where the vent configuration is NA, the vent configuration shall not be permitted and an alternative venting configuration shall be utilized.

G2428.3.2 (504.3.2) Connector length limit.
The vent connector shall be routed to the vent utilizing the shortest possible route. Except as provided in Section G2428.3.3, the maximum vent connector horizontal length shall be $1\frac{1}{2}$ feet for each inch (18 mm per mm) of connector diameter as shown in Table G2428.3.2.

<table>
<thead>
<tr>
<th>CONNECTOR DIAMETER (inches)</th>
<th>CONNECTOR MAXIMUM HORIZONTAL LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>$4\frac{1}{2}$</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>$7\frac{1}{2}$</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>$10\frac{1}{2}$</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>$13\frac{1}{2}$</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

G2428.3.3 (504.3.3) Connectors with longer lengths.
Connectors with longer horizontal lengths than those listed in Section G2428.3.2 are permitted under the following conditions:

1. The maximum capacity (FAN Max or NAT Max) of the vent connector shall be reduced 10 percent for each additional multiple of the length allowed by Section G2428.3.2. For example, the maximum length listed in Table G2428.3.2 for a 4-inch (102 mm) connector is 6 feet (1829 mm). With a connector length greater than 6 feet (1829 mm) but not exceeding 12 feet (3658 mm), the maximum capacity must be reduced by 10 percent (0.90 × maximum vent connector capacity). With a connector length greater than 12 feet (3658 mm), but not exceeding 18 feet (5486 mm), the maximum capacity must be reduced by 20 percent (0.80 × maximum vent capacity).

2. For a connector serving a fan-assisted appliance, the minimum capacity (FAN Min) of the connector shall be determined by referring to the corresponding single-appliance table. For Type B double-wall connectors, Table G2428.2(1) shall be used. For single-wall connectors, Table G2428.2(2) shall be used. The height (H) and
lateral (L) shall be measured according to the procedures for a single-\textit{appliance} vent, as if the other \textit{appliances} were not present.

\textbf{G2428.3.4 (504.3.4) Vent connector manifold.}
Where the \textit{vent connectors} are combined prior to entering the vertical portion of the common vent to form a common vent manifold, the size of the common vent manifold and the common vent shall be determined by applying a 10-percent reduction ($0.90 \times$ maximum common vent capacity) to the common vent capacity part of the common vent tables. The length of the common \textit{vent connector} manifold ($L_m$) shall not exceed $1\frac{1}{2}$ feet for each inch (18 mm per mm) of common \textit{vent connector} manifold diameter ($D$).

\textbf{G2428.3.5 (504.3.5) Common vertical vent offset.}
Where the common vertical vent is \textit{offset}, the maximum capacity of the common vent shall be reduced in accordance with Section G2428.3.6. The horizontal length of the common vent \textit{offset} ($L_o$) shall not exceed $1\frac{1}{2}$ feet for each inch (18 mm per mm) of common vent diameter ($D$). Where multiple \textit{offsets} occur in a common vent, the total horizontal length of all \textit{offsets} combined shall not exceed $1\frac{1}{2}$ feet for each inch (18 mm/mm per) of the common vent diameter ($D$).

\textbf{G2428.3.6 (504.3.6) Elbows in vents.}
For each elbow up to and including 45 degrees (0.79 rad) in the common vent, the maximum common vent capacity listed in the venting tables shall be reduced by 5 percent. For each elbow greater than 45 degrees (0.79 rad) up to and including 90 degrees (1.57 rad), the maximum common vent capacity listed in the venting tables shall be reduced by 10 percent.

\textbf{G2428.3.7 (504.3.7) Elbows in connectors.}
The \textit{vent connector} capacities listed in the common vent sizing tables include allowance for two 90-degree (1.57 rad) elbows. For each additional elbow up to and including 45 degrees (0.79 rad), the maximum \textit{vent connector} capacity listed in the venting tables shall be reduced by 5 percent. For each elbow greater than 45 degrees (0.79 rad) up to and including 90 degrees (1.57 rad), the maximum \textit{vent connector} capacity listed in the venting tables shall be reduced by 10 percent.

\textbf{G2428.3.8 (504.3.8) Common vent minimum size.}
The cross-sectional area of the common vent shall be equal to or greater than the cross-sectional area of the largest connector.

\textbf{G2428.3.9 (504.3.9) Common vent fittings.}
At the point where tee or wye fittings connect to a common vent, the opening size of the fitting shall be equal to the size of the common vent. Such fittings shall not be prohibited from having reduced-size openings at the point of connection of \textit{appliance vent connectors}.

\textbf{G2428.3.9.1 (504.3.9.1) Tee and wye fittings.}
Tee and wye fittings connected to a common gas vent shall be considered as part of the common gas vent and shall be constructed of materials consistent with that of the common gas vent.
G2428.3.10 (504.3.10) High-altitude installations.
Sea-level input ratings shall be used when determining maximum capacity for high-altitude installation. Actual input, derated for altitude, shall be used for determining minimum capacity for high-altitude installation.

G2428.3.11 (504.3.11) Connector rise measurement.
Connector rise (R) for each appliance connector shall be measured from the draft hood outlet or flue collar to the centerline where the vent gas streams come together.

G2428.3.12 (504.3.12) Vent height measurement.
For multiple appliances all located on one floor, available total height (H) shall be measured from the highest draft hood outlet or flue collar up to the level of the outlet of the common vent.

G2428.3.13 (504.3.17) Vertical vent maximum size.
Where two or more appliances are connected to a vertical vent or chimney, the flow area of the largest section of vertical vent or chimney shall not exceed seven times the smallest listed appliance categorized vent areas, flue collar area, or draft hood outlet area unless designed in accordance with approved engineering methods.

G2428.3.14 (504.3.18) Multiple input rate appliances.
For appliances with more than one input rate, the minimum vent connector capacity (FAN Min) determined from the tables shall be less than the lowest appliance input rating, and the maximum vent connector capacity (FAN Max or NAT Max) determined from the tables shall be greater than the highest appliance input rating.

G2428.3.15 (504.3.19) Liner system sizing and connections.
Listed, corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table G2428.3(1) or G2428.3(2) for Type B vents, with the maximum capacity reduced by 20 percent (0.80 × maximum capacity) and the minimum capacity as shown in Table G2428.3(1) or G2428.3(2). Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with Sections G2428.3.5 and G2428.3.6. The 20-percent reduction for corrugated metallic chimney liner systems includes an allowance for one long-radius 90-degree (1.57 rad) turn at the bottom of the liner. Where double-wall connectors are required, tee and wye fittings used to connect to the common vent chimney liner shall be listed double-wall fittings. Connections between chimney liners and listed double-wall fittings shall be made with listed adapter fittings designed for such purpose.

G2428.3.16 (504.3.20) Chimney and vent location.
Tables G2428.3(1), G2428.3(2), G2428.3(3) and G2428.3(4) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 feet (1524 mm) higher than required by Figure G2427.6.3 and where vents terminate in accordance with Section G2427.6.3, Item 2, the outdoor portion of the vent shall be enclosed as required by this section for vents not considered to be exposed to the outdoors or such venting system shall be engineered. A Type B vent shall not be considered
to be exposed to the outdoors where it passes through an unventilated enclosure or chase insulated to a value of not less than R8.

G2428.3.17 (504.3.21) Connector maximum and minimum size. 
Vent connectors shall not be increased in size more than two sizes greater than the listed appliance categorized vent diameter, flue collar diameter or draft hood outlet diameter. Vent connectors for draft-hood-equipped appliances shall not be smaller than the draft hood outlet diameter. Where a vent connector size(s) determined from the tables for a fan-assisted appliance(s) is smaller than the flue collar diameter, the use of the smaller size(s) shall be permitted provided that the installation complies with all of the following conditions:

1. Vent connectors for fan-assisted appliance flue collars 12 inches (305 mm) in diameter or smaller are not reduced by more than one table size [e.g., 12 inches to 10 inches (305 mm to 254 mm) is a one-size reduction] and those larger than 12 inches (305 mm) in diameter are not reduced more than two table sizes [e.g., 24 inches to 20 inches (610 mm to 508 mm) is a two-size reduction].

2. The fan-assisted appliance(s) is common vented with a draft-hood-equipped appliance(s).

3. The vent connector has a smooth interior wall.

G2428.3.18 (504.3.22) Component commingling.
All combinations of pipe sizes, single-wall and double-wall metal pipe shall be allowed within any connector run(s) or within the common vent, provided that all of the appropriate tables permit all of the desired sizes and types of pipe, as if they were used for the entire length of the subject connector or vent. Where single-wall and Type B double-wall metal pipes are used for vent connectors within the same venting system, the common vent must be sized using Table G2428.3(2) or G2428.3(4), as appropriate.

G2428.3.19 (504.3.23) Draft hood conversion accessories.
Draft hood conversion accessories for use with masonry chimneys venting listed Category I fan-assisted appliances shall be listed and installed in accordance with the manufacturer’s instructions for such listed accessories.

G2428.3.20 (504.3.24) Multiple sizes permitted.
Where a table permits more than one diameter of pipe to be used for a connector or vent, all the permitted sizes shall be permitted to be used.

G2428.3.21 (504.3.25) Table interpolation.
Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries.

G2428.3.22 (504.3.26) Extrapolation prohibited.
Extrapolation beyond the table entries shall not be permitted.

G2428.3.23 (504.3.27) Engineering calculations.
For vent heights less than 6 feet (1829 mm) and greater than shown in the tables, engineering methods shall be used to calculate vent capacities.
G2428.3.24 (504.3.28) Height entries.
Where the actual height of a vent falls between entries in the height column of the applicable table in Tables G2428.3(1) through G2428.3(4), either interpolation shall be used or the lower appliance input rating shown in the table shall be used for FAN Max and NAT Max column values and the higher appliance input rating shall be used for the FAN Min column values.

SECTION G2429 (505)
DIRECT-VENT, INTEGRAL VENT, MECHANICAL VENT AND VENTILATION/EXHAUST HOOD VENTING

G2429.1 (505.1) General.
The installation of direct-vent and integral vent appliances shall be in accordance with Section G2427. Mechanical venting systems shall be designed and installed in accordance with Section G2427.

SECTION G2430 (506)
FACTORY-BUILT CHIMNEYS

G2430.1 (506.1) Listing.
Factory-built chimneys for building heating appliances producing flue gases having a temperature not greater than 1,000ºF (538ºC), measured at the entrance to the chimney, shall be listed and labeled in accordance with UL 103 and shall be installed and terminated in accordance with the manufacturer’s instructions.

G2430.2 (506.2) Support.
Where factory-built chimneys are supported by structural members, such as joists and rafters, such members shall be designed to support the additional load.

SECTION G2431 (601)
GENERAL

G2431.1 (601.1) Scope.
Sections G2432 through G2454 shall govern the approval, design, installation, construction, maintenance, alteration and repair of the appliances and equipment specifically identified herein.

SECTION G2432 (602)
DECORATIVE APPLIANCES FOR INSTALLATION IN FIREPLACES

G2432.1 (602.1) General.
Decorative appliances for installation in approved solid fuel-burning fireplaces shall be tested in accordance with ANSI Z21.60 and shall be installed in accordance with the manufacturer’s instructions. Manually lighted natural gas decorative appliances shall be tested in accordance with ANSI Z21.84.
G2432.2 (602.2) Flame safeguard device.
Decorative appliances for installation in approved solid fuel-burning fireplaces, with the exception of those tested in accordance with ANSI Z21.84, shall utilize a direct ignition device, an ignitor or a pilot flame to ignite the fuel at the main burner, and shall be equipped with a flame safeguard device. The flame safeguard device shall automatically shut off the fuel supply to a main burner or group of burners when the means of ignition of such burners becomes inoperative.

G2432.3 (602.3) Prohibited installations.
Decorative appliances for installation in fireplaces shall not be installed where prohibited by Section G2406.2.

SECTION G2433 (603)
LOG LIGHTERS

G2433.1 (603.1) General.
Log lighters shall be tested in accordance with CSA 8 and shall be installed in accordance with the manufacturer’s instructions.

SECTION G2434 (604)
VENTED GAS FIREPLACES (DECORATIVE APPLIANCES)

G2434.1 (604.1) General.
Vented gas fireplaces shall be tested in accordance with ANSI Z21.50, shall be installed in accordance with the manufacturer’s instructions and shall be designed and equipped as specified in Section G2432.2.

G2434.2 (604.2) Access.
Panels, grilles and access doors that are required to be removed for normal servicing operations shall not be attached to the building.

SECTION G2435 (605)
VENTED GAS FIREPLACE HEATERS

G2435.1 (605.1) General.
Vented gas fireplace heaters shall be installed in accordance with the manufacturer’s instructions, shall be tested in accordance with ANSI Z21.88 and shall be designed and equipped as specified in Section G2432.2.

SECTION G2436 (608)
VENTED WALL FURNACES
G2436.1 (608.1) General.
*Vented wall furnaces* shall be tested in accordance with ANSI Z21.86/CSA 2.32 and shall be installed in accordance with the manufacturer’s instructions.

G2436.2 (608.2) Venting.
*Vented wall furnaces* shall be vented in accordance with Section G2427.

G2436.3 (608.3) Location.
*Vented wall furnaces* shall be located so as not to cause a fire hazard to walls, floors, combustible furnishings or doors. *Vented wall furnaces* installed between bathrooms and adjoining rooms shall not circulate air from bathrooms to other parts of the building.

G2436.4 (608.4) Door swing.
*Vented wall furnaces* shall be located so that a door cannot swing within 12 inches (305 mm) of an air inlet or air outlet of such furnace measured at right angles to the opening. Doorstops or door closers shall not be installed to obtain this clearance.

G2436.5 (608.5) Ducts prohibited.
Ducts shall not be attached to *wall furnaces*. Casing extension boots shall not be installed unless listed as part of the *appliance*.

G2436.6 (608.6) Access.
*Vented wall furnaces* shall be provided with access for cleaning of heating surfaces, removal of *burners*, replacement of sections, motors, *controls*, filters and other working parts, and for adjustments and lubrication of parts requiring such attention. Panels, grilles and access doors that are required to be removed for normal servicing operations shall not be attached to the building construction.

**SECTION G2437 (609)
FLOOR FURNACES**

G2437.1 (609.1) General.
*Floor furnaces* shall be tested in accordance with ANSI Z21.86/CSA 2.32 and shall be installed in accordance with the manufacturer’s instructions.

G2437.2 (609.2) Placement.
The following provisions apply to *floor furnaces*:

1. Floors. *Floor furnaces* shall not be installed in the floor of any doorway, stairway landing, aisle or passageway of any enclosure, public or private, or in an exitway from any such room or space.

2. Walls and corners. The register of a *floor furnace* with a horizontal warm air outlet shall not be placed closer than 6 inches (152 mm) to the nearest wall. A distance of at least 18 inches (457 mm) from two adjoining sides of the *floor furnace* register to walls shall be provided to eliminate the necessity of occupants walking over the warm-air discharge. The remaining sides shall be permitted to be placed not closer than 6 inches (152 mm) to a wall. Wall-register models shall not be placed closer than 6 inches (152 mm) to a corner.
3. Draperies. The furnace shall be placed so that a door, drapery, or similar object cannot be nearer than 12 inches (305 mm) to any portion of the register of the furnace.

4. Floor construction. Floor furnaces shall not be installed in concrete floor construction built on grade.

5. Thermostat. The controlling thermostat for a floor furnace shall be located within the same room or space as the floor furnace or shall be located in an adjacent room or space that is permanently open to the room or space containing the floor furnace.

G2437.3 (609.3) Bracing.
The floor around the furnace shall be braced and headed with a support framework designed in accordance with Chapter 5.

G2437.4 (609.4) Clearance.
The lowest portion of the floor furnace shall have not less than a 6-inch (152 mm) clearance from the grade level; except where the lower 6-inch (152 mm) portion of the floor furnace is sealed by the manufacturer to prevent entrance of water, the minimum clearance shall be reduced to not less than 2 inches (51 mm). Where such clearances cannot be provided, the ground below and to the sides shall be excavated to form a pit under the furnace so that the required clearance is provided beneath the lowest portion of the furnace. A 12-inch (305 mm) minimum clearance shall be provided on all sides except the control side, which shall have an 18-inch (457 mm) minimum clearance.

G2437.5 (609.5) First floor installation.
Where the basement story level below the floor in which a floor furnace is installed is utilized as habitable space, such floor furnaces shall be enclosed as specified in Section G2437.6 and shall project into a nonhabitable space.

G2437.6 (609.6) Upper floor installations.
Floor furnaces installed in upper stories of buildings shall project below into nonhabitable space and shall be separated from the nonhabitable space by an enclosure constructed of noncombustible materials. The floor furnace shall be provided with access, clearance to all sides and bottom of not less than 6 inches (152 mm) and combustion air in accordance with Section G2407.

SECTION G2438 (613)
CLOTHES DRYERS

G2438.1 (613.1) General.
Clothes dryers shall be tested in accordance with ANSI Z21.5.1 and shall be installed in accordance with the manufacturer’s instructions.

SECTION G2439 (614)
CLOTHES DRYER EXHAUST
G2439.1 (614.1) Installation.
Clothes dryers shall be exhausted in accordance with the manufacturer’s instructions. Dryer exhaust systems shall be independent of all other systems and shall convey the moisture and any products of combustion to the outside of the building.

G2439.2 (614.2) Duct penetrations.
Ducts that exhaust clothes dryers shall not penetrate or be located within any fireblocking, draftstopping or any wall, floor/ceiling or other assembly required by this code to be fire-resistance rated, unless such duct is constructed of galvanized steel or aluminum of the thickness specified in the mechanical provisions of this code and the fire-resistance rating is maintained in accordance with this code. Fire dampers shall not be installed in clothes dryer exhaust duct systems.

G2439.3 (614.4) Exhaust installation.
Exhaust ducts for clothes dryers shall terminate on the outside of the building and shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct the flow. Clothes dryer exhaust ducts shall not be connected to a vent connector, vent or chimney. Clothes dryer exhaust ducts shall not extend into or through ducts or plenums.

G2439.4 (614.5) Dryer exhaust duct power ventilators.
Domestic dryer exhaust duct power ventilators shall be listed and labeled to UL 705 for use in dryer exhaust duct systems. The dryer exhaust duct power ventilator shall be installed in accordance with the manufacturer’s instructions.

G2439.5 (614.6) Makeup air.
Installations exhausting more than 200 cfm (0.09 m³/s) shall be provided with makeup air. Where a closet is designed for the installation of a clothes dryer, an opening having an area of not less than 100 square inches (0.0645 m²) for makeup air shall be provided in the closet enclosure, or makeup air shall be provided by other approved means.

G2439.6 (614.7) Protection required.
Protective shield plates shall be placed where nails or screws from finish or other work are likely to penetrate the clothes dryer exhaust duct. Shield plates shall be placed on the finished face of all framing members where there is less than 1 1/4 inches (32 mm) between the duct and the finished face of the framing member. Protective shield plates shall be constructed of steel, shall have a minimum thickness of 0.062 inch (1.6 mm) and shall extend a minimum of 2 inches (51 mm) above sole plates and below top plates.

G2439.7 (614.8) Domestic clothes dryer exhaust ducts.
Exhaust ducts for domestic clothes dryers shall conform to the requirements of Sections G2439.7.1 through G2439.7.6.

G2439.7.1 (614.8.1) Material and size.
Exhaust ducts shall have a smooth interior finish and shall be constructed of metal a minimum 0.016-0.0157-inch (0.4 mm) thick (26 ga galv., 26 ga AL). The exhaust duct size shall be 4 inches (102 mm) nominal in diameter. With the exception of the transition duct, flexible ducts are prohibited.
G2439.7.2 (614.8.2) Duct installation.
Exhaust ducts shall be supported at 4-foot (1219 mm) intervals and secured in place. The insert end of the duct shall extend into the adjoining duct or fitting in the direction of airflow.

Ducts shall not be joined with screws or similar fasteners that protrude more than \( \frac{1}{8} \) inch (3.2 mm) into the inside of the duct. Ducts shall not be joined with screws or similar fasteners that protrude into the inside of the duct. Ducts shall be sealed in accordance with M1601.4.1.

a. Nonmetallic mechanical fasteners (tie- straps) shall be listed to UL 181B.

b. Metal band duct clamps are not required to be listed.

G2439.7.3 (614.8.3) Transition ducts.
Transition ducts used to connect the dryer to the exhaust duct system shall be a single length that is listed and labeled in accordance with UL 2158A. Transition ducts shall be not more than 8 feet (2438 mm) in length and shall not be concealed within construction, and must remain entirely within the room in which the appliance is located.

G2439.7.4 (614.8.4) Duct length.
The maximum allowable exhaust duct length shall be determined by one of the methods specified in Sections G2439.7.4.1 through G2439.7.4.3.

G2439.7.4.1 (614.8.4.1) Specified length.
The maximum length of the exhaust duct shall be 35 feet (10 668 mm) from the connection to the transition duct from the dryer to the outlet terminal. Where fittings are used, the maximum length of the exhaust duct shall be reduced in accordance with Table G2439.7.4.1.

<table>
<thead>
<tr>
<th>DRYER EXHAUST DUCT FITTING TYPE</th>
<th>EQUIVALENT LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inch radius mitered 45-degree elbow</td>
<td>2 feet, 6 inches</td>
</tr>
<tr>
<td>4 inch radius mitered 90-degree elbow</td>
<td>5 feet</td>
</tr>
<tr>
<td>6 inch radius smooth 45-degree elbow</td>
<td>1 foot</td>
</tr>
<tr>
<td>6 inch radius smooth 90-degree elbow</td>
<td>1 foot, 9 inches</td>
</tr>
<tr>
<td>8 inch radius smooth 45-degree elbow</td>
<td>1 foot</td>
</tr>
<tr>
<td>8 inch radius smooth 90-degree elbow</td>
<td>1 foot, 7 inches</td>
</tr>
<tr>
<td>10 inch radius smooth 45-degree elbow</td>
<td>9 inches</td>
</tr>
<tr>
<td>10 inch radius smooth 90-degree elbow</td>
<td>1 foot, 6 inches</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

G2439.7.4.2 (614.8.4.2) Manufacturer's instructions.
The maximum length of the exhaust duct shall be determined by the dryer manufacturer’s installation instructions. The code official shall be provided with a copy of the installation instructions for the make and model of the dryer. Where the exhaust duct is to be concealed, the installation instructions shall be provided to the code official prior to the concealment inspection. In the absence of fitting equivalent length calculations from the clothes dryer manufacturer, Table G2439.5.5.1 shall be utilized.
G2439.7.4.3 (614.8.4.3) Dryer exhaust duct power ventilator length.
The maximum length of the exhaust duct shall be determined by the dryer exhaust duct power ventilator manufacturer’s installation instructions.

G2439.7.5 (614.8.5) Length identification.
Where the exhaust duct equivalent length exceeds 35 feet (10 668 mm), the equivalent length of the exhaust duct shall be identified on a permanent label or tag. The label or tag shall be located within 6 feet (1829 mm) of the exhaust duct connection

- Label shall be permanently stenciled, laminated, or commercially available plastic or metal tags.
- Labels shall state, at a minimum (fill in the blank):
  - Caution: Equivalent length _____ ft. Any installed dryer must be equipped with exhaust system that meets or exceeds this equivalent length requirement.
- Labels can be attached to wall or vent receptor.

G2439.7.6 (614.8.6) Exhaust duct required.
Where space for a clothes dryer is provided, an exhaust duct system shall be installed.

Where the clothes dryer is not installed at the time of occupancy, the exhaust duct shall be capped at location of the future dryer.

Exception: Where a listed condensing clothes dryer is installed prior to occupancy of the structure.

G2439.7.7 (614.8.7) Exhaust duct termination.
Exhaust duct shall terminate not less than 12 inches (305 mm) above finished grade.

Exception: Where the duct termination is less than 12 inches (305 mm) above finished grade an areaway shall be provided with a cross-sectional area not less than 200 square inches (1290 cm²). The bottom of the duct termination shall be no less than 12 inches (305 mm) above the areaway bottom.

SECTION G2440 (615)
SAUNA HEATERS

G2440.1 (615.1) General.
Sauna heaters shall be installed in accordance with the manufacturer’s instructions.

G2440.2 (615.2) Location and protection.
Sauna heaters shall be located so as to minimize the possibility of accidental contact by a person in the room.

G2440.2.1 (615.2.1) Guards.
Sauna heaters shall be protected from accidental contact by an approved guard or barrier of material having a low coefficient of thermal conductivity. The guard shall not substantially affect the transfer of heat from the heater to the room.

2018 North Carolina Residential Code
G2440.3 (615.3) Access.
Panels, grilles and access doors that are required to be removed for normal servicing operations, shall not be attached to the building.

G2440.4 (615.4) Combustion and dilution air intakes.
Sauna heaters of other than the direct-vent type shall be installed with the draft hood and combustion air intake located outside the sauna room. Where the combustion air inlet and the draft hood are in a dressing room adjacent to the sauna room, there shall be provisions to prevent physically blocking the combustion air inlet and the draft hood inlet, and to prevent physical contact with the draft hood and vent assembly, or warning notices shall be posted to avoid such contact. Any warning notice shall be easily readable, shall contrast with its background and the wording shall be in letters not less than $\frac{1}{4}$ inch (6.4 mm) high.

G2440.5 (615.5) Combustion and ventilation air.
Combustion air shall not be taken from inside the sauna room. Combustion and ventilation air for a sauna heater not of the direct-vent type shall be provided to the area in which the combustion air inlet and draft hood are located in accordance with Section G2407.

G2440.6 (615.6) Heat and time controls.
Sauna heaters shall be equipped with a thermostat which will limit room temperature to 194°F (90°C). If the thermostat is not an integral part of the sauna heater, the heat-sensing element shall be located within 6 inches (152 mm) of the ceiling. If the heat-sensing element is a capillary tube and bulb, the assembly shall be attached to the wall or other support, and shall be protected against physical damage.

G2440.6.1 (615.6.1) Timers.
A timer, if provided to control main burner operation, shall have a maximum operating time of 1 hour. The control for the timer shall be located outside the sauna room.

G2440.7 (615.7) Sauna room.
A ventilation opening into the sauna room shall be provided. The opening shall be not less than 4 inches by 8 inches (102 mm by 203 mm) located near the top of the door into the sauna room.
A ventilation opening into the sauna room shall be provided as required by the manufacturer.

SECTION G2441 (617)
POOL AND SPA HEATERS

G2441.1 (617.1) General.
Pool and spa heaters shall be tested in accordance with ANSI Z21.56/CSA 4.7 and shall be installed in accordance with the manufacturer’s instructions.

SECTION G2442 (618)
FORCED-AIR WARM-AIR FURNACES

2018 North Carolina Residential Code
G2442.1 (618.1) General.
Forced-air warm-air furnaces shall be tested in accordance with ANSI Z21.47 or UL 795 and shall be installed in accordance with the manufacturer’s instructions.

G2442.2 (618.2) Forced-air furnaces.
The minimum unobstructed total area of the outside and return air ducts or openings to a forced-air warm-air furnace shall be not less than 2 square inches for each 1,000 Btu/h (4402 mm²/W) output rating capacity of the furnace and not less than that specified in the furnace manufacturer’s installation instructions. The minimum unobstructed total area of supply ducts from a forced-air warm-air furnace shall be not less than 2 square inches for each 1,000 Btu/h (4402 mm²/W) output rating capacity of the furnace and not less than that specified in the furnace manufacturer’s installation instructions.

With the addition of a cooling coil, the sizing criteria shall be based on 6 square inches (3870 mm²) for each 1,000 Btu/h (13 206 mm²/W) output.

**Exception:** The total area of the supply air ducts and outside and return air ducts shall not be required to be larger than the minimum size required by the furnace manufacturer’s installation instructions.

G2442.3 (618.3) Dampers.
Volume dampers shall not be placed in the air inlet to a furnace in a manner that will reduce the required air to the furnace.

G2442.4 (618.4) Prohibited sources.
Outdoor or return air for forced-air heating and cooling systems shall not be taken from the following locations:

1. Closer than 10 feet (3048 mm) from an appliance vent outlet, a vent opening from a plumbing drainage system or the discharge outlet of an exhaust fan, unless the outlet is 3 feet (914 mm) above the outside air inlet.

2. Where there is the presence of objectionable odors, fumes or flammable vapors; or where located less than 10 feet (3048 mm) above the surface of any abutting public way or driveway; or where located at grade level by a sidewalk, street, alley or driveway.

3. A hazardous or insanitary location or a refrigeration machinery room as defined in the International Mechanical Code.

4. A room or space, the volume of which is less than 25 percent of the entire volume served by such system. Where connected by a permanent opening having an area sized in accordance with Section G2442.2, adjoining rooms or spaces shall be considered as a single room or space for the purpose of determining the volume of such rooms or spaces.

**Exception:** The minimum volume requirement shall not apply where the amount of return air taken from a room or space is less than or equal to the amount of supply air delivered to such room or space.
5. A room or space containing an appliance where such a room or space serves as the sole source of return air.

**Exception:** This shall not apply where:

1. The appliance is a direct-vent appliance or an appliance not requiring a vent in accordance with Section G2425.8.

2. The room or space complies with the following requirements:

   2.1. The return air shall be taken from a room or space having a volume exceeding 1 cubic foot for each 10 Btu/h (9.6L/W) of combined input rating of all fuel-burning appliances therein.

   2.2. The volume of supply air discharged back into the same space shall be approximately equal to the volume of return air taken from the space.

   2.3. Return-air inlets shall not be located within 10 feet (3048 mm) of a draft hood in the same room or space or the combustion chamber of any atmospheric burner appliance in the same room or space.

3. Rooms or spaces containing solid fuel-burning appliances, provided that return-air inlets are located not less than 10 feet (3048 mm) from the firebox of such appliances.

6. A closet, bathroom, toilet room, kitchen, garage, boiler room, furnace room or unconditioned attic.

**Exceptions:**

1. Where return air intakes are located not less than 10 feet (3048 mm) from cooking appliances **and serve only the kitchen area**, taking return air from a kitchen area shall not be prohibited.

2. Dedicated forced air systems serving only a garage shall not be prohibited from obtaining return air from the garage.

7. A crawl space by means of direct connection to the return side of a forced-air system. Transfer openings in the crawl space enclosure shall not be prohibited. **Deleted.**

**G2442.5 (618.5) Screen.**

Required outdoor air inlets shall be covered with a screen having \( \frac{1}{4} \)-inch (6.4 mm) openings.

**G2442.6 (618.6) Return-air limitation.**

Return air from one dwelling unit shall not be discharged into another dwelling unit.

**G2442.7 (618.7) Furnace plenums and air ducts.**

Where a furnace is installed so that supply ducts carry air circulated by the furnace to areas
outside of the space containing the furnace, the return air shall be handled by a duct(s) sealed to the furnace casing and terminating outside of the space containing the furnace.

**G2442.7.1 (618.9) Refrigeration coils in warm-air furnaces.**
When a cooling coil is located in the supply plenum of a warm-air furnace, the furnace blower shall be rated at not less than 0.5-inch water column (124 Pa) static pressure unless the furnace is listed and labeled for use with a cooling coil. Cooling coils shall not be located upstream from heat exchangers unless listed and labeled for such use. Conversion of existing furnaces for use with cooling coils shall be permitted, provided the furnace will operate within the temperature rise specified for the furnace.

**G2442.7.2 (618.10) Return-air intake (nonengineered systems).**
If only one central return-air grille is installed, it shall be of a size sufficient to return a volume of air compatible with the cubic foot per minute requirements and the temperature rise limitations specified by the equipment manufacturer. The face velocity of return air grilles shall not exceed 450 feet per minute (fpm) (2.3 m/s). At least one separate return shall be installed on each level of a multilevel structure. For split-level and split-foyer structures, one return may serve more than one level if located within the split area and the total area of the levels does not exceed 1,600 square feet (148.6 m²). Return-air grilles shall not be located in bathrooms. The return air from one residential living unit shall not be mixed with the return air from other living units. In dwellings with 1,600 square feet (148.6 m²) or less of conditioned area, a central return is permitted. When the dwelling contains more than 1,600 square feet (148.6 m²) of conditioned area, additional returns shall be provided. Each return shall serve not more than 1,600 square feet (148.6 m²) of area and shall be located in the area it serves. Return air may travel through the living space to the return-air intake if there are no restrictions, such as solid doors, to the air movement. Undercut doors are allowed. When panned joists are used for return air, the structural integrity shall be maintained. Air capacity for joists 16 inches (406 mm) on center shall be a maximum of 375 cubic foot per minute (0.177 m³/s) for 8-inch (203 mm) joists and 525 cubic foot per minute (0.248 m³/s) for 10-inch (254 mm) joists. Wiring located in spaces used for return-air ducts shall comply with the North Carolina Electrical Code.

**SECTION G2443 (619)**
**CONVERSION BURNERS**

**G2443.1 (619.1) Conversion burners.**
The installation of conversion burners shall conform to ANSI Z21.8.

**SECTION G2444 (620)**
**UNIT HEATERS**

**G2444.1 (620.1) General.**
Unit heaters shall be tested in accordance with ANSI Z83.8 and shall be installed in accordance with the manufacturer's instructions.

**G2444.2 (620.2) Support.**
Suspended-type unit heaters shall be supported by elements that are designed and constructed.
to accommodate the weight and dynamic loads. Hangers and brackets shall be of noncombustible material.

G2444.3 (620.3) Ductwork.
Ducts shall not be connected to a unit heater unless the heater is listed for such installation.

G2444.4 (620.4) Clearance.
Suspended-type unit heaters shall be installed with clearances to combustible materials of not less than 18 inches (457 mm) at the sides, 12 inches (305 mm) at the bottom and 6 inches (152 mm) above the top where the unit heater has an internal draft hood or 1 inch (25 mm) above the top of the sloping side of the vertical draft hood.

Floor-mounted-type unit heaters shall be installed with clearances to combustible materials at the back and one side only of not less than 6 inches (152 mm). Where the flue gases are vented horizontally, the 6-inch (152 mm) clearance shall be measured from the draft hood or vent instead of the rear wall of the unit heater. Floor-mounted-type unit heaters shall not be installed on combustible floors unless listed for such installation.

Clearances for servicing all unit heaters shall be in accordance with the manufacturer’s installation instructions.

Exception: Unit heaters listed for reduced clearance shall be permitted to be installed with such clearances in accordance with their listing and the manufacturer’s instructions.

SECTION G2445 (621)
UNVENTED ROOM HEATERS

G2445.1 (621.1) General.
Unvented room heaters shall be tested in accordance with ANSI Z21.11.2 and shall be installed in accordance with the conditions of the listing and the manufacturer’s instructions.

G2445.2 (621.2) Prohibited use.
One or more unvented room heaters shall not be used as the sole source of comfort heating in a dwelling unit.

G2445.3 (621.3) Input rating.
Unvented room heaters shall not have an input rating in excess of 40,000 Btu/h (11.7 kW).

G2445.4 (621.4) Prohibited locations.
The location of unvented room heaters shall comply with Section G2406.2.

G2445.5 (621.5) Room or space volume.
The aggregate input rating of all unvented appliances installed in a room or space shall not exceed 20 Btu/h per cubic foot (207 W/m³) of volume of such room or space. Where the room or space in which the appliances are installed is directly connected to another room or space by a doorway, archway or other opening of comparable size that cannot be closed, the volume of such adjacent room or space shall be permitted to be included in the calculations.
G2445.6 (621.6) Oxygen-depletion safety system.
Unvented room heaters shall be equipped with an oxygen-depletion-sensitive safety shutoff system. The system shall shut off the gas supply to the main and pilot burners when the oxygen in the surrounding atmosphere is depleted to the percent concentration specified by the manufacturer, but not lower than 18 percent. The system shall not incorporate field adjustment means capable of changing the set point at which the system acts to shut off the gas supply to the room heater.

G2445.7 (621.7) Unvented decorative (log) room heaters.
An unvented decorative room heater shall not be installed in a factory-built fireplace unless the fireplace system has been specifically tested, listed and labeled for such use in accordance with UL 127.

G2445.7.1 (621.7.1) Ventless firebox enclosures.
Ventless firebox enclosures used with unvented decorative (log) room heaters shall be listed as complying with ANSI Z21.91.

SECTION G2446 (622)
VENTED ROOM HEATERS

G2446.1 (622.1) General.
Vented room heaters shall be tested in accordance with ANSI Z21.86/CSA 2.32, shall be designed and equipped as specified in Section G2432.2 and shall be installed in accordance with the manufacturer’s instructions.

SECTION G2447 (623)
COOKING APPLIANCES

G2447.1 (623.1) Cooking appliances.
Cooking appliances that are designed for permanent installation, including ranges, ovens, stoves, broilers, grills, fryers, griddles, hot plates and barbecues, shall be tested in accordance with ANSI Z21.1 or ANSI Z21.58 and shall be installed in accordance with the manufacturer’s instructions.

G2447.2 (623.2) Prohibited location.
Cooking appliances designed, tested, listed and labeled for use in commercial occupancies shall not be installed within dwelling units or within any area where domestic cooking operations occur.

Exception: Appliances that are also listed as domestic cooking appliances.

G2447.3 (623.3) Domestic appliances.
Cooking appliances installed within dwelling units and within areas where domestic cooking operations occur shall be listed and labeled as household-type appliances for domestic use.

G2447.4 (623.4) Range installation.
Ranges installed on combustible floors shall be set on their own bases or legs and shall be installed with clearances of not less than that shown on the label.
**G2447.5 (623.7) Vertical clearance above cooking top.**
Household cooking *appliances* shall have a vertical *clearance* above the cooking top of not less than 30 inches (760 mm) to combustible material and metal cabinets. A minimum *clearance* of 24 inches (610 mm) is permitted where one of the following is installed:

1. The underside of the combustible material or metal cabinet above the cooking top is protected with not less than $\frac{1}{4}$-inch (6 mm) insulating millboard covered with sheet metal not less than 0.0122 inch (0.3 mm) thick.

2. A metal ventilating hood constructed of sheet metal not less than 0.0122 inch (0.3 mm) thick is installed above the cooking top with a *clearance* of not less than $\frac{1}{4}$ inch (6 mm) between the hood and the underside of the combustible material or metal cabinet. The hood shall have a width not less than the width of the *appliance* and shall be centered over the *appliance*.

3. A listed cooking *appliance* or microwave oven is installed over a listed cooking *appliance* and in compliance with the terms of the manufacturer’s installation instructions for the upper *appliance*.

**SECTION G2448 (624)
WATER HEATERS**

**G2448.1 (624.1) General.**
Water heaters shall be tested in accordance with ANSI Z21.10.1 and ANSI Z21.10.3 and shall be installed in accordance with the manufacturer’s instructions.

**G2448.1.1 (624.1.1) Installation requirements.**
The requirements for *water heaters* relative to sizing, *relief valves*, drain pans and scald protection shall be in accordance with this code.

**G2448.2 (624.2) Water heaters utilized for space heating.**
*Water heaters* utilized both to supply potable hot water and provide hot water for space-heating applications shall be listed and labeled for such applications by the manufacturer and shall be installed in accordance with the manufacturer’s instructions and this code.

**SECTION G2449 (627)
AIR-CONDITIONING APPLIANCES**

**G2449.1 (627.1) General.**
Gas-fired air-conditioning *appliances* shall be tested in accordance with ANSI Z21.40.1 or ANSI Z21.40.2 and shall be installed in accordance with the manufacturer’s instructions.
G2449.2 (627.2) Independent piping.  
Gas piping serving heating appliances shall be permitted to also serve cooling appliances where such heating and cooling appliances cannot be operated simultaneously (see Section G2413).

G2449.3 (627.3) Connection of gas engine-powered air conditioners.  
To protect against the effects of normal vibration in service, gas engines shall not be rigidly connected to the gas supply piping.

G2449.4 (627.6) Installation.  
Air conditioning appliances shall be installed in accordance with the manufacturer’s instructions. Unless the appliance is listed for installation on a combustible surface such as a floor or roof, or unless the surface is protected in an approved manner, the appliance shall be installed on a surface of noncombustible construction with noncombustible material and surface finish and with no combustible material against the underside thereof.

SECTION G2450 (628)  
ILLUMINATING APPLIANCES

G2450.1 (628.1) General.  
Illuminating appliances shall be tested in accordance with ANSI Z21.42 and shall be installed in accordance with the manufacturer’s instructions.

G2450.2 (628.2) Mounting on buildings.  
Illuminating appliances designed for wall or ceiling mounting shall be securely attached to substantial structures in such a manner that they are not dependent on the gas piping for support.

G2450.3 (628.3) Mounting on posts.  
Illuminating appliances designed for post mounting shall be securely and rigidly attached to a post. Posts shall be rigidly mounted. The strength and rigidity of posts greater than 3 feet (914 mm) in height shall be at least equivalent to that of a 2\(\frac{1}{2}\)\(\times\)inch-diameter (64 mm) post constructed of 0.064-inch-thick (1.6 mm) steel or a 1-inch (25 mm) Schedule 40 steel pipe. Posts 3 feet (914 mm) or less in height shall not be smaller than a 3\(\frac{3}{4}\)\(\times\)-inch (19.1 mm) Schedule 40 steel pipe. Drain openings shall be provided near the base of posts where there is a possibility of water collecting inside them.

G2450.4 (628.4) Appliance pressure regulators.  
Where an appliance pressure regulator is not supplied with an illuminating appliance and the service line is not equipped with a service pressure regulator, an appliance pressure regulator shall be installed in the line to the illuminating appliance. For multiple installations, one regulator of adequate capacity shall be permitted to serve more than one illuminating appliance.

SECTION G2451 (630)  
INFRARED RADIANT HEATERS
G2451.1 (630.1) General.
Infrared radiant heaters shall be tested in accordance with ANSI Z83.19 or Z83.20 and shall be installed in accordance with the manufacturer’s instructions.

G2451.2 (630.2) Support.
Infrared radiant heaters shall be fixed in a position independent of gas and electric supply lines. Hangers and brackets shall be of noncombustible material.

SECTION G2452 (631)
BOILERS

G2452.1 (631.1) Standards.
Boilers shall be listed in accordance with the requirements of ANSI Z21.13 or UL 795. If applicable, the boiler shall be designed and constructed in accordance with the requirements of ASME CSD-1 and as applicable, the ASME Boiler and Pressure Vessel Code, Sections I, II, IV, V and IX and NFPA 85.

G2452.2 (631.2) Installation.
In addition to the requirements of this code, the installation of boilers shall be in accordance with the manufacturer’s instructions. Operating instructions of a permanent type shall be attached to the boiler. Boilers shall have all controls set, adjusted and tested by the installer. A complete control diagram together with complete boiler operating instructions shall be furnished by the installer. The manufacturer’s rating data and the nameplate shall be attached to the boiler.

G2452.3 (631.3) Clearance to combustible material.
Clearances to combustible materials shall be in accordance with Section G2409.4.

SECTION G2453 (634)
CHIMNEY DAMPER OPENING AREA

Deleted.

G2453.1 (634.1) Free opening area of chimney dampers.
Where an unlisted decorative appliance for installation in a vented fireplace is installed, the fireplace damper shall have a permanent free opening equal to or greater than specified in Table G2453.1.

<table>
<thead>
<tr>
<th>CHIMNEY HEIGHT (feet)</th>
<th>MINIMUM PERMANENT FREE OPENING (square inches)³</th>
<th>8</th>
<th>13</th>
<th>20</th>
<th>29</th>
<th>39</th>
<th>51</th>
<th>64</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Appliance input rating (Btu per hour)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>7,800</td>
<td>14,000</td>
<td>23,200</td>
<td>34,000</td>
<td>46,400</td>
<td>62,400</td>
<td>80,000</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>8,400</td>
<td>15,200</td>
<td>25,200</td>
<td>37,000</td>
<td>50,400</td>
<td>68,000</td>
<td>86,000</td>
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<tr>
<td>10</td>
<td></td>
<td>9,000</td>
<td>16,800</td>
<td>27,600</td>
<td>40,400</td>
<td>55,800</td>
<td>74,400</td>
<td>96,400</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
SECTION G2454 (636)

OUTDOOR DECORATIVE APPLIANCES

G2454.1 (636.1) General.
Permanently fixed-in-place outdoor decorative appliances shall be tested in accordance with ANSI Z21.97 and shall be installed in accordance with the manufacturer’s instructions.

SECTION G2455 (616)

ENGINE AND GAS TURBINE-POWERED EQUIPMENT

G2455.1 (616.1) Powered equipment.
Permanently installed equipment powered by internal combustion engines and turbines shall be installed in accordance with the manufacturer’s instructions and NFPA 37. Stationary engine generator assemblies shall meet the requirements of UL 2200.

G2455.2 (616.2) Gas supply connection.
Equipment powered by internal combustion engines and turbines shall not be rigidly connected to the gas supply piping.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square inch = 645.16 mm

a. The first six minimum permanent free openings (8 to 51 square inches) correspond approximately to the cross-sectional areas of chimneys having diameters of 3 through 8 inches, respectively. The 64-square-inch opening corresponds to the cross-sectional area of standard 8-inch by 8-inch chimney tile.
**Part VII—Plumbing**

**CHAPTER 25**

**PLUMBING ADMINISTRATION**

*User note: Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.*

The text of this chapter is extracted from the 2018 edition of the North Carolina Plumbing Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Plumbing Code.

**SECTION P2501**

**GENERAL**

**P2501.1 (101.1) Scope.**

The provisions of this chapter shall establish the general administrative requirements applicable to plumbing systems and inspection requirements of this code. The provisions of Chapters 25 through 33 of this code shall apply to the erection, installation, alteration, repairs, relocation, replacement, addition to, use or maintenance of plumbing systems within this jurisdiction. The installation of fuel gas distribution piping and equipment, fuel-gas-fired water heaters and water heater venting systems shall be regulated by the International Fuel Gas Code. Provisions in the appendices shall not apply unless specifically adopted.

**P2501.2 (102.1) Application.**

In addition to the general administration requirements of Chapter 1, the administrative provisions of this chapter shall also apply to the plumbing requirements of Chapters 25 through 32.

**P2501.3 Intent.**

The purpose of this code is to establish minimum standards to provide a reasonable level of safety, health, property protection and public welfare by regulating and controlling the design, construction, installation, quality of materials, location, operation and maintenance or use of plumbing equipment and systems.

**P2501.4 Severability.**

If any section, subsection, sentence, clause or phrase of this code is for any reason held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this code.

**P2501.5 Appendices.**

Provisions in the appendices shall not apply unless specifically adopted or referenced in this
P2501.6 Requirements of other State agencies, occupational licensing board or commissions.
The North Carolina State Building Codes do not include all additional requirements for buildings and structures that may be imposed by other State agencies, occupational licensing boards and commissions. It shall be the responsibility of a permit holder, design professional, contractor or occupational license holder to determine whether any additional requirements exist.

SECTION P2502
EXISTING PLUMBING SYSTEMS

P2502.1 Existing building sewers and building drains.
Where the entire sanitary drainage system of an existing building is replaced, existing building drains under concrete slabs and existing building sewers that will serve the new system shall be internally examined to verify that the piping is sloping in the correct direction, is not broken, is not obstructed and is sized for the drainage load of the new plumbing drainage system to be installed. Plumbing systems lawfully in existence at the time of the adoption of this code shall be permitted to have their use and maintenance continued if the use, maintenance or repair is in accordance with the original design and hazard to life, health or property is not created by such plumbing system.

P2502.2 Additions, alterations or repairs.
Additions, alterations, renovations or repairs to any plumbing system shall conform to that required for a new plumbing system without requiring the existing plumbing system to comply with the requirements of this code. Additions, alterations or repairs shall not cause an existing system to become unsafe, insanitary or overloaded.

Minor additions, alterations, renovations and repairs to existing plumbing systems shall be permitted in the same manner and arrangement as in the existing system, provided that such repairs or replacement are not hazardous and are approved.

P2502.3 Change in occupancy.
It shall be unlawful to make any change in the occupancy of any structure that will subject the structure to any special provision of this code applicable to the new occupancy without approval of the code official. The code official shall certify that such structure meets the intent of the provisions of law governing building construction for the proposed new occupancy and that such change of occupancy does not result in any hazard to the public health, safety or welfare.

P2502.4 Historic buildings.
The provisions of this code relating to the construction, alteration, repair, enlargement, restoration, relocation or moving of buildings or structures shall not be mandatory for existing buildings or structures identified and classified by the state or local jurisdiction as historic buildings where such buildings or structures are judged by the code official to be safe and in the public interest of health, safety and welfare regarding any proposed construction, alteration, repair, enlargement, restoration, relocation or moving of buildings.

P2502.5 Moved buildings.
Except as determined by Section P2502.1, plumbing systems that are a part of buildings or structures moved into or within the jurisdiction shall comply with the provisions of this code for
new installations.

**P2502.6 Referenced codes and standards.**
The codes and standards referenced in this code shall be those that are listed in Chapter 44 and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections P2502.6.1 and P2502.6.2.

**P2502.6.1 Conflicts.**
Where conflicts occur between provisions of this code and the referenced standards, the provisions of this code shall apply.

**P2502.6.2 Provisions in referenced codes and standards.**
Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code the provisions of this code shall be the minimum requirements.

**P2502.7 Requirements not covered by code.**
Any requirements necessary for the strength, stability or proper operation of an existing or proposed plumbing system, or for the public safety, health and general welfare, not specifically covered by this code shall be determined by the code official.

**P2502.8 Other laws.**
The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.

**P2502.9 Application of references.**
Reference to chapter section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

SECTION P2503
INSPECTION AND TESTS

**P2503.1 Inspection required.**
New plumbing work and parts of existing systems affected by new work or alterations shall be inspected by the building official to ensure compliance with the requirements of this code.

**P2503.2 Concealment.**
A plumbing or drainage system, or part thereof, shall not be covered, concealed or put into use until it has been tested, inspected and approved by the building official.

**P2503.3 (312.1) Responsibility of permittee.**
Test equipment, materials and labor shall be furnished by the permittee. The permit holder shall make the applicable tests prescribed in Sections P2503.4 through P2503.8 to determine compliance with the provisions of this code. The permit holder shall give reasonable advance notice to the code official when the plumbing work is ready for tests. The equipment, material, power and labor necessary for the inspection and test shall be furnished by the permit holder and the permit holder shall be responsible for determining that the work will withstand the test pressure prescribed in the following tests. All plumbing system piping shall be tested with either water or by air. After the plumbing fixtures have been set and their traps filled with water, the
entire drainage system shall be submitted to final tests. The code official shall require the removal of any cleanouts if necessary to ascertain whether the pressure has reached all parts of the system.

P2503.4 Building sewer testing. Deleted.
The building sewer shall be tested by insertion of a test plug at the point of connection with the public sewer, filling the building sewer with water and pressurizing the sewer to not less than 10-foot (3048 mm) head of water. The test pressure shall not decrease during a period of not less than 15 minutes. The building sewer shall be watertight at all points.

A forced sewer test shall consist of pressurizing the piping to a pressure of not less than 5 psi (34.5 kPa) greater than the pump rating and maintaining such pressure for not less than 15 minutes. The forced sewer shall be water tight at all points.

P2503.5 Drain, waste and vent systems testing.
Rough-in and finished plumbing installations of drain, waste and vent systems shall be tested in accordance with Sections P2503.5.1 and P2503.5.2.

P2503.5.1 Rough plumbing.
DWV systems shall be tested on completion of the rough piping installation by water or, for piping systems other than plastic, by air, without evidence of leakage. Either test shall be applied to the drainage system in its entirety or in sections after rough-in piping has been installed, as follows:

1. Water test. Each section shall be filled with water to a point not less than 5 feet (1524 mm) above the highest fitting connection in that section, or to the highest point in the completed system. Water shall be held in the section under test for a period of 15 minutes. The system shall prove leak free by visual inspection. A water test shall be applied to the drainage system within the building either in its entirety or in sections. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening shall be tightly plugged except the highest openings of the section under test, and each section shall be filled with water, but no section shall be tested with less than a 10-foot (3048 mm) head of water. In testing successive sections, at least the upper 10 feet (3048 mm) of the next preceding section shall be tested so that no joint or pipe in the building, except the uppermost 10 feet (3048 mm) of the system, shall have been submitted to a test of less than a 10-foot (3048 mm) head of water. This pressure shall be held for not less than 15 minutes. The system shall then be tight at all points.

Exception: Rough plumbing testing for one- and two-family dwellings shall be as specified above except the water level shall be a minimum of 3 feet (914 mm) above the highest drainage fitting. Under slab piping systems shall be tested with a minimum of 10 feet (3048 mm) of head.

2. Air test. The portion under test shall be maintained at a gauge pressure of 5 pounds per square inch (psi) (34 kPa) or 10 inches of mercury column (34 kPa). This pressure shall be held without introduction of additional air for a period of 15 minutes. Drainage and vent air test. An air test shall be made by forcing air into the system until there is a uniform gauge pressure of 5 psi (34.5 kPa) or sufficient to balance a 10-inch (254 mm)
column of mercury. This pressure shall be held for a test period of not less than 15 minutes. Any adjustments to the test pressure required because of changes in ambient temperatures or the seating of gaskets shall be made prior to the beginning of the test period.

P2503.5.2 Finished plumbing.
After the plumbing fixtures have been set and their traps filled with water, their connections shall be tested and proved gas tight or water tight as follows:

1. Water tightness. Each fixture shall be filled and then drained. Traps and fixture connections shall be proven water tight by visual inspection.

2. Gas tightness. Where required by the local administrative authority, a final test for gas tightness of the DWV system shall be made by the smoke or peppermint test as follows:

   2.1. Smoke test. Introduce a pungent, thick smoke into the system. When the smoke appears at vent terminals, such terminals shall be sealed and a pressure equivalent to a 1-inch water column (249 Pa) shall be applied and maintained for a test period of not less than 15 minutes.

   2.2. Peppermint test. Introduce 2 ounces (59 mL) of oil of peppermint into the system. Add 10 quarts (9464 mL) of hot water and seal the vent terminals. The odor of peppermint shall not be detected at any trap or other point in the system.

P2503.6 Shower liner or pan test.
Where shower floors and receptors are made water tight by the application of materials required by Section P2709.2, the completed liner installation shall be tested. The pipe from the shower drain shall be plugged water tight for the test. The floor and receptor area shall be filled with potable water to a depth of not less than 2 inches (51 mm) measured at the threshold. Where a threshold of not less than 2 inches (51 mm) in height does not exist, a temporary threshold shall be constructed to retain the test water in the lined floor or receptor area to a level not less than 2 inches (51 mm) in depth measured at the threshold. The water shall be retained for a test period of not less than 15 minutes and there shall not be evidence of leakage.

P2503.7 Water-supply system testing.
Upon completion of the water-supply system or a section of it, the system or portion completed shall be tested and proved tight under a water pressure of not less than the working pressure of the system or, for piping systems other than plastic, by an air test of not less than 50 psi (345 kPa). This pressure shall be held for not less than 15 minutes. The water used for tests shall be obtained from a potable water source. Upon completion of a section of or the entire water distribution system, the system, or portion completed, shall be tested and proved tight under a water or air test of not less than 100 psi (688 kPa). Repaired sections of existing water systems shall be tested at existing operating pressure. This pressure shall be held for not less than 15 minutes. The water utilized for tests shall be obtained from a potable source of supply. The required tests shall be performed in accordance with this section.
P2503.8 Inspection and testing of backflow prevention devices. Deleted.
Inspection and testing of backflow prevention devices shall comply with Sections P2503.8.1 and P2503.8.2.

**P2503.8.1 Inspections.**
Inspections shall be made of backflow prevention assemblies to determine whether they are operable.

**P2503.8.2 Testing.**
Reduced pressure principle, double check, double check detector and pressure vacuum breaker backflow preventer assemblies shall be tested at the time of installation, immediately after repairs or relocation and every year thereafter.

P2503.9 (312.1.1) Test gauges.
Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 psi or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.

2. Tests requiring a pressure higher than 10 psi (0.69 kPa) but less than or equal to 100 psi (690 kPa) shall use a testing gauge having increments of 1 psi (6.9 kPa) or less.

3. Tests requiring a pressure higher than 100 psi (690 kPa) shall use a testing gauge having increments of 2 psi (14 kPa) or less.

SECTION P2504
APPROVAL

P2504.1 Modifications.
Where there are practical difficulties involved in carrying out the provisions of this code, the code official shall have the authority to grant modifications for individual cases, upon application of the owner or owner’s authorized agent, provided the code official shall first find that special individual reason makes the strict letter of this code impractical and the modification conforms to the intent and purpose of this code and that such modification does not lessen health, life and fire safety requirements. The details of action granting modifications shall be recorded and entered in the files of the plumbing inspection department.

P2504.2 Alternative materials, methods and equipment.
The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material or method of construction shall be approved where the code official finds that the proposed alternative material, method or equipment complies with the intent of the provisions of this code and is not less than the equivalent of that prescribed in this code. Where the alternative material, design or method of construction is not approved, the code official shall respond in writing, stating the reasons why the alternative was not approved.

P2504.2.1 Research reports.
Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from approved
P2504.3 Required testing.
Where there is insufficient evidence of compliance with the provisions of this code, or evidence
that a material or method does not conform to the requirements of this code, or in order to
substantiate claims for alternate materials or methods, the code official shall have the authority
to require tests as evidence of compliance to be made at no expense to the jurisdiction.

P2504.3.1 Test methods.
Test methods shall be as specified in this code or by other recognized test standards. In the
absence of recognized and accepted test methods, the code official shall approve the
testing procedures.

P2504.3.2 Testing agency.
Tests shall be performed by an approved agency.

P2504.3.3 Test reports.
Reports of tests shall be retained by the code official for the period required for retention of
public records.

P2504.4 Alternative engineered design.
The design, documentation, inspection, testing and approval of an alternative engineered
design plumbing system shall comply with Sections P2504.4.1 through P2504.4.6.

P2504.4.1 Design criteria.
An alternative engineered design shall conform to the intent of the provisions of this code
and shall provide an equivalent level of quality, strength, effectiveness, fire resistance,
durability and safety. Material, equipment or components shall be designed and installed in
accordance with the manufacturer’s installation instructions.

P2504.4.2 Submittal.
The registered design professional shall indicate on the permit application that the plumbing
system is an alternative engineered design. The permit and permanent permit records shall
indicate that an alternative engineered design was part of the approved installation.

P2504.4.3 Technical data.
The registered design professional shall submit sufficient technical data to substantiate the
proposed alternative engineered design and to prove that the performance meets the intent
of this code.

P2504.4.4 Construction documents.
The registered design professional shall submit to the code official two complete sets of
signed and sealed construction documents for the alternative engineered design. The
construction documents shall include floor plans and a riser diagram of the work. Where
appropriate, the construction documents shall indicate the direction of flow, all pipe sizes,
grade of horizontal piping, loading, and location of fixtures and appliances.

P2504.4.5 Design approval.
Where the code official determines that the alternative engineered design conforms to the
intent of this code, the plumbing system shall be approved. If the alternative engineered
design is not approved, the code official shall notify the registered design professional in
writing, stating the reasons thereof.

**P2504.4.6 Inspection and testing.**
The *alternative engineered design* shall be tested and inspected in accordance with the requirements of Section P2503.

**P2504.5 Approved materials and equipment.**
Materials, equipment and devices *approved* by the code official shall be constructed and installed in accordance with such approval.

**P2504.5.1 Material and equipment reuse.**
Materials, equipment and devices shall not be reused unless such elements have been reconditioned, tested, placed in good and proper working condition and *approved*.

### SECTION P2505
TEMPORARY EQUIPMENT, SYSTEMS AND USES

**P2505.1 General.**
The code official is authorized to issue a permit for temporary equipment, systems and uses. Such permits shall be limited as to time of service, but shall not be permitted for more than 180 days. The code official is authorized to grant extensions for demonstrated cause.

**P2505.2 Conformance.**
Temporary equipment, systems and uses shall conform to the structural strength, fire safety, means of egress, accessibility, light, ventilation and sanitary requirements of this code as necessary to ensure the public health, safety and general welfare.

**P2505.3 Temporary utilities.**
The code official is authorized to give permission to temporarily supply utilities before an installation has been fully completed and the final certificate of completion has been issued. The part covered by the temporary certificate shall comply with the requirements specified for temporary lighting, heat or power in the code.

**P2505.4 Termination of approval.**
The code official is authorized to terminate such permit for temporary equipment, systems or uses and to order the temporary equipment, systems or uses to be discontinued.

**P2505.5 (311.1)Toilet Facilities**
Toilet facilities shall be provided for construction workers in accordance with the table below and such facilities shall be maintained in a sanitary condition. Construction worker toilet facilities of the non-sewer type shall conform to ANSI Z4.3.

<table>
<thead>
<tr>
<th>Number of Employees</th>
<th>Minimum Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 20</td>
<td>1 toilet</td>
</tr>
<tr>
<td>20 to 200</td>
<td>1 toilet &amp; 1 urinal per 40 workers</td>
</tr>
<tr>
<td>More than 200</td>
<td>1 toilet &amp; urinal per 50 workers</td>
</tr>
</tbody>
</table>

There shall be at least one facility for every two contiguous construction sites. Such facilities may be portable, enclosed, chemically treated, tank-tight units. Portable toilets shall be enclosed, screened and weatherproofed with internal latches. Temporary toilet facilities need not be provided on site for crews on a job site for no more than one working day and having
transportation readily available to toilet facilities.
CHAPTER 26
GENERAL PLUMBING REQUIREMENTS

User note: Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.

The text of this chapter is extracted from the 2018 edition of the North Carolina Plumbing Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Plumbing Code.

SECTION P2601
GENERAL

P2601.1 (301.1) Scope.  
The provisions of this chapter shall govern the installation of plumbing not specifically covered in other chapters applicable to plumbing systems. The installation of plumbing, appliances, equipment and systems not addressed by this code shall comply with the applicable provisions of the International Plumbing Code.

P2601.2 (301.3) Connections to drainage system.  
Plumbing fixtures, drains, appurtenances and appliances used to receive or discharge liquid wastes or sewage shall be directly connected to the sanitary drainage system of the building or premises, in accordance with the requirements of this code. This section shall not be construed to prevent indirect waste connections where required by the code.

Exception: Bathtubs, showers, lavatories, clothes washers and laundry trays shall not be required to discharge to the sanitary drainage system where such fixtures discharge to systems complying with Sections P2910 and P2911. All drain, waste and vent piping associated with gray water or rain water recycling systems shall be installed in compliance with this code.

P2601.3 Flood hazard areas.  
In flood hazard areas as established by Table R301.2(1), plumbing fixtures, drains, and appliances shall be located or installed in accordance with Section R322.1.6.

SECTION P2602
INDIVIDUAL WATER SUPPLY AND SEWAGE DISPOSAL

P2602.1 General.  
The water-distribution and drainage system of any building or premises where plumbing fixtures are installed shall be connected to a public water supply or sewer system, respectively, if
available. Where either a public water-supply or sewer system, or both, are not available, or connection to them is not feasible, an individual water supply or individual (private) sewage-disposal system, or both, shall be provided.

**Exception:** All drain, waste and vent piping associated with gray water or rain water recycling systems shall be installed in compliance with this code.

**P2602.2 (309.2) Flood-resistant installation.**
In flood hazard areas as established by Table R301.2(1):

1. Water supply systems shall be designed and constructed to prevent infiltration of floodwaters.

2. Pipes for sewage disposal systems shall be designed and constructed to prevent infiltration of floodwaters into the systems and discharges from the systems into floodwaters.

**SECTION P2603**  
**STRUCTURAL AND PIPING PROTECTION**

**P2603.1 General.**
In the process of installing or repairing any part of a plumbing and drainage installation, the finished floors, walls, ceilings, tile work or any other part of the building or premises that must be changed or replaced shall be left in a safe structural condition in accordance with the requirements of the building portion of this code.

**P2603.2 Drilling and notching.**
Wood-framed structural members shall not be drilled, notched or altered in any manner except as provided in Sections R502.8, R602.6, R802.7 and R802.7.1. Holes in load-bearing members of cold-formed steel light-frame construction shall be made only in accordance with Sections R505.2.6, R603.2.6 and R804.2.6. In accordance with the provisions in Sections R505.3.5, R603.3.3 and R804.3.4, cutting and notching of flanges and lips of load-bearing members of cold-formed steel light-frame construction shall be prohibited. Structural insulated panels (SIPs) shall be drilled and notched or altered in accordance with the provisions of Section R613.7.

**P2603.2.1 Protection against physical damage.**
In concealed locations, where piping, other than cast-iron or galvanized steel, is installed through holes or notches in studs, joists, rafters or similar members less than 11/4 inches (31.8 mm) from the nearest edge of the member, the pipe shall be protected by steel shield plates. Such shield plates shall have a thickness of not less than 0.0575 inch (1.463 mm) (No. 16 Gage). Such plates shall cover the area of the pipe where the member is notched or bored, and shall extend not less than 2 inches (51 mm) above sole plates and below top plates.

**P2603.3 (305.1) Protection against corrosion.**
Metallic piping, except for cast iron, ductile iron and galvanized steel, shall not be placed in direct contact with steel framing members, concrete or masonry. Metallic piping shall not be placed in direct contact with corrosive soil. Where sheathing is used to prevent direct contact, the sheathing material thickness shall be not less than 0.008 inch (8 mil) (0.203 mm) and shall
be made of plastic. Where sheathing protects piping that penetrates concrete or masonry walls or floors, the sheathing shall be installed in a manner that allows movement of the piping within the sheathing. Pipes passing through concrete or cinder walls and floors or other corrosive material shall be protected against external corrosion by a protective sheathing or wrapping or other means that will withstand any reaction from the lime and acid of concrete, cinder or other corrosive material. Sheathing or wrapping shall allow for movement including expansion and contraction of piping. The wall thickness of the material shall be not less than 0.025 inch (0.64 mm).

P2603.4 (305.3) Pipes through foundation walls. Pipes through or under footings or foundation walls
A pipe that passes through a foundation wall shall be provided with a relieving arch, or a pipe sleeve shall be built into the foundation wall. The sleeve shall be two pipe sizes greater than the pipe passing through the wall. Any pipe that passes within 12 inches (305 mm) of the bottom of the footing or through a foundation wall shall be provided with a relieving arch or a pipe sleeve. Pipe sleeves for foundation walls shall be built into the foundation wall. The sleeve shall be two pipe sizes greater than the pipe passing through the wall. Piping shall not be run under pier footings (refer to Section P2604). Annular spaces between sleeves and pipes shall be filled or tightly sealed in an approved manner. Annular spaces between sleeves and pipes in fire-resistance-rated assemblies shall be filled or tightly sealed in accordance with the North Carolina Building Code. Only sleeves through foundation or exterior building walls shall be sealed on both sides.

P2603.5 Freezing.
In localities having a winter design temperature of 32°F (0°C) or lower as shown in Table R301.2(1) of this code, a water, soil or waste pipe shall not be installed outside of a building, in exterior walls, in attics or crawl spaces, or in any other place subjected to freezing temperature unless adequate provision is made to protect it from freezing by insulation or heat or both. Water service pipe shall be installed not less than 12 inches (305 mm) deep and not less than 6 inches (152 mm) below the frost line. Water pipes installed in a wall exposed to the exterior shall be located on the heated side of the wall insulation. In other cases water, soil and waste pipes shall not be installed outside of a building, in unconditioned attics, unconditioned utility rooms or in any other place subjected to freezing temperatures unless adequate provision is made to protect such pipes from freezing by a minimum of R-6.5 insulation determined at 75°F (24°C) in accordance with ASTM C-177 or heat or both.

Exterior water supply system piping shall be installed not less than 6 inches (152 mm) below the frost line and not less than 12 inches (305 mm) below grade.

Note: These provisions are minimum requirements, which have been found suitable for normal weather conditions. Abnormally low temperatures for extended periods may require additional provisions to prevent freezing.

P2603.5.1 Sewer depth.
Building sewers that connect to private sewage disposal systems shall be installed not less than [NUMBER] 3 inches (76.2 mm) below finished grade at the point of septic tank connection. Building sewers shall be not less than [NUMBER] 3 inches (76.2 mm) below grade.
SECTION P2604
TRENCHING AND BACKFILLING

P2604.1 (306.2) Trenching and bedding.
Where trenches are excavated such that the bottom of the trench forms the bed for the pipe, solid and continuous load-bearing support shall be provided between joints. Where over-excavated, the trench shall be backfilled to the proper grade with compacted earth, sand, fine gravel or similar granular material. Piping shall not be supported on rocks or blocks at any point. Rocky or unstable soil shall be over-excavated by two or more pipe diameters and brought to the proper grade with suitable compacted granular material. Where trenches are excavated such that the bottom of the trench forms the bed for the pipe, solid and continuous load-bearing support shall be provided between joints. Bell holes, hub holes and coupling holes shall be provided at points where the pipe is joined. Such pipe shall not be supported on blocks to grade. In instances where the materials manufacturer’s installation instructions are more restrictive than those prescribed by the code, the material shall be installed in accordance with the more restrictive requirement.

P2604.1.1 Over-excavation.
Where trenches are excavated below the installation level of the pipe such that the bottom of the trench does not form the bed for the pipe, the trench shall be backfilled to the installation level of the bottom of the pipe with sand or fine gravel placed in layers not greater than 6 inches (152 mm) in depth and such backfill shall be compacted after each placement.

P2604.1.2 Rock removal.
Where rock is encountered in trenching, the rock shall be removed to not less than 3 inches (76 mm) below the installation level of the bottom of the pipe, and the trench shall be backfilled to the installation level of the bottom of the pipe with sand tamped in place so as to provide uniform load-bearing support for the pipe between joints. The pipe, including the joints, shall not rest on rock at any point.

P2604.1.3 Soft load-bearing materials.
If soft materials of poor load-bearing quality are found at the bottom of the trench, stabilization shall be achieved by over excavating not less than two pipe diameters and backfilling to the installation level of the bottom of the pipe with fine gravel, crushed stone or a concrete foundation. The concrete foundation shall be bedded with sand tamped into place so as to provide uniform load-bearing support for the pipe between joints.

P2604.2 Water service and building sewer in same trench.
Where the water service piping and building sewer piping is installed in same trench, the installation shall be in accordance with Section P2906.4.1.

P2604.3 Backfilling.
Backfill shall be free from discarded construction material and debris. Backfill shall be free from rocks, broken concrete and frozen chunks until the pipe is covered by not less than 12 inches (305 mm) of tamped earth. Backfill shall be placed evenly on both sides of the pipe and tamped to retain proper alignment. Loose earth shall be carefully placed in the trench in 6-inch (152 mm) layers and tamped in place.
P2604.4 Protection of footings.
Trenching installed parallel to footings and walls shall not extend into the bearing plane of a footing or wall. The upper boundary of the bearing plane is a line that extends downward, at an angle of 45 degrees from horizontal, from the outside bottom edge of the footing or wall.

SECTION P2605
SUPPORT

P2605.1 General.
Piping shall be supported in accordance with the following:

1. Piping shall be supported to ensure alignment and prevent sagging, and allow movement associated with the expansion and contraction of the piping system.

2. Piping in the ground shall be laid on a firm bed for its entire length, except where support is otherwise provided.

3. Hangers and anchors shall be of sufficient strength to maintain their proportional share of the weight of pipe and contents and of sufficient width to prevent distortion to the pipe. Hangers and strapping shall be of approved material that will not promote galvanic action. Rigid support sway bracing shall be provided at changes in direction greater than 45 degrees (0.79 rad) for pipe sizes 4 inches (102 mm) and larger.

4. Piping shall be supported at distances not to exceed those indicated in Table P2605.1.

| TABLE P2605.1 |
| PIPING SUPPORT |

<table>
<thead>
<tr>
<th>PIPING MATERIAL</th>
<th>MAXIMUM HORIZONTAL SPACING (feet)</th>
<th>MAXIMUM VERTICAL SPACING (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS pipe</td>
<td>4</td>
<td>10^b</td>
</tr>
<tr>
<td>Aluminum tubing</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Cast-iron pipe</td>
<td>5^a</td>
<td>15</td>
</tr>
<tr>
<td>Copper or copper alloy pipe</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Copper or copper alloy tubing (1 1/4 inches in diameter and smaller)</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Copper or copper alloy tubing (1 1/2 inches in diameter and larger)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX) pipe, 1 inch and smaller</td>
<td>2.67 (32 inches)</td>
<td>10^b</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX) pipe, 1 1/4 inch and larger</td>
<td>4</td>
<td>10^b</td>
</tr>
<tr>
<td>Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe</td>
<td>2.67 (32 inches)</td>
<td>10^b</td>
</tr>
<tr>
<td>CPVC pipe or tubing (1 inch in diameter and smaller)</td>
<td>3</td>
<td>10^b</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
CPVC pipe or tubing (1 \( \frac{1}{4} \) inches in diameter and larger) & 4 & 10\textsuperscript{b} \\
Lead pipe & Continuous & 4 \\
PB pipe or tubing & 2.67 (32 inches) & 4 \\
Polyethylene of raised temperature (PE-RT) pipe, 1 inch and smaller & 2.67 (32 inches) & 10\textsuperscript{b} \\
Polyethylene of raised temperature (PE-RT) pipe, 1 \( \frac{1}{4} \) inch and larger & 4 & 10\textsuperscript{b} \\
Polypropylene (PP) pipe or tubing (1 inch and smaller) & 2.67 (32 inches) & 10\textsuperscript{b} \\
Polypropylene (PP) pipe or tubing (1 \( \frac{1}{4} \) inches and larger) & 4 & 10\textsuperscript{b} \\
PVC pipe & 4 & 10\textsuperscript{b} \\
Stainless steel drainage systems & 10 & 10\textsuperscript{b} \\
Steel pipe & 12 & 15 \\

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. The maximum horizontal spacing of cast-iron pipe hangers shall be increased to 10 feet where 10-foot lengths of pipe are installed.
b. For sizes 2 inches and smaller, a guide shall be installed midway between required vertical supports. Such guides shall prevent pipe movement in a direction perpendicular to the axis of the pipe.

SECTION P2606
PENETRATIONS

P2606.1 (315.1) Sealing of annular spaces.
The annular space between the outside of a pipe and the inside of a pipe sleeve or between the outside of a pipe and an opening in a building envelope wall, floor, or ceiling assembly penetrated by a pipe shall be sealed with caulking material or foam sealant or closed with a gasketing system. The caulking material, foam sealant or gasketing system shall be designed for the conditions at the penetration location and shall be compatible with the pipe, sleeve and building materials in contact with the sealing materials. Annular spaces created by pipes penetrating fire-resistance-rated assemblies or membranes of such assemblies shall be sealed or closed in accordance with the building portion of this code.

SECTION P2607
WATERPROOFING OF OPENINGS

P2607.1 (305.5) Pipes penetrating roofs.
Where a pipe penetrates a roof, a flashing of lead, copper, galvanized steel or an approved elastomeric material shall be installed in manner that prevents water entry into the building. Counterflushing into the opening of pipe serving as a vent terminal shall not reduce the required internal cross-sectional area of the vent pipe to less than the internal cross-sectional area of one pipe size smaller. Joints at the roof and around vent pipes shall be made watertight by the use of lead, copper, galvanized steel, aluminum, plastic or other approved flashings or flashing material.
P2607.2 (305.5) Pipes penetrating exterior walls.
Where a pipe penetrates an exterior wall, a waterproof seal shall be made on the exterior of the wall by one of the following methods:

1. A waterproof sealant applied at the joint between the wall and the pipe.

2. A flashing of an approved elastomeric material.

SECTION P2608
WORKMANSHIP

P2608.1 General.
Valves, pipes and fittings shall be installed in correct relationship to the direction of the flow. Burred ends shall be reamed to the full bore of the pipe.

SECTION P2609
MATERIALS EVALUATION AND LISTING

P2609.1 Identification.
Each length of pipe and each pipe fitting, trap, fixture, material and device utilized in a plumbing system shall bear the identification of the manufacturer and any markings required by the applicable referenced standards. Nipples created from the cutting and threading of approved pipe shall not be required to be identified.

Exception: Where the manufacturer identification cannot be marked on pipe fittings and pipe nipples because of the small size of such fittings, the identification shall be printed on the item packaging or on documentation provided with the item.

P2609.2 Installation of materials.
Materials used shall be installed in strict accordance with the standards under which the materials are accepted and approved. In the absence of such installation procedures, the manufacturer's instructions shall be followed. Where the requirements of referenced standards or manufacturer's instructions do not conform to the minimum provisions of this code, the provisions of this code shall apply.

P2609.2.1 (402.2) Materials for specialty fixtures.
Materials for specialty fixtures not otherwise covered in this code shall be of stainless steel, soapstone, chemical stoneware or plastic, or shall be lined with lead, copper-base alloy, nickel-copper alloy, corrosion-resistant steel or other material especially suited to the application for which the fixture is intended.

P2609.2.2 (402.3) Sheet copper.
Sheet copper for general applications shall conform to ASTM B 152 and shall not weigh less than 12 ounces per square foot (3.7 kg/m²).

P2609.2.3 (402.4) Sheet lead.
Sheet lead for pans shall not weigh less than 4 pounds per square foot (19.5 kg/m²) and shall be coated with an asphalt paint or other approved coating.
P2609.3 Plastic pipe, fittings and components.
Plastic pipe, fittings and components shall be third-party certified as conforming to NSF 14.

P2609.4 Third-party certification.
Plumbing products and materials required by the code to be in compliance with a referenced standard shall be listed by a third-party certification agency as complying with the referenced standards. Products and materials shall be identified in accordance with Section P2609.1.

P2609.5 Water supply systems.
Water service pipes, water distribution pipes and the necessary connecting pipes, fittings, control valves, faucets and appurtenances used to dispense water intended for human ingestion shall be evaluated and listed as conforming to the requirements of NSF 61.
CHAPTER 27
PLUMBING FIXTURES

User note: Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.

The text of this chapter is extracted from the 2018 edition of the North Carolina Plumbing Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Plumbing Code.

SECTION P2701
FIXTURES, FAUCETS AND FIXTURE FITTINGS

P2701.1 (402.1) Quality of fixtures.
Plumbing fixtures, faucets and fixture fittings shall have smooth impervious surfaces, shall be free from defects, shall not have concealed fouling surfaces, and shall conform to the standards indicated in Table P2701.1 and elsewhere in this code. All porcelain enameled surfaces on plumbing fixtures shall be acid resistant.

TABLE P2701.1
PLUMBING FIXTURES, FAUCETS AND FIXTURE FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air gap fittings for use with plumbing fixtures, appliances and appurtenances</td>
<td>ASME A 112.1.3</td>
</tr>
<tr>
<td>Bathtub/whirlpool pressure-sealed doors</td>
<td>ASME A 112.19.15</td>
</tr>
<tr>
<td>Diverters for faucets with hose spray, anti-syphon type, residential application</td>
<td>ASTM A 112.18.1/CSA B125.1</td>
</tr>
<tr>
<td>Enameled cast-iron plumbing fixtures</td>
<td>ASME A 112.19.1M/CSA B45.2</td>
</tr>
<tr>
<td>Floor drains</td>
<td>ASME A 112.6.3</td>
</tr>
<tr>
<td>Floor-affixed supports for off-the-floor plumbing fixtures for public use</td>
<td>ASME A 112.6.1M</td>
</tr>
<tr>
<td>Framing-affixed supports for off-the-floor water closets with concealed tanks</td>
<td>ASME A 112.6.2</td>
</tr>
<tr>
<td>Hose connection vacuum breaker</td>
<td>ASSE 1052</td>
</tr>
<tr>
<td>Hot water dispensers, household storage type, electrical</td>
<td>ASSE 1023</td>
</tr>
<tr>
<td>Household disposers</td>
<td>ASSE 1008</td>
</tr>
<tr>
<td>Hydraulic performance for water closets and urinals</td>
<td>ASME A 112.19.2/CSA B45.1</td>
</tr>
<tr>
<td>Individual automatic compensating valves for individual fixture fittings</td>
<td>ASME A 112.18.1/CSA B125.1</td>
</tr>
<tr>
<td>Individual shower control valves anti-scald</td>
<td>ASSE 1016/ASME A 112.1016/CSA B125.16</td>
</tr>
<tr>
<td>Macerating toilet systems and related components</td>
<td>ASME A 112.3.4/CSA B45.9</td>
</tr>
<tr>
<td>Nonvitreous ceramic plumbing fixtures</td>
<td>ASME A 112.19.2/CSA B45.1</td>
</tr>
<tr>
<td>Plastic bathtub units</td>
<td>CSA B45.5/IAPMO Z124, ASME A112.19.2/CSA B45.1</td>
</tr>
<tr>
<td>Plastic lavatories</td>
<td>CSA B45.5/IAPMO Z124</td>
</tr>
<tr>
<td>Plastic shower receptors and shower stall</td>
<td>CSA B45.5/IAPMO Z124</td>
</tr>
</tbody>
</table>
SECTION P2702
FIXTURE ACCESSORIES

P2702.1 (802.3.3) Plumbing fixtures.
Plumbing fixtures, other than water closets, shall be provided with approved strainers.

Exception: Hub drains receiving only clear water waste and standpipes shall not require strainers.

P2702.2 Waste fittings.
Waste fittings shall conform to ASME A112.18.2/CSA B125.2, ASTM F 409 or shall be made from pipe and pipe fittings complying with any of the standards indicated in Tables P3002.1(1) and P3002.3.

P2702.3 Plastic tubular fittings.
Plastic tubular fittings shall conform to ASTM F 409 as indicated in Table P2701.1.

P2702.4 (405.4.3) Carriers for wall-hung water closets.
Wall hung water closet bowls shall be supported by a concealed metal carrier that is attached to the building structural members so that strain is not transmitted to the closet connector or any other part of the plumbing system. Carriers for wall-hung water closets shall conform to ASME A112.6.1 or ASME A112.6.2.
P2703.1 Minimum size.
Fixture tail pieces shall be not less than $1\frac{1}{2}$ inches (38 mm) in diameter for sinks, dishwashers, laundry tubs, bathtubs and similar fixtures, and not less than $1\frac{1}{4}$ inches (32 mm) in diameter for bidets, lavatories and similar fixtures.

SECTION P2704
ACCESS TO CONNECTIONS

P2704.1 (405.8) General.
Slip joints shall be made with an approved elastomeric gasket and shall be installed only on the trap outlet, trap inlet and within the trap seal. Fixtures with concealed slip-joint connections shall be provided with an access panel or utility space not less than 12 inches (305 mm) in its smallest dimension or other approved arrangement so as to provide access to the slip connections for inspection and repair. Where such access cannot be provided, access doors shall not be required, provided that all joints are soldered, solvent cemented or screwed to form a solid connection.

SECTION P2705
INSTALLATION

P2705.1 General.
The installation of fixtures shall conform to the following:

1. Floor-outlet or floor-mounted fixtures shall be secured to the drainage connection and to the floor, where so designed, by screws, bolts, washers, nuts and similar fasteners of copper, copper alloy or other corrosion-resistant material.

2. Wall-hung fixtures shall be rigidly supported so that strain is not transmitted to the plumbing system.

3. Where fixtures come in contact with walls and floors, the contact area shall be sealed water tight.

4. Plumbing fixtures shall be usable.

5. Water closets, lavatories and bidets. A water closet, lavatory or bidet shall not be set closer than 15 inches (381 mm) from its center to any side wall, partition or vanity or closer than 30 inches (762 mm) center-to-center between adjacent fixtures. There shall be a clearance of not less than 21 inches (533 mm) in front of a water closet, lavatory or bidet to any wall, fixture or door. See Figure R307.1 for minimum fixture clearances.

6. The location of piping, fixtures or equipment shall not interfere with the operation of windows or doors.

7. In flood hazard areas as established by Table R301.2(1), plumbing fixtures shall be located or installed in accordance with Section R322.1.7.
8. Integral fixture-fitting mounting surfaces on manufactured plumbing fixtures or plumbing fixtures constructed on site, shall meet the design requirements of ASME A112.19.2/CSA B45.1 or ASME A112.19.3/CSA B45.4.

9. Floor flanges for water closets or similar fixtures shall be not less than 0.125 inch (3.2 mm) thick for brass, 0.25 inch (6.4 mm) thick for plastic and 0.25 inch (6.4 mm) thick and not less than a 2-inch (51 mm) caulking depth for cast iron or galvanized malleable iron. Floor flanges of hard lead shall weigh not less than 1 pound, 9 ounces (0.7 kg) and shall be composed of lead alloy with not less than 7.75-percent antimony by weight. Flanges shall be secured to the building structure with corrosion-resistant screws or bolts.

10. Where any fixture is provided with an overflow, the waste shall be designed and installed so that standing water in the fixture will not rise in the overflow when the stopper is closed, and no water will remain in the overflow when the fixture is empty. The overflow from any fixture shall discharge into the drainage system on the inlet or fixture side of the trap.

   Exception: The overflow from a flush tank serving a water closet or urinal shall discharge into the fixture served.

11. Fixtures shall be set level and in proper alignment with reference to adjacent walls.

SECTION P2706
WASTE RECEPTORS

P2706.1 General.
For other than hub drains that receive only clear-water waste and standpipes, a removable strainer or basket shall cover the waste outlet of waste receptors. Waste receptors shall not be installed in concealed spaces. Every waste receptor shall be of an approved type. A removable strainer or basket shall cover the waste outlet of waste receptors. Waste receptors shall be installed in ventilated spaces. Waste receptors shall not be installed in plenums, attics, crawl spaces or interstitial spaces above ceilings and below floors. Waste receptors shall be readily accessible.

   Exception: Hub drains.

P2706.1.1 Hub drains.
Hub drains shall be in the form of a hub or a pipe that extends not less than 1 inch (25 mm) above a water-impervious floor and shall not be required to have a strainer.

P2706.1.2 Standpipes.
Standpipes shall extend not less than 18 inches (457 mm) and not greater than 42 inches (1067 mm) above the trap weir. Standpipes shall be individually trapped. Access shall be provided to standpipes and drains for rodding. Standpipes shall be 2 inches (51 mm) in diameter and not less than 18 inches (762 mm) or more than 48 inches (1219 mm) in height as measured from the crown weir. The standpipe shall extend 34 inches (864 mm) minimum above the base of the clothes washer unless recommended otherwise by the manufacturer. The connection of a laundry tray waste line may be made into a standpipe for the automatic clothes-washer drain.
The standpipe shall extend above the flood level rim of the laundry tray. The outlet of the laundry tray shall be a maximum horizontal distance of 30 inches (762 mm) from the standpipe trap.

P2706.1.2.1 Laundry tray connection to standpipe. Deleted.
Where a laundry tray waste line connects into a standpipe for an automatic clothes washer drain, the standpipe shall extend not less than 30 inches (762 mm) above the standpipe trap weir and shall extend above the flood level rim of the laundry tray. The outlet of the laundry tray shall not be greater than 30 inches (762 mm) horizontally from the standpipe trap.

P2706.3 Prohibited waste receptors.
Plumbing fixtures that are used for washing or bathing shall not be used to receive the discharge of indirect waste piping.

Exceptions:

1. A kitchen sink trap is acceptable for use as a receptor for a dishwasher.
2. A laundry tray is acceptable for use as a receptor for a clothes washing machine.

SECTION P2707
DIRECTIONAL FITTINGS
Deleted

P2707.1 Directional fitting required.
Approved directional-type branch fittings shall be installed in fixture tailpieces receiving the discharge from food-waste disposer units or dishwashers.

SECTION P2708
SHOWERS

P2708.1 General.
Shower compartments shall have not less than 900 square inches (0.6 m²) of interior cross-sectional area. Shower compartments shall be not less than 30 inches (762 mm) in minimum dimension measured from the finished interior dimension of the shower compartment, exclusive of fixture valves, shower heads, soap dishes, and safety grab bars or rails. The minimum required area and dimension shall be measured from the finished interior dimension at a height equal to the top of the threshold and at a point tangent to its centerline and shall be continued to a height of not less than 70 inches (1778 mm) above the shower drain outlet. Hinged shower doors shall open outward. The wall area above built-in tubs having installed shower heads and in shower compartments shall be constructed in accordance with Section R702.4. Such walls shall form a water-tight joint with each other and with either the tub, receptor or shower floor.

Exceptions:

1. Fold-down seats shall be permitted in the shower, provided the required 900-square-inch (0.6 m²) dimension is maintained when the seat is in the folded-up position.
2. Shower compartments having not less than 25 inches (635 mm) in minimum dimension measured from the finished interior dimension of the compartment provided that the shower compartment has a cross-sectional area of not less than 1,300 square inches (0.838 m\(^2\)).

3. Shower compartments with prefabricated receptors conforming to the standards listed in Table P2708.1 (417.4).

4. Where load-bearing, bonded, waterproof membranes meeting ANSI A118.10 are used, integrated bonding flange drains shall be approved. Clamping devices and weep holes are not required where shower drains include an integrated bonding flange. Manufacturer’s installation instructions shall be followed to achieve a watertight seal between the bonded waterproof membrane and the integrated bonding flange drain. Integrated bonding flange drains shall conform to ASME A112.6.3, ASME A112.18.2/CSA B125.2, or CSA B79.

<table>
<thead>
<tr>
<th>TABLE P2708.1 (417.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFABRICATED SHOWER</td>
</tr>
<tr>
<td>RECEPTOR STANDARDS MATERIALS STANDARDS</td>
</tr>
<tr>
<td>Plastic shower receptors and shower stalls</td>
</tr>
<tr>
<td>Shower pans, nonmetallic</td>
</tr>
</tbody>
</table>

P2708.1.1 Access.
The shower compartment access and egress opening shall have a clear and unobstructed finished width of not less than 22 inches (559 mm).

P2708.2 (417.3) Shower drain.
Shower drains shall have an outlet size of not less than \(\frac{1}{2}\) \(\frac{1}{2}\) inches [38 51 mm] in diameter and for other than waste outlets in bathtubs, shall have removable strainers not less than 3 inches (76 mm) in diameter with strainer openings not less than 1/4 inch (6.4 mm) in least dimension. Where each shower space is not provided with an individual waste outlet, the waste outlet shall be located and the floor pitched so that waste from one shower does not flow over the floor area serving another shower. Waste outlets shall be fastened to the waste pipe in an approved manner.

Exception: Retaining pre-existing 1-1/2 inch (38 mm) in diameter waste outlets shall be permitted when removing an existing bathtub and installing a shower in its place.

P2708.3 (417.2) Water supply riser.
Water supply risers from the shower valve to the shower head outlet, whether exposed or concealed, shall be attached to the structure using support devices designed for use with the specific piping material or fittings anchored with screws with corrosion resistant screws of a minimum nominal length of 3/4 inch (19 mm).

P2708.4 (424.3) Shower control valves.
Individual shower and tub/shower combination valves shall be equipped with control valves of the pressure-balance, thermostatic-mixing or combination pressure-balance/thermostatic-mixing valve types with a high limit stop in accordance with ASSE 1016/ASME A112.1016/CSA.
B125.16. The high limit stop shall be set to limit the water temperature to not greater than 120°F (49°C), which shall be field adjusted in accordance with the manufacturer’s instructions. In-line thermostatic valves shall not be used for compliance with this section. Scald preventative valves are not required in dwelling units with individual water heaters set at 120°F (49°C).

P2708.5 Hand showers.
Hand-held showers shall conform to ASME A112.18.1/CSA B125.1. Hand-held showers shall provide backflow protection in accordance with ASME A112.18.1/CSA B125.1 or shall be protected against backflow by a device complying with ASME A112.18.3.

SECTION P2709
SHOWER RECEPTORS

P2709.1 Construction.
Where a shower receptor has a finished curb threshold, it shall be not less than 1 inch (25 mm) below the sides and back of the receptor. The curb shall be not less than 2 inches (51 mm) and not more than 9 inches (229 mm) deep when measured from the top of the curb to the top of the drain. The finished floor shall slope uniformly toward the drain not less than \( \frac{1}{4} \) unit vertical in 12 units horizontal (2-percent slope) nor more than \( \frac{1}{2} \) unit vertical per 12 units horizontal (4-percent slope) and floor drains shall be flanged to provide a water-tight joint in the floor.

P2709.2 (417.5.2) Lining required.
The adjoining walls and floor framing enclosing on-site built-up shower receptors shall be lined with one of the following materials:

1. Sheet lead. Sheet lead shall weigh not less than 4 pounds per square foot (19.5 kg/m²) and shall be coated with an asphalt paint or other approved coating. The lead sheet shall be insulated from conducting substances other than the connecting drain by 15-pound (6.80 kg) asphalt felt or an equivalent. Sheet lead shall be joined by burning.

2. Sheet copper. Sheet copper shall conform to ASTM B 152 and shall weigh not less than 12 ounces per square foot (3.7 kg/m²). The copper sheet shall be insulated from conducting substances other than the connecting drain by 15-pound (6.80 kg) asphalt felt or an equivalent. Sheet copper shall be joined by brazing or soldering.

3. Plastic liner material that complies shall be a minimum of 0.040 inch (1.02mm) thick and shall comply with ASTM D 4068 or ASTM D 4551.

4. Hot mopping in accordance with Section P2709.2.3

5. Sheet-applied load-bearing, bonded waterproof membranes that comply with ANSI A118.10.

The lining material shall extend not less than 2 inches (51 mm) beyond or around the rough jambs and not less than 2 inches (51 mm) above finished thresholds. Sheet-applied load bearing, bonded waterproof membranes shall be applied in accordance with the manufacturer’s instructions.
P2709.2.1 (417.5.2.1) PVC sheets.
Plasticized polyvinyl chloride (PVC) sheet shall be a minimum of 0.040 inch (1.02 mm) thick and shall meet the requirements of ASTM D 4551. Sheets shall be joined by solvent welding in accordance with the manufacturer’s instructions.

P2709.2.2 (417.5.2.2) Chlorinated polyethylene (CPE) sheets.
Nonplasticized chlorinated polyethylene sheet shall be a minimum of 0.040 inch (1.02 mm) thick and shall meet the requirements of ASTM D 4068. The liner shall be joined in accordance with the manufacturer’s instructions.

P2709.2.3 Hot-mopping.
Shower receptors lined by hot mopping shall be built-up with not less than three layers of standard grade Type 15 asphalt-impregnated roofing felt. The bottom layer shall be fitted to the formed subbase and each succeeding layer thoroughly hot-mopped to that below. Corners shall be carefully fitted and shall be made strong and water tight by folding or lapping, and each corner shall be reinforced with suitable webbing hot-mopped in place. Folds, laps and reinforcing webbing shall extend not less than 4 inches (102 mm) in all directions from the corner and webbing shall be of approved type and mesh, producing a tensile strength of not less than 50 pounds per inch (893 kg/m) in either direction.

P2709.2.4 Liquid-type, trowel-applied, load-bearing, bonded waterproof materials.
Liquid-type, trowel-applied, load-bearing, bonded waterproof materials shall meet the requirements of ANSI A118.10 and shall be applied in accordance with the manufacturer’s instructions.

P2709.3 Installation.
Lining materials shall be sloped a minimum of one-fourth unit vertical in 12 units horizontal (2-percent slope) to weep holes in the subdrain by means of a smooth, solidly formed subbase, shall be properly recessed and fastened to approved backing so as not to occupy the space required for the wall covering, and shall not be nailed or perforated at any point less than 1 inch (25.4 mm) above the finished threshold.

P2709.3.1 Materials.
Lead and copper linings shall be insulated from conducting substances other than the connecting drain by 15-pound (6.80 kg) asphalt felt or its equivalent. Sheet lead liners shall weigh not less than 4 pounds per square foot (19.5 kg/m^2) and shall be coated with an asphalt paint or other approved coating. Sheet copper liners shall weigh not less than 12 ounces per square foot (3.7 kg/m^2). Joints in lead and copper pans or liners shall be burned or silver brazed, respectively. Joints in plastic liner materials shall be joined in accordance with the manufacturer’s instructions.

P2709.4 Receptor drains.
An approved flanged drain shall be installed with shower subpans or linings. The flange shall be placed flush with the subbase and be equipped with a clamping ring or other device to make a water-tight connection between the lining and the drain. The flange shall have weep holes into the drain.

SECTION P2710
SHOWER WALLS
P2710.1 Bathtub and shower spaces.
Walls in shower compartments and walls above bathtubs that have a wall-mounted showerhead shall be finished in accordance with Section R307.2.

SECTION P2711
LAVATORIES

P2711.1 Approval.
Lavatories shall conform to ASME A112.19.1/CSA B45.2, ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124.

P2711.2 Cultured marble lavatories.
Cultured marble vanity tops with an integral lavatory shall conform to CSA B45.5/IAPMO Z124.

P2711.3 Lavatory waste outlets.
Lavatories shall have waste outlets not less than 1\(\frac{1}{4}\) inch (32 mm) in diameter. A strainer, pop-up stopper, crossbar or other device shall be provided to restrict the clear opening of the waste outlet.

P2711.4 Movable lavatory systems.
Movable lavatory systems shall comply with ASME A112.19.12.

SECTION P2712
WATER CLOSETS

P2712.1 Approval.
Water closets shall conform to the water consumption requirements of Section P2903.2 and shall conform to ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124. Water closets shall conform to the hydraulic performance requirements of ASME A112.19.2/CSA B45.1. Water closet tanks shall conform to ASME A112.19.2/CSA B45.1, ASME A112.19.3/CSA B45.4 or CSA B45.5/IAPMO Z124. Water closets that have an invisible seal and unventilated space or walls that are not thoroughly washed at each discharge shall be prohibited. Water closets that allow backflow of the contents of the bowl into the flush tank shall be prohibited. Water closets equipped with a dual flushing device shall comply with ASME A112.19.14.

P2712.2 Flushing devices required.
Water closets shall be provided with a flush tank, flushometer tank or flushometer valve designed and installed to supply water in sufficient quantity and flow to flush the contents of the fixture, to cleanse the fixture and refill the fixture trap in accordance with ASME A112.19.2/CSA B45.1.

P2712.3 Water supply for flushing devices.
An adequate quantity of water shall be provided to flush and clean the fixture served. The water supply to flushing devices equipped for manual flushing shall be controlled by a float valve or other automatic device designed to refill the tank after each discharge and to completely shut off the water flow to the tank when the tank is filled to operational capacity. Provision shall be made to automatically supply water to the fixture so as to refill the trap after each flushing.
P2712.4 Flush valves in flush tanks.
Flush valve seats in tanks for flushing water closets shall be not less than 1 inch (25 mm) above the flood-level rim of the bowl connected thereto, except an approved water closet and flush tank combination designed so that when the tank is flushed and the fixture is clogged or partially clogged, the flush valve will close tightly so that water will not spill continuously over the rim of the bowl or backflow from the bowl to the tank.

P2712.5 Overflows in flush tanks.
Flush tanks shall be provided with overflows discharging to the water closet connected thereto and such overflow shall be of sufficient size to prevent flooding the tank at the maximum rate at which the tanks are supplied with water according to the manufacturer’s design conditions.

P2712.6 Access.
Parts in a flush tank shall be accessible for repair and replacement.

P2712.7 Water closet seats.
Water closets shall be equipped with seats of smooth, nonabsorbent material and shall be properly sized for the water closet bowl type.

P2712.8 Flush tank lining.
Sheet copper used for flush tank linings shall have a weight of not less than 10 ounces per square foot (3 kg/m²).

P2712.9 Electro-hydraulic water closets.
Electro-hydraulic water closets shall conform to ASME A112.19.2/CSA B45.1.

P2712.10 (420.4) Water closet connections.
A 4-inch by 3-inch (102 mm by 76 mm) closet bend shall be acceptable. Where a 3-inch (76 mm) bend is utilized on water closets, a 4-inch by 3-inch (102 mm by 76 mm) flange shall be installed to receive the fixture horn.

SECTION P2713
BATHTUBS

P2713.1 Bathtub waste outlets and overflows.
Bathtubs shall be equipped with a waste outlet and an overflow outlet. The outlets shall be connected to waste tubing or piping not less than 1\frac{1}{2} inches (38 mm) in diameter. The waste outlet shall be equipped with a water-tight stopper.

P2713.2 Bathtub enclosures.
Doors within a bathtub enclosure shall conform to ASME A112.19.15.

P2713.3 Bathtub and whirlpool bathtub valves.
Hot water supplied to bathtubs and whirlpool bathtubs shall be limited to a temperature of not greater than 120°F (49°C) by a water-temperature limiting device that conforms to ASSE 1070 or CSA B125.3, except where such protection is otherwise provided by a combination tub/shower valve in accordance with Section P2708.4.
P2713.4 (407.1) Approval.

SECTION P2714
SINKS

P2714.1 Sink waste outlets.
Sinks shall be provided with waste outlets not less than $1\frac{1}{2}$ inches (38 mm) in diameter. A strainer, crossbar or other device shall be provided to restrict the clear opening of the waste outlet.

P2714.2 Movable sink systems.
Movable sink systems shall comply with ASME A112.19.12.

SECTION P2715
LAUNDRY TUBS

P2715.1 Laundry tub waste outlet.
Each compartment of a laundry tub shall be provided with a waste outlet not less than $1\frac{1}{2}$ inches (38 mm) in diameter. A strainer or crossbar shall restrict the clear opening of the waste outlet.

SECTION P2716
FOOD-WASTE DISPOSER

P2716.1 Food-waste disposer waste outlets.
Food-waste disposers shall be connected to a drain of not less than $1\frac{1}{2}$ inches (38 mm) in diameter.

P2716.2 Water supply required.
A sink equipped with a food-waste disposer shall be provided with a faucet.

SECTION P2717
DISHWASHING MACHINES

P2717.1 Protection of water supply.
The water supply to a dishwasher shall be protected against backflow by an air gap complying with ASME A112.1.3 or A112.1.2 that is installed integrally within the machine or a backflow preventer in accordance with Section P2902.

P2717.2 Sink and dishwasher.
The combined discharge from a dishwasher and a one- or two-compartment sink, with or without a food-waste disposer, shall be served by a trap of not less than $1\frac{1}{2}$ inches (38 mm) in outside diameter. The dishwasher discharge pipe or tubing shall rise to the underside of the counter and be fastened or otherwise held in that position and shall be securely fastened to the

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underside of the sink rim or counter before connecting to the head of the food-waste disposer or to a wye fitting in the sink tailpiece.

SECTION P2718
CLOTHES WASHING MACHINE

P2718.1 (406.2) Waste connection.
The discharge from a clothes washing machine shall be through an air break. The waste from an automatic clothes washer shall connect to a vertical drain of not less than 2 inches (51 mm) in diameter, or a horizontal drain of not less than 3 inches (76 mm) in diameter. The 2-inch (51 mm) trap in the waste connection may be used as a cleanout for both the 2-inch (51 mm) and the 3-inch (76 mm). In retrofit or remodel work automatic domestic clothes washers shall be permitted to drain to a laundry sink. Automatic clothes washers that discharge by gravity shall be permitted to drain to a waste receptor or an approved trench drain.

P2718.2 (406.1) Water connection.
The water supply to an automatic clothes washer shall be protected against backflow by an air gap that is integral with the machine or a backflow preventer shall be installed in accordance with Section 608. Air gaps shall comply with ASME A112.1.2 or A112.1.3.

SECTION P2719
FLOOR DRAINS

P2719.1 Floor drains.
Floor drains shall have waste outlets not less than 2 inches (51 mm) in diameter and a removable strainer. Floor drains shall be constructed so that the drain can be cleaned. Access shall be provided to the drain inlet. Floor drains shall not be located under or have their access restricted by permanently installed appliances.

P2719.2 (412.5) Location.
Floor drains shall be located to drain the entire floor area.

SECTION P2720
WHIRLPOOL BATHTUBS

P2720.1 Access to pump.
Access shall be provided to circulation pumps in accordance with the fixture or pump manufacturer's installation instructions. Where the manufacturer's instructions do not specify the location and minimum size of field-fabricated access openings, an opening of not less than 12-inches by 12-inches (305 mm by 305 mm) shall be installed for access to the circulation pump. Where pumps are located more than 2 feet (610 mm) from the access opening, an opening of not less than 18 inches by 18 inches (457 mm by 457 mm) shall be installed. A door or panel shall be permitted to close the opening. The access opening shall be unobstructed and be of the size necessary to permit the removal and replacement of the circulation pump. A minimum clearance of 21 inches (533 mm) is required in front of the access door. Removal of a toilet cannot be used to obtain the required clearance.

P2720.2 Piping drainage.
The circulation pump shall be accessibly located above the crown weir of the trap. The pump
drain line shall be properly graded to ensure minimum water retention in the volute after fixture use. The circulation piping shall be installed to be self-draining. The pump drain and circulation piping shall be sloped to drain the water in the volute and the circulation piping when the whirlpool bathtub is empty.

**P2720.3 Leak testing.**
Leak testing and pump operation shall be performed in accordance with the manufacturer’s instructions.

**P2720.4 Manufacturer's instructions.**
The product shall be installed in accordance with the manufacturer’s instructions.

**P2720.5 (421.4) Suction fittings.**
Suction fittings for whirlpool bathtubs shall comply with ASME A112.19.7/CSA B45.10.

**SECTION P2721**
**BIDET INSTALLATIONS**

**P2721.1 Water supply.**
The bidet shall be equipped with either an air-gap-type or vacuum-breaker-type fixture supply fitting.

**P2721.2 Bidet water temperature.**
The discharge water temperature from a bidet fitting shall be limited to not greater than 110°F (43°C) by a water-temperature-limiting device conforming to ASSE 1070 or CSA B125.3.

**P2721.3 (408.1) Approval.**
Bidets shall conform to ASME A112.19.2/ CSA B45.1.

**SECTION P2722**
**FIXTURE FITTING**

**P2722.1 (424.1) General.**
Fixture supply valves and faucets shall comply with ASME A112.18.1/CSA B125.1 as indicated in Table P2701.1. Faucets and fixture fittings that supply drinking water for human ingestion shall conform to the requirements of NSF 61, Section 9. Flexible water connectors shall conform to the requirements of Section P2905.7.

**P2722.2 (607.5) Hot water.**
Fixture fittings supplied with both hot and cold water shall be installed and adjusted so that the left-hand side of the water temperature control represents the flow of hot water when facing the outlet.

**Exception:** Shower and tub/shower mixing valves conforming to ASSE 1016/ASME A112.1016/CSA B125.16, where the water temperature control corresponds to the markings on the device.

**P2722.3 (424.6) Hose-connected outlets.**
Faucets and fixture fittings with hose-connected outlets shall conform to ASME A112.18.3 or ASME A112.18.1/CSA B125.1.
P2722.4 (604.11) Individual pressure-balancing in-line valves for individual fixture fittings.
Individual pressure-balancing in-line valves for individual fixture fittings shall comply with ASSE 1066. Such valves shall be installed in an accessible location and shall not be used as a substitute for the balanced pressure, thermostatic or combination shower valves required in Section P2708.3.

P2722.5 (424.9) Water closet personal hygiene devices.
Personal hygiene devices integral to water closets or water closet seats shall conform to ASME A112.4.2.

SECTION P2723
MACERATING TOILET SYSTEMS

P2723.1 General.
Macerating toilet systems shall comply with ASME A112.3.4/CSA B45.9 and shall be installed in accordance with manufacturer’s instructions.

P2723.2 Drain.
The size of the drain from the macerating toilet system shall be not less than \( \frac{3}{4} \) inch (19 mm) in diameter.

SECTION P2724
SPECIALTY TEMPERATURE CONTROL DEVICES AND VALVES

P2724.1 Temperature-actuated mixing valves.
Temperature-actuated mixing valves, which are installed to reduce water temperatures to defined limits, shall comply with ASSE 1017. Such valves shall be installed at the hot water source.

P2724.2 Temperature-actuated, flow-reduction devices for individual fixtures.
Temperature-actuated, flow-reduction devices, where installed for individual fixture fittings, shall conform to ASSE 1062. Such valves shall not be used as a substitute for the balanced pressure, thermostatic or combination shower valves required for showers in Section P2708.3.

SECTION P2725
NONLIQUID SATURATED TREATMENT SYSTEMS

P2725.1 General.
Materials, design, construction and performance of nonliquid saturated treatment systems shall comply with NSF 41.

CHAPTER 28
WATER HEATERS
SECTION P2801  
GENERAL

P2801.1 Required.  
Hot water shall be supplied to plumbing fixtures and plumbing appliances intended for bathing, washing or culinary purposes.

P2801.2 Drain valves.  
Drain valves for emptying shall be installed at the bottom of each tank-type water heater and hot water storage tank. The drain valve inlet shall be not less than 3/4-inch (19.1 mm) nominal iron pipe size and the outlet shall be provided with a male hose thread. Drain valves shall conform to ASSE 1005.

P2801.3 Installation.  
Water heaters shall be installed in accordance with this chapter and Chapters 20 and 24.

P2801.4 Location.  
Water heaters and storage tanks shall be installed in accordance with Section M1305 and shall be located and connected to provide access for observation, maintenance, servicing and replacement.

P2801.5 Prohibited locations.  
Water heaters shall be located in accordance with Chapter 20.

P2801.6 Required pan.  
Where a storage tank-type water heater or a hot water storage tank is installed in a location where water leakage from the tank will cause damage, the tank shall be installed in a pan constructed of one of the following:

1. Galvanized steel or aluminum of not less than 0.0236 inch (0.6010 mm) in thickness.
2. Plastic not less than 0.036 inch (0.9 mm) in thickness.
3. Other approved materials.

A plastic pan shall not be installed beneath a gas-fired water heater. Where a storage tank-type water heater or a hot water storage tank is installed in: (a) remote locations such as a suspended ceiling, (b) attics, (c) above occupied spaces, or (d) unventilated crawl spaces, a location where water leakage from the tank will cause damage to primary
structural members, the tank or water heater shall be installed in a galvanized steel or aluminum pan having a material thickness of not less than 0.0236 inch (0.6010 mm) (No. 24 gage for steel or No. 26 gage for aluminum), or other pans approved for such use.

Exceptions:

1. Electric water heaters may rest in a high-impact plastic pan of at least 1/16 inch (1.6 mm) thickness.

2. Water heater mounted on concrete floor with a floor drain.

P2801.6.1 Pan size and drain.
The pan shall be not less than \(\frac{1}{2} \) inches (38 mm) deep and shall be of sufficient size and shape to receive dripping or condensate from the tank or water heater. The pan shall be drained by an indirect waste pipe of not less than \(\frac{3}{4} \) inch (19 mm) diameter. Piping for safety pan drains shall be of those materials indicated in Table P2905.5. Where a pan drain was not previously installed, a pan drain shall not be required for a replacement water heater installation.

P2801.6.2 Pan drain termination.
The pan drain shall extend full-size and terminate over a suitably located indirect waste receptor or shall extend to the exterior of the building and terminate not less than 6 inches (152 mm) and not more than 24 inches (610 mm) above the adjacent ground surface.

P2801.7 (502.5) Water heaters installed in garages.
Water heaters having an ignition source shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the garage floor. Appliances shall be located or protected so that they are not subject to physical damage by a moving vehicle. The ignition source would apply to both electric and gas water heaters. The ignition source (not the bottom of the water heater) shall be elevated to minimum of 18 inches (457 mm) above the garage floor.

Exception: Elevation of the ignition source is not required for appliances that are listed as flammable vapor ignition-resistant.

P2801.8 Water heater seismic bracing.
In Seismic Design Categories D0, D1 and D2 and townhouses in Seismic Design Category C, water heaters shall be anchored or strapped in the upper one-third and in the lower one-third of the appliance to resist a horizontal force equal to one-third of the operating weight of the water heater, acting in any horizontal direction, or in accordance with the appliance manufacturer’s recommendations.

P2801.9 (502.2) Rooms used as a plenum.
Water heaters using solid, liquid or gas fuel shall not be installed in a room containing air-handling machinery where such room is used as a plenum.

P2801.10 (502.3) Water heaters installed in attics.
Attics containing a water heater shall be provided with an opening and unobstructed passageway large enough to allow removal of the water heater. The passageway shall be not less than 30 inches (762 mm) in height and 22 inches (559 mm) in width and not more than 20
feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the water heater. If 6 feet (1829 mm) of headroom is provided along the centerline of the passageway from the opening to the water heater, the length of the passageway is permitted to exceed 20 feet (6096 mm) in length. The passageway shall have continuous solid flooring not less than 24 inches (610 mm) in width. A level service space not less than 30 inches (762 mm) in length and 30 inches (762 mm) in width shall be present at the front or service side of the water heater. The clear access opening dimensions shall be not less than 20 inches by 30 inches (508 mm by 762 mm) where such dimensions are large enough to allow removal of the water heater.

P2801.11 (502.6) Installation in crawl spaces.
Under-floor spaces containing appliances requiring access shall be provided with an access opening and unobstructed passageway large enough to remove the largest component of the appliance. The passageway shall not be less than 22 inches (559 mm) high and 36 inches (914 mm) wide, nor more than 20 feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the equipment. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the appliance. If the depth of the passageway or the service space exceeds 12 inches (305mm) below the adjoining grade, the walls of the passageway shall be lined with concrete or masonry extending 4 inches (102 mm) above the adjoining grade and having sufficient lateral-bearing capacity to resist collapse. The clear access opening dimensions shall be a minimum of 22 inches by 30 inches (559 mm by 762 mm), where such dimensions are large enough to allow removal of the largest component of the appliance.

Exceptions:

1. The passageway is not required where the level service space is present when the access is open and the appliance is capable of being serviced and removed through the required opening.

2. Where the passageway is not less than 6 feet high (1829 mm) for its entire length, the passageway shall not be limited in length.

P2801.12 (502.7) Under-floor and exterior-grade installation.

Equipment and appliances installed above grade level shall be supported on a solid base or approved material a minimum of 2 inches (51 mm) thick.

P2801.12.2 (502.7.2) Under-floor installation.
Suspended equipment shall be a minimum of 6 inches (152 mm) above the adjoining grade.

P2801.12.3 (502.7.3) Crawl space supports.
The support shall be a minimum of a 2-inch (51 mm) thick solid base, 2-inch (51 mm) thick formed concrete, or stacked masonry units held in place by mortar or other approved method. The water heater shall be supported not less than 2 inches (51 mm) above grade.

P2801.12.4 (502.7.4) Drainage.
Below-grade installations shall be provided with a natural drain or an automatic lift or sump pump. Existing installation that can be terminated outdoors must terminate outdoors. Where
the installation is such that outdoor termination is impossible, indoor termination is allowable.

P2801.13 (502.8) Prohibited installations.
Water heaters, (using solid, liquid or gas fuel) with the exception of those having direct vent systems, shall not be installed in bathrooms and bedrooms or in a closet with access only through a bedroom or bathroom. However, water heaters of the automatic storage type may be installed as replacement in a bathroom, when approved by the plumbing official, provided they are vented and supplied with adequate combustion air.

Exception: When a closet, having a weather-stripped solid door with an approved closing device, has been designed exclusively for the water heater and where all air for combustion and ventilation is supplied from outdoors.

SECTION P2802
SOLAR WATER HEATING SYSTEMS

P2802.1 Water temperature control.
Where heated water is discharged from a solar thermal system to a hot water distribution system, a thermostatic mixing valve complying with ASSE 1017 shall be installed to temper the water to a temperature of not greater than 140°F (60°C). Solar thermal systems supplying hot water for both space heating and domestic uses shall comply with Section P2802.3. A temperature-indicating device shall be installed to indicate the temperature of the water discharged from the outlet of the mixing valve. The thermostatic mixing valve required by this section shall not be a substitute for water temperature limiting devices required by Chapter 27 for specific fixtures.

P2802.2 Isolation valves.
Isolation valves in accordance with P2903.9.2 shall be provided on the cold water feed to the water heater. Isolation valves and associated piping shall be provided to bypass solar storage tanks where the system contains multiple storage tanks.

SECTION P2803
WATER HEATERS USED FOR SPACE HEATING

P2803.1 Protection of potable water.
Piping and components connected to a water heater for space heating applications shall be suitable for use with potable water in accordance with Chapter 29. Water heaters that will be used to supply potable water shall not be connected to a heating system or components previously used with nonpotable-water heating appliances. Chemicals for boiler treatment shall not be introduced into the water heater.

P2803.2 Temperature control.
Where a combination water heater-space heating system requires water for space heating at temperatures exceeding 140°F (60°C), a master thermostatic mixing valve complying with ASSE 1017 shall be installed to temper the water to a temperature of not greater than 140°F (60°C) for domestic uses.

SECTION P2804
RELIEF VALVES
P2804.1 Relief valves required.
Appliances and equipment used for heating water or storing hot water shall be protected by one of the following:

1. A separate pressure-relief valve and a separate temperature-relief valve.


P2804.2 Rating.
Relief valves shall have a minimum rated capacity for the equipment served and shall conform to ANSI Z21.22.

P2804.3 Pressure-relief valves.
Pressure-relief valves shall have a relief rating adequate to meet the pressure conditions for the appliances or equipment protected. In tanks, they shall be installed directly into a tank tapping or in a water line close to the tank. They shall be set to open at not less than 25 psi (172 kPa) above the system pressure and not greater than 150 psi (1034 kPa). The relief-valve setting shall not exceed the rated working pressure of the tank.

P2804.4 Temperature-relief valves.
Temperature-relief valves shall have a relief rating compatible with the temperature conditions of the appliances or equipment protected. The valves shall be installed such that the temperature-sensing element monitors the water within the top 6 inches (152 mm) of the tank. The valve shall be set to open at a temperature of not greater than 210°F (99°C).

P2804.5 Combination pressure-and-temperature relief valves.
Combination pressure and temperature-relief valves shall comply with the requirements for separate pressure- and temperature-relief valves.

P2804.6 Installation of relief valves.
A check or shutoff valve shall not be installed in any of the following locations:

1. Between a relief valve and the termination point of the relief valve discharge pipe.

2. Between a relief valve and a tank.

3. Between a relief valve and heating appliances or equipment.

P2804.6.1 Requirements for discharge pipe.
The discharge piping serving a pressure-relief valve, temperature-relief valve or combination valve shall:

1. Not be directly connected to the drainage system.

2. Discharge through an air gap located in the same room as the water heater either on the floor, into an indirect waste receptor or into a water heater pan.

   a. Discharge through an air gap or air gap fitting to a remote termination point that is observable by the building occupants.

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3. Not be smaller than the diameter of the outlet of the valve served and shall discharge full size to the air gap.

4. Serve a single relief device and shall not connect to piping serving any other relief device or equipment.

5. Discharge to the floor, to the pan serving the water heater or storage tank, to a waste receptor or to the outdoors.

6. Discharge in a manner that does not cause personal injury or structural damage.

7. Discharge to a termination point that is readily observable by the building occupants. Deleted.

8. Not be trapped.

9. Be installed to flow by gravity.

10. Terminate not more than 6 inches (152 mm) and not less than two times the discharge pipe diameter above the floor or waste receptor flood level rim.

11. Not have a threaded connection at the end of the piping.

12. Not have valves or tee fittings.

13. Be constructed of those materials indicated in Section P2906.5 or materials tested, rated and approved for such use in accordance with ASME A112.4.1.

14. Be one nominal size larger than the size of the relief-valve outlet, where the relief-valve discharge piping is constructed of PEX or PE-RT tubing. The outlet end of such tubing shall be fastened in place. The discharge pipe shall be clamped or otherwise supported with not less than one clamp or support within 12-inches (305 mm) of the point of discharge.

P2804.7 Vacuum-relief valve.
Bottom fed tank-type water heaters and bottom fed tanks connected to water heaters shall have a vacuum-relief valve installed that complies with ANSI Z21.22.

P2804.8 (501.9) Relief valve installation by manufacturer.
The following is a reprint of GS 66-27.1, “Safety Features of Hot Water Heaters."

a. No individual, firm, corporation or business shall install, sell or offer for sale any automatic hot water tank or heater of 120-gallon (454 L) capacity or less, except for a tankless water heater, which does not have installed thereon by the manufacturer of the tank or heater an American Society of Mechanical Engineers and National Board of Boiler and Pressure Vessel Inspectors approved type pressure-temperature relief valve set at or below the safe working pressure of the tank as indicated, and so labeled by the
b. No individual, firm, corporation or business shall install, sell or offer for sale any relief valve, whether it be pressure type, temperature type or pressure-temperature type, which does not carry the stamp of approval of the American Society of Mechanical Engineers and the National Board of Boiler and Pressure Vessel Inspectors.

The following is a reprint of GS 66-27.1A, “Water heater thermostat settings.”

a. The thermostat of any new residential water heater offered for sale or lease for use in a single-family or multifamily dwelling in the State shall be preset by the manufacturer or installer no higher than approximately 120°F (49°C). A water heater reservoir temperature may be set higher if it is supplying space heaters that require higher temperatures. For purposes of this section, a water heater shall mean the primary source of hot water for any single-family or multifamily residential dwelling including, but not limited to any solar or other hot water heating systems.

b. Nothing in this section shall prohibit the occupant of a single-family or multiunit residential dwelling with an individual water heater from resetting or having reset the thermostat on the water heater. Any such resetting shall relieve the manufacturer or installer of the water heater and, in the case of a residential dwelling that is leased or rented, also the unit’s owner, from liability for damages attributed to the resetting.

c. A warning tag or sticker shall be placed on or near the operating thermostat control of any residential water heater. This tag or sticker shall state that the thermostat settings above the preset temperature may cause severe burns. This tag or sticker may carry such other appropriate warnings as may be agreed upon by manufacturers, installers and other interested parties.

P2804.9 (501.10) Fossil fuel equipment installation.
The installation of the following equipment and systems shall comply with the North Carolina Fuel Gas Code:

a. Fuel piping for any fossil fuel-burning equipment.

b. Venting systems for fossil fuel-burning equipment which is part of the plumbing system.

SECTION P2805 (503)
CONNECTIONS

P2805.1 (503.1) Cold water line valve.
The cold water branch line from the main water supply line to each hot water storage tank or water heater shall be provided with a valve, located within 3 feet (914 mm) of the equipment and serving only the hot water storage tank or water heater. The valve shall not interfere or cause a disruption of the cold water supply to the remainder of the cold water system. The valve shall be provided with access on the same floor level as the water heater served.

P2805.2 (503.2) Water circulation.
The method of connecting a circulating water heater to the tank shall provide circulation of water through the water heater. The pipe or tubes required for the installation of appliances that will draw from the water heater or storage tank shall comply with the provisions of this code for material and installation. Installation shall comply with the manufacturer’s instructions and the requirements of the *North Carolina Energy Conservation Code*.

**SECTION P2806 (504) SAFETY DEVICES**

**P2806.1 (504.1) Antisiphon devices.**
An approved means, such as a cold water “dip” tube with a hole at the top or a vacuum relief valve installed in the cold water supply line above the top of the heater or tank, shall be provided to prevent siphoning of any storage water heater or tank.

**P2806.2 (504.3) Shutdown.**
A means for disconnecting an electric hot water supply system from its energy supply shall be provided in accordance with NFPA 70. A separate valve shall be provided to shut off the energy fuel supply to all other types of hot water supply systems.

**SECTION P2807 (505) INSULATION**

**P2807.1 (505.1) Unfired vessel insulation.**
Unfired hot water storage tanks shall be insulated to R-12.5 (h · ft² · °F)/Btu (R-2.2 m² · K/W).
CHAPTER 29
WATER SUPPLY AND DISTRIBUTION

**User note:** Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Plumbing Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Plumbing Code*.

**SECTION P2901**
GENERAL

**P2901.1 Potable water required.**  
Potable water shall be supplied to plumbing fixtures and plumbing *appliances* except where treated rainwater, treated gray water or municipal reclaimed water is supplied to water closets, urinals and trap primers. The requirements of this section shall not be construed to require signage for water closets and urinals.

**P2901.2 Identification of nonpotable water systems.**  
Where *nonpotable* water systems are installed, the piping conveying the nonpotable water shall be identified either by color marking, metal tags or tape in accordance with Sections P2901.2.1 through P2901.2.2.3.

**P2901.2.1 Signage required.**  
Nonpotable water outlets such as hose connections, open-ended pipes and faucets shall be identified with signage that reads as follows: “Nonpotable water is utilized for [application name]. CAUTION: NONPOTABLE WATER. DO NOT DRINK.” The words shall be legibly and indelibly printed on a tag or sign constructed of corrosion-resistant water-proof material or shall be indelibly printed on the fixture. The letters of the words shall be not less than 0.5 inches (12.7 mm) in height and in colors in contrast to the background on which they are applied. In addition to the required wordage, the pictograph shown in Figure P2901.2.1 shall appear on the required signage.
P2901.2.2 Distribution pipe labeling and marking.
Nonpotable distribution piping shall be purple in color and shall be embossed or integrally stamped or marked with the words: “CAUTION: NONPOTABLE WATER—DO NOT DRINK” or the piping shall be installed with a purple identification tape or wrap. Pipe identification shall include the contents of the piping system and an arrow indicating the direction of flow. Hazardous piping systems shall contain information addressing the nature of the hazard. Pipe identification shall be repeated at intervals not exceeding 25 feet (7620 mm) and at each point where the piping passes through a wall, floor or roof. Lettering shall be readily observable within the room or space where the piping is located.

P2901.2.2.1 Color.
The color of the pipe identification shall be discernable and consistent throughout the building. The color purple shall be used to identify reclaimed, rain and gray water distribution systems.

P2901.2.2.2 Lettering size.
The size of the background color field and lettering shall comply with Table P2901.2.2.2.

<table>
<thead>
<tr>
<th>PIPE DIAMETER (inches)</th>
<th>LENGTH OF BACKGROUND COLOR FIELD (inches)</th>
<th>SIZE OF LETTERS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/48 to 1 1/4</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>1/2 to 2</td>
<td>8</td>
<td>0.75</td>
</tr>
<tr>
<td>2 1/2 to 6</td>
<td>12</td>
<td>1.25</td>
</tr>
<tr>
<td>8 to 10</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>over 10</td>
<td>32</td>
<td>3.5</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
P2901.2.2.3 Identification Tape.
Where used, identification tape shall be not less than 3 inches (76 mm) wide and have white or black lettering on a purple field stating "CAUTION: NONPOTABLE WATER—DO NOT DRINK." Identification tape shall be installed on top of nonpotable rainwater distribution pipes and fastened not greater than every 10 feet (3048 mm) to each pipe length, and run continuously the entire length of the pipe.

P2901.3 (608.10) Reuse of piping.
Piping that has been utilized for any purpose other than conveying potable water shall not be utilized for conveying potable water.

SECTION P2902
PROTECTION OF POTABLE WATER SUPPLY

P2902.1 General.
A potable water supply system shall be designed and installed as to prevent contamination from nonpotable liquids, solids or gases being introduced into the potable water supply. Connections shall not be made to a potable water supply in a manner that could contaminate the water supply or provide a cross-connection between the supply and a source of contamination except where approved backflow prevention assemblies, backflow prevention devices or other means or methods are installed to protect the potable water supply. Cross-connections between an individual water supply and a potable public water supply shall be prohibited.

P2902.2 Plumbing fixtures.
The supply lines and fittings for every plumbing fixture shall be installed so as to prevent backflow. Plumbing fixture fittings shall provide backflow protection in accordance with ASME A112.18.1/CSA B125.1.

P2902.3 Backflow protection.
A means of protection against backflow shall be provided in accordance with Sections P2902.3.1 through P2902.3.6. Backflow prevention applications shall conform to Table P2902.3, except as specifically stated in Sections P2902.4 through P2902.5.5.

| TABLE P2902.3
APPLICATION FOR BACKFLOW PREVENTERS |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DEVICE</td>
</tr>
<tr>
<td>Backflow Prevention Assemblies</td>
</tr>
<tr>
<td>Double check backflow prevention assembly and double check fire protection backflow prevention assembly</td>
</tr>
<tr>
<td>Double check detector fire protection backflow prevention assemblies</td>
</tr>
<tr>
<td>Pressure vacuum breaker assembly</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
### Reduced pressure principle backflow prevention assembly and reduced pressure principle fire protection backflow prevention assembly

<table>
<thead>
<tr>
<th>High or low hazard</th>
<th>Backpressure or backsiphonage</th>
<th>Sizes</th>
<th>ASSE 1013, AWWA C511, CSA B64.4, CSA B64.4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 – 16”</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Reduced pressure detector fire protection backflow prevention assemblies

<table>
<thead>
<tr>
<th>High or low hazard</th>
<th>Backsiphonage or backpressure (Fire sprinkler systems)</th>
<th>ASSE 1047</th>
</tr>
</thead>
</table>

### Spill-resistant vacuum breaker

<table>
<thead>
<tr>
<th>High or low hazard</th>
<th>Backsiphonage only</th>
<th>Sizes</th>
<th>ASSE 1056, CSA B64.1.3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1/4 – 2”</td>
<td></td>
</tr>
</tbody>
</table>

### Backflow Preventer Plumbing Devices

<table>
<thead>
<tr>
<th>Antisiphon-type fill valves for gravity water closet flush tanks</th>
<th>High hazard</th>
<th>Backsiphonage only</th>
<th>ASSE 1002, CSA B125.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backflow preventer with intermediate atmospheric vents</td>
<td>Low hazard</td>
<td>Backpressure or backsiphonage Sizes 1/8 – 3/4</td>
<td>ASSE 1012, CSA B64.3</td>
</tr>
<tr>
<td>Dual-check-valve-type backflow preventers</td>
<td>Low hazard</td>
<td>Backpressure or backsiphonage Sizes 1/4 – 1”</td>
<td>ASSE 1024, CSA B64.6</td>
</tr>
<tr>
<td>Hose-connection backflow preventer</td>
<td>High or low hazard</td>
<td>Low head backpressure, rated working pressure backpressure or backsiphonage Sizes 1/2 – 1”</td>
<td>ASSE 1052, CSA B64.2.1.1</td>
</tr>
<tr>
<td>Hose-connection vacuum breaker</td>
<td>High or low hazard</td>
<td>Low head backpressure or backsiphonage Sizes 1/2, 3/4, 1”</td>
<td>ASSE 1011, CSA B64.2, B64.2.1</td>
</tr>
<tr>
<td>Laboratory faucet backflow preventer</td>
<td>High or low hazard</td>
<td>Low head backpressure and backsiphonage</td>
<td>ASSE 1035, CSA B64.7</td>
</tr>
<tr>
<td>Pipe-applied atmospheric-type vacuum breaker</td>
<td>High or low hazard</td>
<td>Backsiphonage only Sizes 1/4 – 4”</td>
<td>ASSE 1001, CSA B64.1.1</td>
</tr>
<tr>
<td>Vacuum breaker wall hydrants, frost-resistant, automatic-draining type</td>
<td>High or low hazard</td>
<td>Low head backpressure or backsiphonage Sizes 3/4 – 1”</td>
<td>ASSE 1019, CSA B64.2.2</td>
</tr>
</tbody>
</table>

### Other Means Or Methods

<table>
<thead>
<tr>
<th>Air gap</th>
<th>High or low hazard</th>
<th>Backsiphonage only</th>
<th>ASME A112.1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air gap fittings for use with plumbing fixtures, appliances and appurtenances</td>
<td>High or low hazard</td>
<td>Backsiphonage or backpressure</td>
<td>ASME A112.1.3</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. Low hazard—See Pollution (Section R202). High hazard—See Contamination (Section R202).
b. See Backpressure (Section R202). See Backpressure, Low Head (Section R202). See Backsiphonage (Section R202).
P2902.3.1 Air gaps.
Air gaps shall comply with ASME A112.1.2 and air gap fittings shall comply with ASME A112.1.3. An air gap shall be measured vertically from the lowest end of a water outlet to the flood level rim of the fixture or receptor into which the water outlets discharges to the floor. The required air gap shall be not less than twice the diameter of the effective opening of the outlet and not less than the values specified in Table P2902.3.1.

### TABLE P2902.3.1 MINIMUM AIR GAPS

<table>
<thead>
<tr>
<th>FIXTURE</th>
<th>MINIMUM AIR GAP</th>
<th>Close to a wall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(inches)</td>
</tr>
<tr>
<td><strong>Away from a wall</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective openings greater than 1 inch</td>
<td>Two times the diameter of the effective opening</td>
<td></td>
</tr>
<tr>
<td>Lavatories and other fixtures with effective opening not greater than $\frac{1}{2}$ inch in diameter</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Over-rim bath fillers and other fixtures with effective openings not greater than 1 inch in diameter</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sink, laundry trays, gooseneck back faucets and other fixtures with effective openings not greater than $\frac{3}{4}$ inch in diameter</td>
<td>1.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
a. Applicable where walls or obstructions are spaced from the nearest inside edge of the spout opening a distance greater than three times the diameter of the effective opening for a single wall, or a distance greater than four times the diameter of the effective opening for two intersecting walls.

P2902.3.2 Atmospheric-type vacuum breakers.
Atmospheric-type vacuum breakers shall conform to ASSE 1001 or CSA B64.1.1. Hose-connection vacuum breakers shall conform to ASSE 1011, ASSE 1019, ASSE 1035, ASSE 1052, CSA B64.2, CSA B64.2.1, CSA B64.2.1.1, CSA B64.2.2 or CSA B64.7. Both types of vacuum breakers shall be installed with the outlet continuously open to the atmosphere. The critical level of the atmospheric vacuum breaker shall be set at not less than 6 inches (152 mm) above the highest elevation of downstream piping and the flood level rim of the fixture or device.

P2902.3.3 Backflow preventer with intermediate atmospheric vent.
Backflow preventers with intermediate atmospheric vents shall conform to ASSE 1012 or CSA B64.3. These devices shall be permitted to be installed where subject to continuous pressure conditions. These devices shall be prohibited as a means of protection where any hazardous chemical additives are introduced downstream of the device. The relief opening shall discharge by air gap and shall be prevented from being submerged.
P2902.3.4 Pressure vacuum breaker assemblies.
Pressure vacuum breaker assemblies shall conform to ASSE 1020 or CSA B64.1.2. Spill-resistant vacuum breaker assemblies shall comply with ASSE 1056. These assemblies are designed for installation under continuous pressure conditions where the critical level is installed at the required height. The critical level of a pressure vacuum breaker and a spill-resistant vacuum breaker assembly shall be set at not less than 12 inches (304 mm) above the highest elevation of downstream piping and the flood level rim of the fixture or device. Pressure vacuum breaker assemblies shall not be installed in locations where spillage could cause damage to the structure.

P2902.3.5 Reduced pressure principle backflow prevention assemblies.
Reduced pressure principle backflow prevention assemblies and reduced pressure principle fire protection backflow prevention assemblies shall conform to ASSE 1013, AWWA C511, CSA B64.4 or CSA B64.4.1. Reduced pressure detector fire protection backflow prevention assemblies shall conform to ASSE 1047. These devices shall be permitted to be installed where subject to continuous pressure conditions. The relief opening shall discharge by air gap and shall be prevented from being submerged.

P2902.3.6 Double check backflow prevention assemblies.
Double check backflow prevention assemblies shall conform to ASSE 1015, CSA B64.5, CSA B64.5.1 or AWWA C510. Double check detector fire protection backflow prevention assemblies shall conform to ASSE 1048. These assemblies shall be capable of operating under continuous pressure conditions.

P2902.3.7 Dual check backflow preventer.
Dual check backflow preventers shall conform with ASSE 1024 or CSA B64.6.

P2902.4 Protection of potable water outlets.
Potable water openings and outlets shall be protected by an air gap, a reduced pressure principle backflow prevention assembly, an atmospheric vent, an atmospheric-type vacuum breaker, a pressure-type vacuum breaker assembly or a hose connection backflow preventer.

P2902.4.1 Fill valves.
Flush tanks shall be equipped with an antisiphon fill valve conforming to ASSE 1002 or CSA B125.3. The critical level of the fill valve shall be located not less than 1 inch (25 mm) above the top of the flush tank overflow pipe.

P2902.4.2 Deck-mounted and integral vacuum breakers.
Approved deck-mounted or equipment-mounted vacuum breakers and faucets with integral atmospheric vacuum breakers or spill-resistant vacuum breaker assemblies shall be installed in accordance with the manufacturer’s instructions and the requirements for labeling. The critical level of the breakers and assemblies shall be located at not less than 1 inch (25 mm) above the flood level rim.

P2902.4.3 Hose connection.
Sillcocks, hose bibbs, wall hydrants and other openings with a hose connection shall be protected by an atmospheric-type or pressure-type vacuum breaker, a pressure vacuum breaker assembly or a permanently attached hose connection vacuum breaker.

Exceptions:
1. This section shall not apply to water heater and boiler drain valves that are provided with hose connection threads and that are intended only for tank or vessel draining.

2. This section shall not apply to water supply valves intended for connection of clothes washing machines where backflow prevention is otherwise provided or is integral with the machine.

P2902.5 Protection of potable water connections.
Connections to the potable water shall conform to Sections P2902.5.1 through P2902.5.5.

P2902.5.1 Connections to boilers.
Where chemicals will not be introduced into a boiler, the potable water supply to the boiler shall be protected from the boiler by a backflow preventer with an intermediate atmospheric vent complying with ASSE 1012 or CSA B64.3. Where chemicals will be introduced into a boiler, the potable water supply to the boiler shall be protected from the boiler by an air gap or a reduced pressure principle backflow prevention assembly complying with ASSE 1013, CSA B64.4 or AWWA C511.

P2902.5.2 Heat exchangers.
Heat exchangers using an essentially toxic transfer fluid shall be separated from the potable water by double-wall construction. An air gap open to the atmosphere shall be provided between the two walls. Single-wall construction heat exchangers shall be used only where an essentially nontoxic transfer fluid is utilized.

P2902.5.3 Lawn irrigation systems.
The potable water supply to lawn irrigation systems shall be protected against backflow by an atmospheric vacuum breaker, a pressure vacuum breaker assembly or a reduced pressure principle backflow prevention assembly. Valves shall not be installed downstream from an atmospheric vacuum breaker. Where chemicals are introduced into the system, the potable water supply shall be protected against backflow by a reduced pressure principle backflow prevention assembly.

P2902.5.4 Connections to automatic fire sprinkler systems.
The potable water supply to automatic fire sprinkler systems shall be protected against backflow by a double check backflow prevention assembly, a double check fire protection backflow prevention assembly, a reduced pressure principle backflow prevention assembly or a reduced pressure principle fire protection backflow prevention assembly.

Exception: Where systems are installed as a portion of the water distribution system in accordance with the requirements of this code and are not provided with a fire department connection, backflow protection for the water supply system shall not be required.

P2902.5.4.1 Additives or nonpotable source.
Where systems contain chemical additives or antifreeze, or where systems are connected to a nonpotable secondary water supply, the potable water supply shall be protected against backflow by a reduced pressure principle backflow prevention assembly or a reduced pressure principle fire protection backflow prevention assembly. Where chemical additives or antifreeze is added to only a portion of an automatic fire
sprinkler or standpipe-system, the reduced pressure principle fire protection backflow preventer shall be permitted to be located so as to isolate that portion of the system.

**P2902.5.5 Solar thermal systems.**
Where a solar thermal system heats potable water to supply a potable hot water distribution or any other type of heating system, the solar thermal system shall be in accordance with Section P2902.5.5.1, P2902.5.5.2 or P2902.5.5.3 as applicable. Solar energy systems used for heating potable water or using an independent medium for heating potable water shall comply with the applicable requirements of this code. The use of solar energy shall not compromise the requirements for cross connection or protection of the potable water supply system required by this code.

**P2902.5.5.1 Indirect systems.**
Water supplies of any type shall not be connected to the solar heating loop of an indirect solar thermal hot water heating system. This requirement shall not prohibit the presence of inlets or outlets on the solar heating loop for the purposes of servicing the fluid in the solar heating loop.

**P2902.5.5.2 Direct systems for potable water distribution systems.**
Where a solar thermal system directly heats potable water for a potable water distribution system, the pipe, fittings, valves and other components that are in contact with the potable water in the system shall comply with the requirements of Chapter 29.

**P2902.5.5.3 Direct systems for other than potable water distribution systems.**
Where a solar thermal system directly heats water for a system other than a potable water distribution system, a potable water supply connected to such system shall be protected by a backflow preventer with an intermediate atmospheric vent complying with ASSE 1012. Where a solar thermal system directly heats chemically treated water for a system other than a potable water distribution system, a potable water supply connected to such system shall be protected by a reduced pressure principle backflow prevention assembly complying with ASSE 1013.

**P2902.6 Location of backflow preventers.**
Access shall be provided to backflow preventers as specified by the manufacturer’s installation instructions.

**P2902.6.1 Outdoor enclosures for backflow prevention devices.**
Outdoor enclosures for backflow prevention devices shall comply with ASSE 1060.

**P2902.6.2 Protection of backflow preventers.**
Backflow preventers shall not be located in areas subject to freezing except where they can be removed by means of unions, or are protected by heat, insulation or both.

**P2902.6.3 Relief port piping.**
The termination of the piping from the relief port or air gap fitting of the backflow preventer shall discharge to an approved indirect waste receptor or to the outdoors where it will not cause damage or create a nuisance.

**SECTION P2903**
WATER SUPPLY SYSTEM
P2903.1 Water supply system design criteria.
The water service and water distribution systems shall be designed and pipe sizes shall be selected such that under conditions of peak demand, the capacities at the point of outlet discharge shall not be less than shown in Table P2903.1.

**TABLE P2903.1**
REQUered CAPACITIES AT POINT OF OUTLET DISCHARGE

<table>
<thead>
<tr>
<th>FIXTURE SUPPLY OUTLET SERVING</th>
<th>FLOW RATE (gpm)</th>
<th>FLOW PRESSURE (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathtub, balanced-pressure, thermostatic or combination balanced-pressure/thermostatic mixing valve</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Bidet, thermostatic mixing valve</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>2.75</td>
<td>8</td>
</tr>
<tr>
<td>Laundry tray</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Lavatory</td>
<td>0.8</td>
<td>8</td>
</tr>
<tr>
<td>Shower, balanced-pressure, thermostatic or combination balanced-pressure/thermostatic mixing valve</td>
<td>2.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20</td>
</tr>
<tr>
<td>Sillcock, hose bibb</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Sink</td>
<td>1.75</td>
<td>8</td>
</tr>
<tr>
<td>Water closet, flushometer tank</td>
<td>1.6</td>
<td>20</td>
</tr>
<tr>
<td>Water closet, tank, close coupled</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Water closet, tank, one-piece</td>
<td>6</td>
<td>20</td>
</tr>
</tbody>
</table>

For SI: 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 3.785 L/m.
<sup>a</sup> Where the shower mixing valve manufacturer indicates a lower flow rating for the mixing valve, the lower value shall be applied.

P2903.2 Maximum flow and water consumption.
The maximum water consumption flow rates and quantities for plumbing fixtures and fixture fittings shall be in accordance with Table P2903.2.

**TABLE P2903.2**
MAXIMUM FLOW RATES AND CONSUMPTION FOR PLUMBING FIXTURES AND FIXTURE FITTINGS<sup>b</sup>

<table>
<thead>
<tr>
<th>PLUMBING FIXTURE OR FIXTURE FITTING</th>
<th>PLUMBING FIXTURE OR FIXTURE FITTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory faucet</td>
<td>2.2 gpm at 60 psi</td>
</tr>
<tr>
<td>Shower head&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.5 gpm at 80 psi</td>
</tr>
<tr>
<td>Sink faucet</td>
<td>2.2 gpm at 60 psi</td>
</tr>
<tr>
<td>Water closet</td>
<td>1.6 gallons per flushing cycle</td>
</tr>
</tbody>
</table>

For SI: 1 gallon per minute = 3.785 L/m,
1 pound per square inch = 6.895 kPa.
<sup>a</sup> A handheld shower spray shall be considered a shower head.
<sup>b</sup> Consumption tolerances shall be determined from referenced standards.
P2903.3 Minimum pressure.
Where the water pressure supplied by the public water main or an individual water supply system is insufficient to provide for the minimum pressures and quantities for the plumbing fixtures in the building, the pressure shall be increased by means of an elevated water tank, a hydro pneumatic pressure booster system or a water pressure booster pump.

P2903.3.1 Maximum pressure.
The static water pressure shall be not greater than 80 psi (551 kPa). Where the main pressure exceeds 80 psi (551 kPa), an approved pressure-reducing valve conforming to ASSE 1003 or CSA B356 shall be installed on the domestic water branch main or riser at the connection to the water service pipe.

Exception: Service lines to sill cocks and outside hydrants when equipped with a shutoff valve.

P2903.4 Thermal expansion control.
A means for controlling increased pressure caused by thermal expansion shall be installed where required in accordance with Sections P2903.4.1 and P2903.4.2.

P2903.4.1 Pressure-reducing valve.
For water service system sizes up to and including 2 inches (51 mm), a device for controlling pressure shall be installed where, because of thermal expansion, the pressure on the downstream side of a pressure-reducing valve exceeds the pressure-reducing valve setting.

P2903.4.2 Backflow prevention device or check valve.
Where a backflow prevention device, check valve or other device is installed on a water supply system using storage water heating equipment such that thermal expansion causes an increase in pressure, a device for controlling pressure shall be installed.

P2903.5 Water hammer.
The flow velocity of the water distribution system shall be controlled to reduce the possibility of water hammer. A water-hammer arrestor shall be installed where quick-closing valves (example: clothes washers, dishwashers, ice makers) and metallic piping are used. The water-hammer arrestor shall not be required on any valves where plastic pipe is used for water distribution piping. Water-hammer arrestors shall be installed in accordance with the manufacturer’s instructions. Water-hammer arrestors shall conform to ASSE 1010.

P2903.6 Determining water supply fixture units.
Supply loads in the building water distribution system shall be determined by total load on the pipe being sized, in terms of water supply fixture units (w.s.f.u.), as shown in Table P2903.6, and gallon per minute (gpm) flow rates [see Table P2903.6(1)]. For fixtures not listed, choose a w.s.f.u. value of a fixture with similar flow characteristics.

<table>
<thead>
<tr>
<th>TYPE OF FIXTURES OR GROUP OF FIXTURES</th>
<th>WATER-SUPPLY FIXTURE-UNIT VALUE (w.s.f.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hot</td>
</tr>
<tr>
<td>Bathtub (with/without overhead shower head)</td>
<td>1.0</td>
</tr>
<tr>
<td>Fixtures</td>
<td>1.0</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Clothes washer</td>
<td></td>
</tr>
<tr>
<td>Dishwasher</td>
<td>1.4</td>
</tr>
<tr>
<td>Full-bath group with bathtub (with/without shower head) or shower stall</td>
<td>1.5</td>
</tr>
<tr>
<td>Half-bath group (water closet and lavatory)</td>
<td>0.5</td>
</tr>
<tr>
<td>Hose bibb (silcock)</td>
<td></td>
</tr>
<tr>
<td>Kitchen group (dishwasher and sink with or without food-waste disposer)</td>
<td>1.9</td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>1.0</td>
</tr>
<tr>
<td>Laundry group (clothes washer standpipe and laundry tub)</td>
<td>1.8</td>
</tr>
<tr>
<td>Laundry tub</td>
<td>1.0</td>
</tr>
<tr>
<td>Lavatory</td>
<td>0.5</td>
</tr>
<tr>
<td>Shower stall</td>
<td>1.0</td>
</tr>
<tr>
<td>Water closet (tank type)</td>
<td>—</td>
</tr>
</tbody>
</table>

For SI: 1 gallon per minute = 3.785 L/m.

a. The fixture unit value 2.5 assumes a flow demand of 2.5 gpm, such as for an individual lawn sprinkler device. If a hose bibb or sill cock will be required to furnish a greater flow, the equivalent fixture-unit value may be obtained from this table or Table P2903.6(1).

**TABLE P2903.6(1)**

**CONVERSIONS FROM WATER SUPPLY FIXTURE UNIT TO GALLON PER MINUTE FLOW RATES**

<table>
<thead>
<tr>
<th>Supply Systems Predominantly for Flush Tanks</th>
<th>Supply Systems Predominantly for Flushometer Valves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load (Water supply fixture units)</td>
<td>Demand (Gallons per minute)</td>
</tr>
<tr>
<td></td>
<td>(Cubic feet per minute)</td>
</tr>
<tr>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>
### TABLE P2903.6(1)—continued

CONVERSIONS FROM WATER SUPPLY FIXTURE UNIT TO GALLON PER MINUTE FLOW RATES

<table>
<thead>
<tr>
<th>Load</th>
<th>Demand</th>
<th>Supply Systems Predominantly for Flush Tanks</th>
<th>Load</th>
<th>Demand</th>
<th>Supply Systems Predominantly for Flushometer Valves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Water supply fixture units)</td>
<td></td>
<td></td>
<td>(Water supply fixture units)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Gallons per minute)</td>
<td></td>
<td></td>
<td>(Gallons per minute)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Cubic feet per minute)</td>
<td></td>
<td></td>
<td>(Cubic feet per minute)</td>
</tr>
<tr>
<td>25</td>
<td>21.5</td>
<td>2.87412</td>
<td>25</td>
<td>38.0</td>
<td>5.07984</td>
</tr>
<tr>
<td>30</td>
<td>23.3</td>
<td>3.114744</td>
<td>30</td>
<td>42.0</td>
<td>5.61356</td>
</tr>
<tr>
<td>35</td>
<td>24.9</td>
<td>3.328632</td>
<td>35</td>
<td>44.0</td>
<td>5.88192</td>
</tr>
<tr>
<td>40</td>
<td>26.3</td>
<td>3.515784</td>
<td>40</td>
<td>46.0</td>
<td>6.14928</td>
</tr>
<tr>
<td>45</td>
<td>27.7</td>
<td>3.702936</td>
<td>45</td>
<td>48.0</td>
<td>6.41664</td>
</tr>
<tr>
<td>50</td>
<td>29.1</td>
<td>3.890088</td>
<td>50</td>
<td>50.0</td>
<td>6.684</td>
</tr>
</tbody>
</table>

For SI: 1 gallon per minute = 3.785 L/m, 1 cubic foot per minute = 0.4719 L/s.

**P2903.7 Size of water-service mains, branch mains and risers.**

The size of the water service pipe shall be not less than $\frac{3}{4} \text{ inch (19 mm)}$ diameter. The size of water service mains, branch mains and risers shall be determined from the water supply demand [gpm (L/m)], available water pressure [psi (kPa)] and friction loss caused by the water meter and developed length of pipe [feet (m)], including equivalent length of fittings. The size of each water distribution system shall be determined according to design methods conforming to acceptable engineering practice, such as those methods in Appendix P and shall be approved by the code official.

**P2903.8 Gridded and parallel water distribution systems.**

Hot water and cold water manifolds installed with parallel-connected individual distribution lines and cold water manifolds installed with gridded distribution lines to each fixture or fixture fitting shall be designed in accordance with Sections P2903.8.1 through P2903.8.5. Gridded systems for hot water distribution systems shall be prohibited.

**P2903.8.1 Sizing of manifolds.**

Manifolds shall be sized in accordance with Table P2903.8.1. Total gallons per minute is the demand for all outlets.

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TABLE P2903.8.1
MANIFOLD SIZING

<table>
<thead>
<tr>
<th>Nominal Size ID (inches)</th>
<th>Maximum a gpm</th>
<th>Nominal Size ID (inches)</th>
<th>Maximum a gpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4</td>
<td>17</td>
<td>3/4</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>29</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>1 1/4</td>
<td>46</td>
<td>1 1/4</td>
<td>31</td>
</tr>
<tr>
<td>1 1/2</td>
<td>66</td>
<td>1 1/2</td>
<td>44</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m,
1 foot per second = 0.3048 m/s.

Note: See Table P2903.6(1) for w.s.f.u and Table 2903.6(1) for gallon-per-minute (gpm) flow rates.

a. Based on velocity limitation: plastic-12 fps; metal-8 fps.

P2903.8.2 Minimum size.
Where the developed length of the distribution line is 60 feet (18 288 mm) or less, and the available pressure at the meter is not less than 40 pounds per square inch (276 kPa), the size of individual distribution lines shall be not less than 3/8 inch (10 mm) diameter. Certain fixtures such as one-piece water closets and whirlpool bathtubs shall require a larger size where specified by the manufacturer. If a water heater is fed from the end of a cold water manifold, the manifold shall be one size larger than the water heater feed.

P2903.8.3 Support and protection.
Plastic piping bundles shall be secured in accordance with the manufacturer’s instructions and supported in accordance with Section P2605. Bundles that have a change in direction equal to or greater than 45 degrees (0.79 rad) shall be protected from chafing at the point of contact with framing members by sleeving or wrapping.

P2903.8.4 Valving.
Fixture valves, when installed, shall be located either at the fixture or at the manifold. Valves installed at the manifold shall be labeled indicating the fixture served.

P2903.8.5 Hose bibb bleed.
A readily accessible air bleed shall be installed in hose bibb supplies at the manifold or at the hose bibb exit point.

P2903.9 Valves.
Valves shall be installed in accordance with Sections P2903.9.1 through P2903.9.5.

P2903.9.1 Service valve.
Each dwelling unit shall be provided with an accessible main shutoff valve near the entrance of the water service. The valve shall be of a full-open type having nominal restriction to flow, with provision for drainage such as a bleed orifice or installation of a separate drain valve.
Additionally, the water service shall be valved at the curb or lot line in accordance with local requirements.

**P2903.9.2 Water heater valve.**  
A *readily accessible* full-open valve shall be installed in the cold-water supply pipe to each water heater at or near within 3 feet (914 mm) of the water heater.

**P2903.9.3 Fixture valves and access.**  
Shutoff valves shall be required on each fixture supply pipe to each plumbing appliance and to each plumbing fixture other than bathtubs and showers. Valves serving individual plumbing fixtures, *plumbing appliances*, risers and branches shall be *accessible*.

**P2903.9.4 Valve requirements.**  
Valves shall be compatible with the type of piping material installed in the system. Valves shall conform to one of the standards listed in Table P2903.9.4 or shall be *approved*. Valves intended to supply drinking water shall meet the requirements of NSF 61.

**TABLE P2903.9.4 VALVES**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC) plastic</td>
<td>ASME A112.4.14, ASME A112.18.1/CSA B125.1, ASTM F 1970, CSA B125.3</td>
</tr>
<tr>
<td>Copper or copper alloy</td>
<td>ASME A112.4.14, ASME A112.18.1/CSA B125.1, ASME B16.34, CSA B125.3, MSS SP-67, MSS SP-80, MSS SP-110</td>
</tr>
<tr>
<td>Gray and ductile iron</td>
<td>ASTM A126, AWWA C500, AWWA C504, AWWA C507, MSS SP-42, MSS SP-67, MSS SP-70, MSS SP-71, MSS SP-72, MSS SP-78</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX) plastic</td>
<td>ASME A112.4.14, ASME A112.18.1/CSA B125.1, CSA B125.3, NSF 359</td>
</tr>
<tr>
<td>Polypropylene (PP) plastic</td>
<td>ASME A112.4.14, ASTM F 2389</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic</td>
<td>ASME A112.4.14, ASTM F 1970</td>
</tr>
</tbody>
</table>

**P2903.9.5 Valves and outlets prohibited below grade.**  
Potable water outlets and combination stop-and-waste valves shall not be installed underground or below grade. Freezeproof yard hydrants that drain the riser into the ground are considered to be stop-and-waste valves.

**Exception:** Installation of freezeproof yard hydrants that drain the riser into the ground shall be permitted if the potable water supply to such hydrants is protected upstream of the hydrants in accordance with Section P2902 and the hydrants are permanently identified as nonpotable outlets by *approved* signage that reads as follows: “Caution, Nonpotable Water. Do Not Drink.”

**P2903.10 Hose bibb.**  
Hose bibbs subject to freezing, including the “frostproof” type, shall be equipped with an accessible stop-and-waste-type valve inside the building so that they can be controlled and drained during cold periods.
Exception: Frostproof hose bibbs installed such that the stem extends through the building insulation into an open heated or semiconditioned space need not be separately valved (see Figure P2903.10).

![Diagram of frostproof hose bibb installation](image)

**Figure P2903.10**
**Typical Frostproof Hose Bibb Installation Not Requiring Separate Valve**

P2903.11 Drain water heat recovery units.
Drain water heat recovery units shall be in accordance with Section N1103.5.4.

SECTION P2904
**DWELLING UNIT FIRE SPRINKLER SYSTEMS**

P2904.1 General.
The design and installation of residential fire sprinkler systems shall be in accordance with NFPA 13D or Section P2904, which shall be considered equivalent to NFPA 13D. Partial residential sprinkler systems shall be permitted to be installed only in buildings not required to be equipped with a residential sprinkler system. Section P2904 shall apply to stand-alone and multipurpose wet-pipe sprinkler systems that do not include the use of antifreeze. A multipurpose fire sprinkler system shall provide domestic water to both fire sprinklers and plumbing fixtures. A stand-alone sprinkler system shall be separate and independent from the water distribution system. A backflow preventer shall not be required to separate a stand-alone sprinkler system from the water distribution system.

P2904.1.1 Required sprinkler locations.
Sprinklers shall be installed to protect all areas of a *dwelling unit*.
Exceptions:

1. Attics, crawl spaces and normally unoccupied concealed spaces that do not contain fuel-fired appliances do not require sprinklers. In attics, crawl spaces and normally unoccupied concealed spaces that contain fuel-fired equipment, a sprinkler shall be installed above the equipment; however, sprinklers shall not be required in the remainder of the space.

2. Clothes closets, linen closets and pantries not exceeding 24 square feet (2.2 m^2) in area, with the smallest dimension not greater than 3 feet (915 mm) and having wall and ceiling surfaces of gypsum board.

3. Bathrooms not more than 55 square feet (5.1 m^2) in area.

4. Garages; carports; exterior porches; unheated entry areas, such as mud rooms, that are adjacent to an exterior door; and similar areas.

**P2904.2 Sprinklers.**
Sprinklers shall be new listed residential sprinklers and shall be installed in accordance with the sprinkler manufacturer’s instructions.

**P2904.2.1 Temperature rating and separation from heat sources.**
Except as provided for in Section P2904.2.2, sprinklers shall have a temperature rating of not less than 135°F (57°C) and not more than 170°F (77°C). Sprinklers shall be separated from heat sources as required by the sprinkler manufacturer’s installation instructions.

**P2904.2.2 Intermediate temperature sprinklers.**
Sprinklers shall have an intermediate temperature rating not less than 175°F (79°C) and not more than 225°F (107°C) where installed in the following locations:

1. Directly under skylights, where the sprinkler is exposed to direct sunlight.

2. In attics.

3. In concealed spaces located directly beneath a roof.

4. Within the distance to a heat source as specified in Table P2904.2.2.

**TABLE P2904.2.2**
**LOCATIONS WHERE INTERMEDIATE TEMPERATURE SPRINKLERS ARE REQUIRED**

<table>
<thead>
<tr>
<th>HEAT SOURCE</th>
<th>RANGE OF DISTANCE FROM HEAT SOURCE WITHIN WHICH INTERMEDIATE TEMPERATURE SPRINKLERS ARE REQUIRED</th>
<th>a, b (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fireplace, side of open or recessed fireplace</td>
<td>12 to 36</td>
<td></td>
</tr>
<tr>
<td>Fireplace, front of recessed fireplace</td>
<td>36 to 60</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Heat Source</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal and wood burning stove</td>
<td>12 to 42</td>
</tr>
<tr>
<td>Kitchen range top</td>
<td>9 to 18</td>
</tr>
<tr>
<td>Oven</td>
<td>9 to 18</td>
</tr>
<tr>
<td>Vent connector or chimney connector</td>
<td>9 to 18</td>
</tr>
<tr>
<td>Heating duct, not insulated</td>
<td>9 to 18</td>
</tr>
<tr>
<td>Hot water pipe, not insulated</td>
<td>6 to 12</td>
</tr>
<tr>
<td>Side of ceiling or wall warm air register</td>
<td>12 to 24</td>
</tr>
<tr>
<td>Front of wall mounted warm air register</td>
<td>18 to 36</td>
</tr>
<tr>
<td>Water heater, furnace or boiler</td>
<td>3 to 6</td>
</tr>
<tr>
<td>Luminaire up to 250 watts</td>
<td>3 to 6</td>
</tr>
<tr>
<td>Luminaire 250 watts up to 499 watts</td>
<td>6 to 12</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. Sprinklers shall not be located at distances less than the minimum table distance unless the sprinkler listing allows a lesser distance.

b. Distances shall be measured in a straight line from the nearest edge of the heat source to the nearest edge of the sprinkler.

**P2904.2.3 Freezing areas.**

Piping shall be protected from freezing as required by Section P2603.6. Where sprinklers are required in areas that are subject to freezing, dry-sidewall or dry-pendent sprinklers extending from a nonfreezing area into a freezing area shall be installed.

**P2904.2.4 Sprinkler coverage.**

Sprinkler coverage requirements and sprinkler obstruction requirements shall be in accordance with Sections P2904.2.4.1 and P2904.2.4.2.

**P2904.2.4.1 Coverage area limit.**

The area of coverage of a single sprinkler shall not exceed 400 square feet (37 m\(^2\)) and shall be based on the sprinkler listing and the sprinkler manufacturer’s installation instructions.

**P2904.2.4.2 Obstructions to coverage.**

Sprinkler discharge shall not be blocked by obstructions unless additional sprinklers are installed to protect the obstructed area. Additional sprinklers shall not be required where the sprinkler separation from obstructions complies with either the minimum distance indicated in Figure P2904.2.4.2 or the minimum distances specified in the sprinkler manufacturer’s instructions where the manufacturer’s instructions permit a lesser distance.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE P2904.2.4.2**
P2904.2.4.2.1 Additional requirements for pendent sprinklers. Pendent sprinklers within 3 feet (915 mm) of the center of a ceiling fan, surface-mounted ceiling luminaire or similar object shall be considered to be obstructed, and additional sprinklers shall be installed.

P2904.2.4.2.2 Additional requirements for sidewall sprinklers. Sidewall sprinklers within 5 feet (1524 mm) of the center of a ceiling fan, surface-mounted ceiling luminaire or similar object shall be considered to be obstructed, and additional sprinklers shall be installed.

P2904.2.5 Sprinkler installation on systems assembled with solvent cement. The solvent cementing of threaded adapter fittings shall be completed and threaded adapters for sprinklers shall be verified as being clear of excess cement prior to the installation of sprinklers on systems assembled with solvent cement.

P2904.2.6 Sprinkler modifications prohibited. Painting, caulking or modifying of sprinklers shall be prohibited. Sprinklers that have been painted, caulked, modified or damaged shall be replaced with new sprinklers.

P2904.3 Sprinkler piping system. Sprinkler piping shall be supported in accordance with requirements for cold water distribution piping. Sprinkler piping shall comply with the requirements for cold water distribution piping. For multipurpose piping systems, the sprinkler piping shall connect to and be a part of the cold water distribution piping system.

Exception: For plastic piping, it shall be permissible to follow the manufacturer's installation instructions.

P2904.3.1 Nonmetallic pipe and tubing. Nonmetallic pipe and tubing, such as CPVC, PEX, and PE-RT shall be listed for use in residential fire sprinkler systems.

P2904.3.1.1 Nonmetallic pipe protection. Nonmetallic pipe and tubing systems shall be protected from exposure to the living space by a layer of not less than 3/8-inch-thick (9.5 mm) gypsum wallboard, 1/2-inch-thick (13 mm) plywood, or other material having a 15-minute fire rating.

Exceptions:

1. Pipe protection shall not be required in areas that do not require protection with sprinklers as specified in Section P2904.1.1.

2. Pipe protection shall not be required where exposed piping is permitted by the pipe listing.

P2904.3.2 Shutoff valves prohibited. With the exception of shutoff valves for the entire water distribution system, valves shall not
be installed in any location where the valve would isolate piping serving one or more sprinklers.

**P2904.3.3 Single dwelling limit.**
Piping beyond the service valve located at the beginning of the water distribution system shall not serve more than one *dwelling*.

**P2904.3.4 Drain.**
A means to drain the sprinkler system shall be provided on the system side of the water distribution shutoff valve.

**P2904.4 Determining system design flow.**
The flow for sizing the sprinkler piping system shall be based on the flow rating of each sprinkler in accordance with Section P2904.4.1 and the calculation in accordance with Section P2904.4.2.

**P2904.4.1 Determining required flow rate for each sprinkler.**
The minimum required flow for each sprinkler shall be determined using the sprinkler manufacturer’s published data for the specific sprinkler model based on all of the following:

1. The area of coverage.
2. The ceiling configuration.
3. The temperature rating.
4. Any additional conditions specified by the sprinkler manufacturer.

**P2904.4.2 System design flow rate.**
The design flow rate for the system shall be based on the following:

1. The design flow rate for a room having only one sprinkler shall be the flow rate required for that sprinkler, as determined by Section P2904.4.1.

2. The design flow rate for a room having two or more sprinklers a shall be determined by identifying the sprinkler in that room with the highest required flow rate, based on Section P2904.4.1, and multiplying that flow rate by 2.

3. Where the sprinkler manufacturer specifies different criteria for ceiling configurations that are not smooth, flat and horizontal, the required flow rate for that room shall comply with the sprinkler manufacturer’s instructions.

4. The design flow rate for the sprinkler system shall be the flow required by the room with the largest flow rate, based on Items 1, 2 and 3.

5. For the purpose of this section, it shall be permissible to reduce the design flow rate for a room by subdividing the space into two or more rooms, where each room is evaluated separately with respect to the required design flow rate. Each room shall be bounded by walls and a ceiling. Openings in walls shall have a lintel not less than
8 inches (203 mm) in depth and each lintel shall form a solid barrier between the ceiling and the top of the opening.

P2904.5 Water supply.
The water supply shall provide not less than the required design flow rate for sprinklers in accordance with Section P2904.4.2 at a pressure not less than that used to comply with Section P2904.6.

P2904.5.1 Water supply from individual sources.
Where a dwelling unit water supply is from a tank system, a private well system or a combination of these, the available water supply shall be based on the minimum pressure control setting for the pump.

P2904.5.2 Required capacity.
The water supply shall have the capacity to provide the required design flow rate for sprinklers for a period of time as follows:

1. Seven minutes for dwelling units one story in height and less than 2,000 square feet (186 m²) in area.
2. Ten minutes for dwelling units two or more stories in height or equal to or greater than 2,000 square feet (186 m²) in area.

Where a well system, a water supply tank system or a combination thereof is used, any combination of well capacity and tank storage shall be permitted to meet the capacity requirement.

P2904.6 Pipe sizing.
The piping to sprinklers shall be sized for the flow required by Section P2904.4.2. The flow required to supply the plumbing fixtures shall not be required to be added to the sprinkler design flow.

P2904.6.1 Method of sizing pipe.
Piping supplying sprinklers shall be sized using the prescriptive method in Section P2904.6.2 or by hydraulic calculation in accordance with NFPA 13D. The minimum pipe size from the water supply source to any sprinkler shall be \( \frac{3}{4} \) inch (19 mm) nominal. Threaded adapter fittings at the point where sprinklers are attached to the piping shall be not less than \( \frac{1}{2} \) inch (13 mm) nominal.

P2904.6.2 Prescriptive pipe sizing method.
Pipe shall be sized by determining the available pressure to offset friction loss in piping and identifying a piping material, diameter and length using the equation in Section P2904.6.2.1 and the procedure in Section P2904.6.2.2.

<table>
<thead>
<tr>
<th>TABLE P2904.6.2(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER SERVICE PRESSURE LOSS ( PL_{svc} )^a,b</td>
</tr>
<tr>
<td>FLOW RATE (gpm)</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute = 0.063 L/s, 1 pound per square inch = 6.895 kPa.
NP = Not permitted. Pressure loss exceeds reasonable limits.

a. Values are applicable for underground piping materials listed in Table P2905.4 and are based on an SDR of 11 and a Hazen Williams C Factor of 150.
b. Values include the following length allowances for fittings: 25% length increase for actual lengths up to 100 feet and 15% length increase for actual lengths over 100 feet.
c. Flow rate from Section P2904.4.2. Add 5 gpm to the flow rate required by Section P2904.4.2 where the water-service pipe supplies more than one dwelling.

**TABLE P2904.6.2(2)**

**MINIMUM WATER METER PRESSURE LOSS ($PL_m$)**

<table>
<thead>
<tr>
<th>FLOW RATE (gallons per minute, gpm)</th>
<th>5/8 -INCH METER PRESSURE LOSS (pounds per square inch, psi)</th>
<th>3/4 -INCH METER PRESSURE LESS (pounds per square inch, psi)</th>
<th>1-INCH METER PRESSURE LOSS (pounds per square inch, psi)</th>
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</thead>
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<td>18</td>
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</table>
For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.063 L/s.
NP—Not permitted unless the actual water meter pressure loss is known.

a. Table P2904.6.2(2) establishes conservative values for water meter pressure loss or installations where the water meter loss is unknown. Where the actual water meter pressure loss is known, $P_m$ shall be the actual loss.

b. Flow rate from Section P2904.4.2. Add 5 gpm to the flow rate required by Section P2904.4.2 where the water-service pipe supplies more than one dwelling.

### TABLE P2904.6.2(3)
**ELEVATION LOSS ($P_L$)**

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</table>

For SI: 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.

### TABLE P2904.6.2(4)
**ALLOWABLE PIPE LENGTH FOR $\frac{3}{4}$-INCH TYPE M COPPER WATER TUBING**

<table>
<thead>
<tr>
<th>SPRINKLER FLOW RATE (^a) (gpm)</th>
<th>WATER DISTRIBUTION SIZE (inch)</th>
<th>AVAILABLE PRESSURE—$P_t$ (psi)</th>
</tr>
</thead>
<tbody>
<tr>
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\(^a\) SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa.
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TABLE P2904.6.2(5)
ALLOWABLE PIPE LENGTH FOR 1-INCH TYPE M COPPER WATER TUBING

<table>
<thead>
<tr>
<th>SPRINKLER FLOW RATE (^a) (gpm)</th>
<th>WATER DISTRIBUTION SIZE (inch)</th>
<th>AVAILABLE PRESSURE—(P_t) (psi)</th>
<th>15</th>
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<th>25</th>
<th>30</th>
<th>35</th>
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<th>55</th>
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</thead>
<tbody>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
NP—Not permitted.
a. Flow rate from Section P2904.4.2.
### TABLE P2904.6.2(6)
#### ALLOWABLE PIPE LENGTH FOR $\frac{3}{4}$-INCH CPVC PIPE

<table>
<thead>
<tr>
<th>SPRINKLER FLOW RATE(^a) (gpm)</th>
<th>WATER DISTRIBUTION SIZE (inch)</th>
<th>AVAILABLE PRESSURE—$P$ (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Allowable length of pipe from service valve to farthest sprinkler (feet)</td>
</tr>
<tr>
<td>8</td>
<td>$\frac{3}{4}$</td>
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<td>$\frac{3}{4}$</td>
<td>193  258  322  387  451  515  580  644  709  773</td>
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<td>124  165  206  247  289  330  371  412  454  495</td>
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<td>$\frac{3}{4}$</td>
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<td>70   94   117  141  164  188  211  234  258  281</td>
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</tbody>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.

* Flow rate from Section P2904.4.2.
<table>
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.
a. Flow rate from Section P2904.4.2.
### TABLE P2904.6.2(7)
**ALLOWABLE PIPE LENGTH FOR 1-INCH CPVC PIPE**

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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.

a. Flow rate from Section P2904.4.2.

### TABLE P2904.6.2(8)
**ALLOWABLE PIPE LENGTH FOR 3/4-INCH PEX AND PE-RT TUBING**

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NP—Not permitted.
a. Flow rate from Section P2904.4.2.

### TABLE P2904.6.2(9)
**ALLOWABLE PIPE LENGTH FOR 1-INCH PEX AND PE-RT TUBING**

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</tbody>
</table>

<sup>a</sup> Flow rate from Section P2904.4.2.
P2904.6.2.1 Available pressure equation.
The pressure available to offset friction loss in the interior piping system (\(P_t\)) shall be determined in accordance with the Equation 29-1.

\[
P_t = P_{sup} - PL_{svc} - PL_m - PL_d - PL_e - P_{sp}
\]  

(Equation 29-1)

where:

- \(P_t\) = Pressure used in applying Tables P2904.6.2(4) through P2904.6.2(9).
- \(P_{sup}\) = Pressure available from the water supply source.
- \(PL_{svc}\) = Pressure loss in the water-service pipe.
- \(PL_m\) = Pressure loss in the water meter.
- \(PL_d\) = Pressure loss from devices other than the water meter.
- \(PL_e\) = Pressure loss associated with changes in elevation.
- \(P_{sp}\) = Maximum pressure required by a sprinkler.

P2904.6.2.2 Calculation procedure.
Determination of the required size for water distribution piping shall be in accordance with the following procedure:

Step 1—Determine \(P_{sup}\)
Obtain the static supply pressure that will be available from the water main from the water purveyor, or for an individual source, the available supply pressure shall be in accordance with Section P2904.5.1.

Step 2—Determine \(PL_{svc}\)

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 0.963 L/s.

a. Flow rate from Section P2904.4.2.
Use Table P2904.6.2(1) to determine the pressure loss in the water service pipe based on the selected size of the water service.

**Step 3—Determine PLm**
Use Table P2904.6.2(2) to determine the pressure loss from the water meter, based on the selected water meter size.

**Step 4—Determine PLd**
Determine the pressure loss from devices other than the water meter installed in the piping system supplying sprinklers, such as pressure-reducing valves, backflow preventers, water softeners or water filters. Device pressure losses shall be based on the device manufacturer’s specifications. The flow rate used to determine pressure loss shall be the rate from Section P2904.4.2, except that 5 gpm (0.3 L/s) shall be added where the device is installed in a water-service pipe that supplies more than one dwelling. As an alternative to deducting pressure loss for a device, an automatic bypass valve shall be installed to divert flow around the device when a sprinkler activates.

**Step 5—Determine PLe**
Use Table P2904.6.2(3) to determine the pressure loss associated with changes in elevation. The elevation used in applying the table shall be the difference between the elevation where the water source pressure was measured and the elevation of the highest sprinkler.

**Step 6—Determine Psp**
Determine the maximum pressure required by any individual sprinkler based on the flow rate from Section P2904.4.1. The required pressure is provided in the sprinkler manufacturer’s published data for the specific sprinkler model based on the selected flow rate.

**Step 7—Calculate Pt**
Using Equation 29-1, calculate the pressure available to offset friction loss in water-distribution piping between the service valve and the sprinklers.

**Step 8—Determine the maximum allowable pipe length**
Use Tables P2904.6.2(4) through P2904.6.2(9) to select a material and size for water distribution piping. The piping material and size shall be acceptable if the developed length of pipe between the service valve and the most remote sprinkler does not exceed the maximum allowable length specified by the applicable table. Interpolation of Pt between the tabular values shall be permitted.

The maximum allowable length of piping in Tables P2904.6.2(4) through P2904.6.2(9) incorporates an adjustment for pipe fittings. Additional consideration of friction losses associated with pipe fittings shall not be required.

**P2904.7 Instructions and signs.**
An owner’s manual for the fire sprinkler system shall be provided to the owner. A sign or valve tag shall be installed at the main shutoff valve to the water distribution system stating the following: “Warning, the water system for this home supplies fire sprinklers that require certain flows and pressures to fight a fire. Devices that restrict the flow or decrease the pressure or automatically shut off the water to the fire sprinkler system, such as water softeners, filtration systems and automatic shutoff valves, shall not be added to this system without a review of the fire sprinkler system by a fire protection specialist. Do not remove this sign.”
P2904.8 Inspections.
The water distribution system shall be inspected in accordance with Sections P2904.8.1 and P2904.8.2.

P2904.8.1 Preconcealment inspection.
The following items shall be verified prior to the concealment of any sprinkler system piping:

1. Sprinklers are installed in all areas as required by Section P2904.1.1.
2. Where sprinkler water spray patterns are obstructed by construction features, luminaires or ceiling fans, additional sprinklers are installed as required by Section P2904.2.4.2.
3. Sprinklers are the correct temperature rating and are installed at or beyond the required separation distances from heat sources as required by Sections P2904.2.1 and P2904.2.2.
4. The pipe size equals or exceeds the size used in applying Tables P2904.6.2(4) through P2904.6.2(9) or, if the piping system was hydraulically calculated in accordance with Section P2904.6.1, the size used in the hydraulic calculation.
5. The pipe length does not exceed the length permitted by Tables P2904.6.2(4) through P2904.6.2(9) or, if the piping system was hydraulically calculated in accordance with Section P2904.6.1, pipe lengths and fittings do not exceed those used in the hydraulic calculation.
6. Nonmetallic piping that conveys water to sprinklers is listed for use with fire sprinklers.
7. Piping is supported in accordance with the pipe manufacturer’s and sprinkler manufacturer’s installation instructions.
8. The piping system is tested in accordance with Section P2503.7.

P2904.8.2 Final inspection.
The following items shall be verified upon completion of the system:

1. Sprinklers are not painted, damaged or otherwise hindered from operation.
2. Where a pump is required to provide water to the system, the pump starts automatically upon system water demand.
3. Pressure-reducing valves, water softeners, water filters or other impairments to water flow that were not part of the original design have not been installed.
4. The sign or valve tag required by Section P2904.7 is installed and the owner’s manual for the system is present.
SECTION P2905
HEATED WATER DISTRIBUTION SYSTEMS

P2905.1 Heated water circulation systems and heat trace systems.
Circulation systems and heat trace systems that are installed to bring heated water in close proximity to one or more fixtures shall meet the requirements of Section N1103.5.1.

P2905.2 Demand recirculation systems.
Demand recirculation water systems shall be in accordance with Section N1103.5.2.

SECTION P2906
MATERIALS, JOINTS AND CONNECTIONS

P2906.1 Soil and groundwater.
The installation of water service pipe, water distribution pipe, fittings, valves, appurtenances and gaskets shall be prohibited in soil and groundwater that is contaminated with solvents, fuels, organic compounds or other detrimental materials that cause permeation, corrosion, degradation or structural failure of the water service or water distribution piping material.

P2906.1.1 Investigation required.
Where detrimental conditions are suspected by or brought to the attention of the building official, a chemical analysis of the soil and groundwater conditions shall be required to ascertain the acceptability of the water service material for the specific installation.

P2906.1.2 Detrimental condition.
Where a detrimental condition exists, approved alternate materials or alternate routing shall be required.

P2906.2 Lead content.
The lead content in pipe and fittings used in the water supply system shall be not greater than 8 percent in accordance with Section P2906.2.1.

P2906.2.1 Lead content of drinking water pipe and fittings.
Pipe, pipe fittings, joints, valves, faucets and fixture fittings utilized to supply water for drinking or cooking purposes shall comply with NSF 372 and shall have a weighted average lead content of 0.25 percent lead or less.

P2906.3 Polyethylene plastic piping installation.
Polyethylene pipe shall be cut square using a cutter designed for plastic pipe. Except where joined by heat fusion, pipe ends shall be chamfered to remove sharp edges. Pipe that has been kinked shall not be installed. For bends, the installed radius of pipe curvature shall be greater than 30 pipe diameters or the coil radius where bending with the coil. Coiled pipe shall not be bent beyond straight. Bends within 10 pipe diameters of any fitting or valve shall be prohibited. Joints between polyethylene plastic pipe and fittings shall comply with Section P2906.3.1 or P2906.3.2.

P2906.3.1 Heat-fusion joints.
Joint surfaces shall be clean and free from moisture. Joint surfaces shall be heated to melting temperature and joined. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM D 2657.
P2906.3.2 Mechanical joints.
Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

P2906.4 Water service pipe.
Water service pipe shall conform to NSF 61 and shall conform to one of the standards indicated in Table P2906.4. Water service pipe or tubing, installed underground and outside of the structure, shall have a working pressure rating of not less than 160 pounds per square inch at 73.4°F (1103 kPa at 23°C). Where the water pressure exceeds 160 pounds per square inch (1103 kPa), piping material shall have a rated working pressure equal to or greater than the highest available pressure. Water service piping materials not third-party certified for water distribution shall terminate at or before the full open valve located at the entrance to the structure 5 feet (1524 mm) outside of the building. Ductile iron water service piping shall be cement mortar lined in accordance with AWWA C104/A21.4.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe</td>
<td>ASTM D 1527; ASTM D 2282</td>
</tr>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC) plastic pipe</td>
<td>ASTM D 2846; ASTM F 441; ASTM F 442; CSA B137.6</td>
</tr>
<tr>
<td>Chlorinated polyvinyl chloride/aluminum/chlorinated polyvinyl chloride (CPVC/AL/CPVC) plastic pipe</td>
<td>ASTM F 2855</td>
</tr>
<tr>
<td>Copper or copper-alloy pipe</td>
<td>ASTM B 42; ASTM B 43; ASTM B 302</td>
</tr>
<tr>
<td>Copper or copper-alloy tubing (Type K, WK, L, WL, M or WM)(^a)</td>
<td>ASTM B 75; ASTM B 88; ASTM B 251; ASTM B 447</td>
</tr>
<tr>
<td>Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe</td>
<td>ASTM F 1281; ASTM F 2262; CSA B137.10</td>
</tr>
<tr>
<td>Cross-linked polyethylene/aluminum/high-density polyethylene (PEX-AL-HDPE) pipe</td>
<td>ASTM F 1986</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX) plastic tubing</td>
<td>ASTM F 876; ASTM F 877; CSA B137.5</td>
</tr>
<tr>
<td>Ductile iron water pipe</td>
<td>AWWA C115/A21.15; AWWA C151/A21.51</td>
</tr>
<tr>
<td>Galvanized steel pipe</td>
<td>ASTM A 53</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) pipe</td>
<td>ASTM F 1282; CSA B137.9</td>
</tr>
<tr>
<td>Polyethylene (PE) plastic pipe</td>
<td>ASTM D 2104; ASTM D 2239; AWWA C901; CSA B137.1</td>
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<tr>
<td>Polyethylene (PE) plastic tubing</td>
<td>ASTM D 2737; AWWA C901; CSA B137.1</td>
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<tr>
<td>Polyethylene of raised temperature (PE-RT) plastic tubing</td>
<td>ASTM F 2769</td>
</tr>
<tr>
<td>Polypropylene (PP) plastic tubing</td>
<td>ASTM F 2389; CSA B137.11</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe</td>
<td>ASTM D 1785; ASTM D 2241; ASTM D 2672; CSA B137.3</td>
</tr>
<tr>
<td>Stainless steel (Type 304/304L) pipe</td>
<td>ASTM A 312; ASTM A 778</td>
</tr>
<tr>
<td>Stainless steel (Type 316/316L) pipe</td>
<td>ASTM A 312; ASTM A 778</td>
</tr>
</tbody>
</table>

\(^a\) Below grade Type K, WK, L, WL

P2906.4.1 Separation of water service and building sewer.
Trenching, pipe installation and backfilling shall be in accordance with Section P2604. Where water service piping is located in the same trench with the building sewer, such sewer shall be constructed of materials listed in Table P3002.1(2). Where the building sewer piping is not constructed of materials indicated in Table P3002.1(2), the water service pipe and the building sewer shall be horizontally separated by not less than 5 feet (1524 mm) of
undisturbed or compacted earth. The required separation distance shall not apply where a water service pipe crosses a sewer pipe, provided the water service is sleeved to a point not less than 5 feet (1524 mm) horizontally from the sewer pipe centerline on both sides of such crossing. The sleeve shall be of pipe materials indicated in Table P2906.4, P3002.1(2) or P3002.2. The required separation distance shall not apply where the bottom of the water service pipe that is located within 5 feet (1524 mm) of the sewer is not less than 12 inches (305 mm) above the highest point of the top of the building sewer.

**P2906.5 Water-distribution pipe.**
Water-distribution piping within *dwelling units* shall conform to NSF 61 and shall conform to one of the standards indicated in Table P2906.5. Hot-water-distribution pipe and tubing shall have a pressure rating of not less than 100 psi at 180°F (689 kPa at 82°C). Cold water distribution pipe and tubing shall have a minimum pressure rating of 160 psi (1100 kPa) at 73.4°F (23°C).

**TABLE P2906.5 WATER DISTRIBUTION PIPE**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
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</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC) plastic pipe and tubing</td>
<td>ASTM D 2846; ASTM F 441; ASTM F 442; CSA B137.6</td>
</tr>
<tr>
<td>Chlorinated polyvinyl chloride/aluminum/chlorinated polyvinyl chloride (CPVC/AL/CPVC) plastic pipe</td>
<td>ASTM F 2855</td>
</tr>
<tr>
<td>Copper or copper-alloy pipe</td>
<td>ASTM B 42; ASTM B 43; ASTM B 302</td>
</tr>
<tr>
<td>Copper or copper-alloy tubing (Type K, WK, L, WL, M or WM)</td>
<td>ASTM B 75; ASTM B 88; ASTM B 251; ASTM B 447</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX) plastic tubing</td>
<td>ASTM F 876; ASTM F 877; CSA B137.5</td>
</tr>
<tr>
<td>Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEx) pipe</td>
<td>ASTM F 1281; ASTM F 2262; CSA B137.10</td>
</tr>
<tr>
<td>Cross-linked polyethylene/aluminum/high-density polyethylene (PEX-AL-HDPE) pipe</td>
<td>ASTM F 1986</td>
</tr>
<tr>
<td>Galvanized steel pipe</td>
<td>ASTM A 53</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) composite pipe</td>
<td>ASTM F 1282</td>
</tr>
<tr>
<td>Polyethylene of raised temperature (PE-RT) plastic tubing</td>
<td>ASTM F 2769</td>
</tr>
<tr>
<td>Polypropylene (PP) plastic pipe or tubing</td>
<td>ASTM F 2389; CSA B137.11</td>
</tr>
<tr>
<td>Stainless steel (Type 304/304L) pipe</td>
<td>ASTM A 312; ASTM A 778</td>
</tr>
</tbody>
</table>

*a. Below grade Type K, WK, L, WL*

**P2906.6 Fittings.**
Pipe fittings shall be *approved* for installation with the piping material installed and shall comply with the applicable standards indicated in Table P2906.6. Pipe fittings used in water supply systems shall comply with NSF 61.

**TABLE P2906.6 PIPE FITTINGS**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
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<tbody>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic</td>
<td>ASTM D 2468</td>
</tr>
<tr>
<td>Cast-iron</td>
<td>ASME B16.4</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
Chlorinated polyvinyl chloride (CPVC) plastic | ASSE 1061; ASTM D 2846; ASTM F 437; ASTM F 438; ASTM F 439; CSA B137.6
---|---
Copper or copper alloy | ASSE 1061; ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.26; ASME B16.51
Cross-linked polyethylene/aluminum/high-density polyethylene (PEX-AL-HDPE) | ASTM F 1986
Fittings for cross-linked polyethylene (PEX) plastic tubing | ASSE 1061; ASTM F 877; ASTM F 1807; ASTM F 1960; ASTM F 2080; ASTM F 2098; ASTM F 2159; ASTM F 2434; ASTM F 2735; CSA B137.5
Gray iron and ductile iron | AWWA C110/A21.10; AWWA C153/A21.53
Malleable iron | ASME B16.3
Polybutylene (PB) plastic | ASSE 1061; CSA B137.8
Insert fittings for Polyethylene/aluminum/polyethylene (PE-AL-PE) and cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) | ASTM F 1974; ASTM F 1281; ASTM F 1282; CSA B137.9; CSA B137.10
Polyethylene (PE) plastic | ASTM D 2609; CSA B137.1
Fittings for polyethylene of raised temperature (PE-RT) plastic tubing | ASTM F 1807; ASTM F2098; ASTM F 2159; ASTM F 2735; ASTM F 2769
Polypropylene (PP) plastic pipe or tubing | ASTM F 2389; CSA B137.11
Polyvinyl chloride (PVC) plastic | ASTM D 2464; ASTM D 2466; ASTM D 2467; CSA B137.2; CSA B137.3
Stainless steel (Type 304/304L) pipe | ASTM A 312; ASTM A 77
Stainless steel (Type 316/316L) pipe | ASTM A 312; ASTM A 778
Steel | ASME B16.9; ASME B16.11; ASME B16.28

**P2906.7 Flexible water connectors.**
Flexible water connectors, exposed to continuous pressure, shall conform to ASME A112.18.6/CSA B125.6. Access shall be provided to flexible water connectors.

**P2906.8 Joint and connection tightness.**
Joints and connections in the plumbing system shall be gas tight and water tight for the intended use or required test pressure.

**P2906.9 Plastic pipe joints.**
Joints in plastic piping shall be made with approved fittings by solvent cementing, heat fusion, corrosion-resistant metal clamps with insert fittings or compression connections. Flared joints for polyethylene pipe shall be permitted in accordance with Section P2906.3.

**P2906.9.1 Solvent cementing.**
Solvent-cemented joints shall comply with Sections P2906.9.1.1 through P2906.9.1.3.

**P2906.9.1.1 ABS plastic pipe.**
Solvent cement for ABS plastic pipe conforming to ASTM D 2235 shall be applied to all joint surfaces. Joint surfaces shall be clean and free from moisture. Solvent cement that conforms to ASTM D 2235 shall be applied to all joint surfaces. The joint shall be made while the cement is wet. Joints shall be made in accordance with ASTM D 2235. Solvent-cement joints shall be permitted above or below ground.
P2906.9.1.2 CPVC plastic pipe.
Joint surfaces shall be clean and free from moisture. Joints shall be made in accordance with the pipe, fitting or solvent cement manufacturer’s installation instructions. Where such instructions require a primer to be used, an approved primer shall be applied, and a solvent cement, orange in color and conforming to ASTM F 493, shall be applied to joint surfaces. Where such instructions allow for a one-step solvent cement, yellow or red in color and conforming to ASTM F 493, to be used, the joint surfaces shall not require application of a primer before the solvent cement is applied. The joint shall be made while the cement is wet, and in accordance with ASTM D 2846 or ASTM F 493. Solvent cement joints shall be permitted above or below ground.

P2906.9.1.3 CPVC/AL/CPVC pipe.
Joint surfaces shall be clean and free from moisture, and an approved primer shall be applied. Solvent cement, orange in color and conforming to ASTM F 493, shall be applied to all joint surfaces. The joint shall be made while the cement is wet, and in accordance with ASTM D 2846 or ASTM F 493. Solvent-cement joints shall be installed above or below ground.

Exception: A primer shall not be required where all of the following conditions apply:

1. The solvent cement used is third-party certified as conforming to ASTM F 493.
2. The solvent cement used is yellow in color.
3. The solvent cement is used only for joining 1/2-inch (12.7 mm) through 1-inch (25 mm) diameter CPVC/AL/CPVC pipe and CPVC fittings.
4. The CPVC fittings systems are manufactured installed in accordance with ASTM D 2846.

P2906.9.1.4 PVC plastic pipe.
A purple primer or an ultraviolet purple primer that conforms to ASTM F 656 shall be applied to PVC solvent-cemented joints. When an ultraviolet primer is used, the installer shall provide an ultraviolet light to the inspector to be used during the inspection. Solvent cement for PVC plastic pipe conforming to ASTM D 2564 shall be applied to all joint surfaces.

P2906.9.1.5 Cross-linked polyethylene plastic (PEX).
Joints between cross-linked polyethylene plastic tubing or fittings shall comply with Section P2906.9.1.5.1 or Section P2906.9.1.5.2.

P2906.9.1.5.1 Flared joints.
Flared pipe ends shall be made by a tool designed for that operation.

P2906.9.1.5.2 Mechanical joints.
Mechanical joints shall be installed in accordance with the manufacturer’s instructions. Fittings for cross-linked polyethylene (PEX) plastic tubing shall comply
with the applicable standards indicated in Table P2906.6 and shall be installed in accordance with the manufacturer’s instructions. PEX tubing shall be factory marked with the applicable standards for the fittings that the PEX manufacturer specifies for use with the tubing.

**P2906.10 Polypropylene (PP) plastic.**
Joints between polypropylene plastic pipe and fittings shall comply with Section P2906.10.1 or P2906.10.2.

**P2906.10.1 Heat-fusion joints.**
Heat fusion joints for polypropylene pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings, butt-fusion polypropylene fittings or electrofusion polypropylene fittings. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F 2389.

**P2906.10.2 Mechanical and compression sleeve joints.**
Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s instructions.

**P2906.11 Cross-linked polyethylene/aluminum/cross-linked polyethylene.**
Joints between polyethylene/aluminum/polyethylene (PE-AL-PE) and cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe and fittings shall comply with Section P2906.11.1.

**P2906.11.1 Mechanical joints.**
Mechanical joints shall be installed in accordance with the manufacturer’s instructions. Fittings for PE-AL-PE and PEX-AL-PEX as described in ASTM F 1974, ASTM F 1281, ASTM F 1282, CSA B137.9 and CSA B137.10 shall be installed in accordance with the manufacturer’s instructions.

**P2906.12 Stainless steel.**
Joints between stainless steel pipe and fittings shall comply with Section P2906.12.1 or P2906.12.2.

**P2906.12.1 Mechanical joints.**
Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

**P2906.12.2 Welded joints.**
Joint surfaces shall be cleaned. The joint shall be welded autogenously or with an approved filler metal in accordance with ASTM A 312.

**P2906.13 Threaded pipe joints.**
Threaded joints shall conform to American National Taper Pipe Thread specifications. Pipe ends shall be deburred and chips removed. Pipe joint compound shall be used only on male threads.

**P2906.14 Soldered and brazed joints.**
Soldered joints in copper and copper alloy tubing shall be made with fittings approved for water piping and shall conform to ASTM B 828. Surfaces to be soldered shall be cleaned bright. Fluxes for soldering shall be in accordance with ASTM B 813. Brazing fluxes shall be in
accordance with AWS A5.31M/A5.31. Solders and fluxes used in potable water-supply systems shall have a lead content of not greater than 0.2 percent.

**P2906.15 Flared joints.**
Flared joints in water tubing shall be made with approved fittings. The tubing shall be reamed and then expanded with a flaring tool.

**P2906.16 Above-ground joints.**
Joints within the building between copper pipe or CPVC tubing, in any combination with compatible outside diameters, shall be permitted to be made with the use of approved push-in mechanical fittings of a pressure-lock design.

**P2906.17 Joints between different materials.**
Joints between different piping materials shall be made in accordance with Section P2906.17.1, P2906.17.2 or P2906.17.3, or with a mechanical joint of the compression or mechanical sealing type having an elastomeric seal conforming to ASTM D 1869 or ASTM F 477. Joints shall be installed in accordance with the manufacturer’s instructions.

**P2906.17.1 Copper or copper-alloy tubing to galvanized steel pipe.**
Joints between copper or copper-alloy tubing and galvanized steel pipe shall be made with a copper alloy fitting or dielectric fitting. The copper tubing shall be joined to the fitting in an approved manner, and the fitting shall be screwed to the threaded pipe.

**P2906.17.2 Plastic pipe or tubing to other piping material.**
Joints between different types of plastic pipe or between plastic pipe and other piping material shall be made with an approved adapter fitting or transition fittings.

**P2906.17.3 Stainless steel.**
Joints between stainless steel and different piping materials shall be made with a mechanical joint of the compression or mechanical-sealing type or a dielectric fitting or a dielectric union conforming to ASSE 1079.

**P2906.18 Press-connect joints.**
Press-connect joints shall conform to one of the standards indicated in Table P2906.6. Press-type mechanical joints in copper tubing shall be made in accordance with the manufacturer’s instructions. Cut tube ends shall be reamed to the full inside diameter of the tube end. Joint surfaces shall be cleaned. The tube shall be fully inserted into the press connect fitting. Press-connect joints shall be pressed with a tool certified by the manufacturer.

**P2906.19 Polyethylene of raised temperature plastic. (PE-RT)**
Joints between polyethylene of raised temperature plastic tubing and fittings shall be in accordance with Section P2906.19.1.

**P2906.19.1 Mechanical joints.**
Mechanical joints shall be installed in accordance with the manufacturer’s instructions. Fittings for polyethylene of raised temperature plastic tubing shall comply with the applicable standards listed in Table P2906.6 and shall be installed in accordance with the manufacturer’s instructions. Polyethylene of raised temperature plastic tubing shall be factory marked with the applicable standards for the fittings that the manufacturer of the tubing specifies for use with the tubing.

**P2906.20 (605.26) Polybutylene plastic.**
Joints between polybutylene plastic pipe and tubing or fittings shall comply with Sections P2906.20.1 through P2906.20.3.

**P2906.20.1 (605.26.1) Flared joints.**
Flared pipe ends shall be made by a tool designed for that operation.

**P2906.20.1 (605.26.2) Heat-fusion joints.**
Joints shall be of the socket-fusion or butt-fusion type. Joint surfaces shall be clean and free from moisture. All joint surfaces shall be heated to the melting temperature and joined. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM D 2657, ASTM D 3309 or CAN3-B137.8M.

**P2906.20.3 (605.26.3) Mechanical joints.**
Mechanical joints shall be installed in accordance with the manufacturer's installation instructions.

**SECTION P2907**
CHANGES IN DIRECTION

**P2907.1 Bends.**
Changes in direction in copper tubing shall be permitted to be made with bends having a radius of not less than four diameters of the tube, provided that such bends are made by use of forming equipment that does not deform or create loss in cross-sectional area of the tube.

**SECTION P2908**
SUPPORT

**P2908.1 General.**
Pipe and tubing support shall conform to Section P2605.

**SECTION P2909**
DRINKING WATER TREATMENT UNITS

**P2909.1 Design.**
Drinking water treatment units shall meet the requirements of NSF42, NSF 44, NSF 53, NSF 60, NSF 62 or CSA B483.1.

**P2909.2 Reverse osmosis drinking water treatment units.**
Point-of-use reverse osmosis drinking water treatment units, designed for residential use, shall meet the requirements of NSF 58 or CSA B483.1. Waste or discharge from reverse osmosis drinking water treatment units shall enter the drainage system through an air gap or an air gap device that meets the requirements of NSF 58.

**P2909.3 Connection tubing.**
The tubing to and from drinking water treatment units shall be of a size and material as recommended by the manufacturer. The tubing shall comply with NSF 14, NSF 42, NSF 44, NSF 53, NSF 58 or NSF 61.
SECTION P2910
NONPOTABLE WATER SYSTEMS

P2910.1 Scope.
The provisions of this section shall govern the materials, design, construction and installation of systems for the collection, storage, treatment and distribution of nonpotable water. The use and application of nonpotable water shall comply with laws, rules and ordinances applicable in the jurisdiction.

P2910.2 Water quality.
Nonpotable water for each end use application shall meet the minimum water quality requirements as established for the intended application by the laws, rules and ordinances applicable in the jurisdiction. Where nonpotable water from different sources is combined in a system, the system shall comply with the most stringent requirements of this code applicable to such sources.

P2910.2.1 Residual disinfectants.
Where chlorine is used for disinfection, the nonpotable water shall contain not more than 4 ppm (4 mg/L) of chloramines or free chlorine. Where ozone is used for disinfection, the nonpotable water shall not contain gas bubbles having elevated levels of ozone at the point of use.

Exception: Reclaimed water sources shall not be required to comply with the requirements of this section.

P2910.2.2 Filtration required.
Nonpotable water utilized for water closet and urinal flushing applications shall be filtered by a 100 micron or finer filter. Non-potable water for use within a building shall be colored blue or green.

Exception: Reclaimed water sources shall not be required to comply with the requirements of this section.

P2910.2.3 (1301.2.3) Applications.
Untreated rainwater shall be utilized in accordance with Section P2910.2.3.1. Treated rainwater shall be utilized in accordance with Section P2910.2.3.2.

P2910.2.3.1 (1301.2.3.1) Examples of acceptable uses without treatment.

1. Outdoor Irrigation
2. Decorative Fountains
3. Yard Hydrants
4. Industrial Processes (eg. Dust Control, Indoor Hose Bibs Spray)
5. Vehicle Washing
6. Outdoor Hose Bibs (not routed through building wall)
**P2910.2.3.2 (1301.2.3.2) Examples of acceptable uses with disinfection and filtration.**

1. Toilet Flushing
2. Urinal Flushing
3. Evaporative Cooling Tower Make-up
4. Trap Primers
5. Fire Suppression Systems
6. Clothes Washers
7. Outdoor Pools and Spas
8. Hose Bibs – Residential

**P2910.3 Signage required.**
Nonpotable water outlets such as hose connections, sillcocks, hose bibs, wall hydrants, yard hydrants, other outdoor outlets, open-ended pipes and faucets shall be identified at the point of use for each outlet with signage that reads as follows: “Nonpotable water is utilized for [application name]. CAUTION: NONPOTABLE WATER. DO NOT DRINK.” The words shall be legibly and indelibly printed on a tag or sign constructed of corrosion-resistant, waterproof material or shall be indelibly printed on the fixture. The letters of the words shall be not less than 0.5 inches (12.7 mm) in height and in colors contrasting the background on which they are applied. In addition to the required wordage, the pictograph shown in Figure P2910.3 shall appear on the signage required by this section.

![FIGURE P2910.3 PICTOGRAPH—DO NOT DRINK](image)

**P2910.4 Permits.**
Permits shall be required for the construction, installation, alteration and repair of nonpotable water systems. Construction documents, engineering calculations, diagrams and other such data pertaining to the nonpotable water system shall be submitted with each permit application.
P2910.5 Potable water connections.
Where a potable system is connected to a nonpotable water system, the potable water supply shall be protected against backflow in accordance with Section P2902.

P2910.6 Approved components and materials.
Piping, plumbing components and materials used in collection and conveyance systems shall be manufactured of material approved for the intended application and compatible with any disinfection and treatment systems used.

P2910.6.1 (1301.6.1) Identification of non-potable water systems.
Where non-potable plumbing systems (drainage or supply within gray water, rain water or reclaimed water systems) are installed, the piping conveying the non-potable water shall be identified either by color marking, metal tags or tape in accordance with Section P2910.6.2.

P2910.6.2 (1301.6.2) Non-potable pipe labeling and marking.
Non-potable distribution piping shall be purple in color or shall be embossed, or integrally stamped or marked, with the words: “CAUTION: NON-POTABLE WATER – DO NOT DRINK” or the piping shall be installed with a purple identification tape or wrap. Pipe identification shall include the contents of the piping system and an arrow indicating the direction of flow. Hazardous piping systems shall also contain information addressing the nature of the hazard. Pipe identification shall be repeated at intervals not exceeding 25 feet (7620 mm) and at each point where the piping passes through a wall, floor or roof. Lettering shall be readily observable within the room or space where the piping is located.

P2910.6.2.1 (1301.6.2.1) Color.
The color of the pipe identification shall be discernable and consistent throughout the building. The color purple shall be used to identify reclaimed, rain and gray water distribution systems.

P2910.6.2.2 (1301.6.2.2) Lettering size.
The size of the background color field and lettering shall comply with Table P2910.6.2.2.

<table>
<thead>
<tr>
<th>PIPE DIAMETER (inches)</th>
<th>LENGTH BACKGROUND COLOR FIELD (inches)</th>
<th>SIZE OF LETTERS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 to 1-1/4</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>1-1/2 to 2</td>
<td>8</td>
<td>0.75</td>
</tr>
<tr>
<td>2-1/2 to 6</td>
<td>12</td>
<td>1.25</td>
</tr>
<tr>
<td>8 to 10</td>
<td>24</td>
<td>2.5</td>
</tr>
<tr>
<td>over 10</td>
<td>32</td>
<td>3.5</td>
</tr>
</tbody>
</table>

For SI 1 inch = 25.4 mm.

P2910.6.2.3 (1301.6.2.3) Identification tape.
Where used, identification tape shall be at least 3 inches (76 mm) wide and have white or black lettering on a purple field stating “CAUTION: NON-POTABLE WATER – DO NOT DRINK.” Identification tape shall be installed on top of non-potable rainwater.
distribution pipes, fastened at least every 10 feet (3048 mm) to each pipe length and run continuously the entire length of the pipe.

P2910.7 Insect and vermin control.
The system shall be protected to prevent the entrance of insects and vermin into storage tanks and piping systems. Screens installed on vent pipes, inlets, and overflow pipes shall have an aperture of not greater than 1/16 inch (1.59 mm) and shall be close-fitting or other approved methods. Screen materials shall be compatible with contacting system components and shall not accelerate the corrosion of system components.

P2910.8 Freeze protection.
Where sustained freezing temperatures occur, provisions shall be made to keep storage tanks and the related piping from freezing.

P2909.9 Nonpotable water storage tanks.
Nonpotable water storage tanks shall comply with Sections P2910.9.1 through P2910.9.11.

P2910.9.1 Sizing.
The holding capacity of the storage tank shall be sized in accordance with the anticipated demand.

P2910.9.2 Location.
Storage tanks shall be installed above or below grade. Above-grade storage tanks shall be protected from direct sunlight and shall be constructed using opaque, UV-resistant materials such as, but not limited to, heavily tinted plastic, lined metal, concrete and wood; or painted to prevent algae growth; or shall have specially constructed sun barriers including, but not limited to, installation in garages, crawlspaces or sheds. Storage tanks and their manholes shall not be located directly under any soil piping, waste piping or any source of contamination.

P2910.9.3 Materials.
Where collected on site, water shall be collected in an approved tank constructed of durable, nonabsorbent and corrosion-resistant materials. The storage tank shall be constructed of materials compatible with any disinfection systems used to treat water upstream of the tank and with any systems used to maintain water quality within the tank. Wooden storage tanks that are not equipped with a makeup water source shall be provided with a flexible liner.

P2910.9.4 Foundation and supports.
Storage tanks shall be supported on a firm base capable of withstanding the weight of the storage tank when filled to capacity. Storage tanks shall be supported in accordance with this code.

P2910.9.4.1 Ballast.
Where the soil can become saturated, an underground storage tank shall be ballasted or otherwise secured to prevent the tank from floating out of the ground when empty. The combined weight of the tank and hold-down ballast shall meet or exceed the buoyancy force of the tank. Where the installation requires a foundation, the foundation shall be flat and shall be designed to support the storage tank weight when full, consistent with the bearing capability of adjacent soil.
P2910.9.4.2 Structural support.
Where installed below grade, storage tank installations shall be designed to withstand earth and surface structural loads without damage and with minimal deformation when empty or filled with water.

P2910.9.5 Makeup water.
Where an uninterrupted nonpotable water supply is required for the intended application, potable or reclaimed water shall be provided as a source of makeup water for the storage tank. The makeup water supply shall be protected against backflow by means of an air gap not less than 4 inches (102 mm) above the overflow or an approved backflow device in accordance with Section P2902. A full-open valve located on the makeup water supply line to the storage tank shall be provided. Inlets to the storage tank shall be controlled by fill valves or other automatic supply valves installed to prevent the tank from overflowing and to prevent the water level from dropping below a predetermined point. Where makeup water is provided, the water level shall be prohibited from dropping below the source water inlet or the intake of any attached pump.

P2910.9.5.1 Inlet control valve alarm.
Makeup water systems shall be fitted with a warning mechanism that alerts the user to a failure of the inlet control valve to close correctly. The alarm shall activate before the water within the storage tank begins to discharge into the overflow system.

P2910.9.6 Overflow.
The storage tank shall be equipped with an overflow pipe having a diameter not less than that shown in Table P2910.9.6. The overflow outlet shall discharge at a point not less than 6 inches (152 mm) above the roof or roof drain; floor or floor drain; or over an open water-supplied fixture. The overflow outlet shall be covered with a corrosion-resistant screen of not less than 16 by 20 mesh per inch (630 by 787 mesh per m) and by 1/4-inch (6.4 mm) hardware cloth or shall terminate in a horizontal angle seat check valve. Drainage from overflow pipes shall be directed to prevent freezing on roof walks. The overflow drain shall not be equipped with a shutoff valve. Not less than one cleanout shall be provided on each overflow pipe in accordance with Section P3005.2.

<table>
<thead>
<tr>
<th>TANK CAPACITY (gallons)</th>
<th>DRAIN PIPE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 750</td>
<td>1</td>
</tr>
<tr>
<td>751 to 1500</td>
<td>1 1/2</td>
</tr>
<tr>
<td>1501 to 3000</td>
<td>2</td>
</tr>
<tr>
<td>3001 to 5000</td>
<td>2 1/2</td>
</tr>
<tr>
<td>5001 to 7500</td>
<td>3</td>
</tr>
<tr>
<td>Over 7500</td>
<td>4</td>
</tr>
</tbody>
</table>

For SI: 1 gallon = 3.875 liters, 1 inch = 25.4 mm.

P2910.9.7 Access.
Not less than one access opening shall be provided to allow inspection and cleaning of the
tank interior. Access openings shall have an approved locking device or other approved method of securing access. Below-grade storage tanks, located outside of the building, shall be provided with a manhole either not less than 24 inches (610 mm) square or with an inside diameter not less than 24 inches (610 mm). Manholes shall extend not less than 4 inches (102 mm) above ground or shall be designed to prevent water infiltration. Finished grade shall be sloped away from the manhole to divert surface water. Manhole covers shall be secured to prevent unauthorized access. Service ports in manhole covers shall be not less than 8 inches (203 mm) in diameter and shall be not less than 4 inches (102 mm) above the finished grade level. The service port shall be secured to prevent unauthorized access.

**Exception:** Storage tanks under 800 gallons (3028 L) in volume installed below grade shall not be required to be equipped with a manhole, but shall have a service port not less than 8 inches (203 mm) in diameter.

P2910.9.8 Venting.
Storage tanks shall be provided with a vent sized in accordance with Chapter 31 and based on the aggregate diameter of all tank influent pipes. The reservoir vent shall not be connected to sanitary drainage system vents. Vents shall be protected from contamination by means of an approved cap or a U-bend installed with the opening directed downward. Vent outlets shall extend not less than 4 inches (102 mm) above grade, or as necessary to prevent surface water from entering the storage tank. Vent openings shall be protected against the entrance of vermin and insects in accordance with the requirements of Section P2902.7.

P2910.9.9 Drain.
A drain shall be located at the lowest point of the storage tank. The tank drain pipe shall discharge as required for overflow pipes and shall not be smaller in size than specified in Table P2910.9.6. Not less than one cleanout shall be provided on each drain pipe in accordance with Section P3005.2.

P2910.10 Marking and signage.
Each nonpotable water storage tank shall be labeled with its rated capacity. The contents of storage tanks shall be identified with the words “CAUTION: NONPOTABLE WATER—DO NOT DRINK.” Where an opening is provided that could allow the entry of personnel, the opening shall be marked with the words, “DANGER—CONFINED SPACE.” Markings shall be indelibly printed on the tank, or on a tag or sign constructed of corrosion-resistant waterproof material that is mounted on the tank. The letters of the words shall be not less than 0.5 inches (12.7 mm) in height and shall be of a color in contrast with the background on which they are applied.

P2910.11 Storage tank tests.
Storage tanks shall be tested in accordance with the following:

1. Storage tanks shall be filled with water to the overflow line prior to and during inspection. Seams and joints shall be left exposed and the tank shall remain water tight without leakage for a period of 24 hours.

   **Exception:** If air testing, system shall be pressurized with air equivalent to the water pressure for the full depth of the tank in accordance with Section P2503.7.
2. After 24 hours, supplemental water shall be introduced for a period of 15 minutes to verify proper drainage of the overflow system and leaks do not exist.

3. Following a successful test of the overflow, the water level in the tank shall be reduced to a level that is 2 inches (51 mm) below the makeup water trigger point by using the tank drain. The tank drain shall be observed for proper operation. The makeup water system shall be observed for proper operation, and successful automatic shutoff of the system at the refill threshold shall be verified. Water shall not be drained from the overflow at any time during the refill test.

P2910.12 System abandonment.
If the owner of an on-site nonpotable water reuse system or rainwater collection and conveyance system elects to cease use of or fails to properly maintain such system, the system shall be abandoned and shall comply with the following:

1. System piping connecting to a utility-provided water system shall be removed or disabled.

2. The distribution piping system shall be replaced with an approved potable water supply piping system. Where an existing potable water pipe system is already in place, the fixtures shall be connected to the existing system.

3. The storage tank shall be secured from accidental access by sealing or locking tank inlets and access points, or filled with sand or equivalent.

P2910.13 Separation requirements for nonpotable water piping.
Nonpotable water collection and distribution piping and reclaimed water piping shall be separated from the building sewer and potable water piping underground by 5 feet (1524 mm) of undisturbed or compacted earth. Nonpotable water collection and distribution piping shall not be located in, under or above cesspools, septic tanks, septic tank drainage fields or seepage pits. Buried nonpotable water piping shall comply with the requirements of Section P2604.

Exceptions:

1. The required separation distance shall not apply where the bottom of the nonpotable water pipe within 5 feet (1524 mm) of the sewer is not less than 12 inches (305 mm) above the top of the highest point of the sewer and the pipe materials conforms to Table P3002.2.

2. The required separation distance shall not apply where the bottom of the potable water service pipe within 5 feet (1524 mm) of the nonpotable water pipe is not less than 12 inches (305 mm) above the top of the highest point of the nonpotable water pipe and the pipe materials comply with the requirements of Table P2906.5.

3. The required separation distance shall not apply where a nonpotable water pipe is located in the same trench with a building sewer that is constructed of materials that comply with the requirements of Table P3002.2.

4. The required separation distance shall not apply where a nonpotable water pipe crosses a sewer pipe provided that the nonpotable water pipe is sleeved to not less
than 5 feet (1524 mm) horizontally from the sewer pipe centerline on both sides of such crossing, with pipe materials that comply with Table P3002.2.

5. The required separation distance shall not apply where a potable water service pipe crosses a nonpotable water pipe, provided that the potable water service pipe is sleeved for a distance of not less than 5 feet (1524 mm) horizontally from the centerline of the nonpotable pipe on both sides of such crossing, with pipe materials that comply with Table P3002.2.

6. The required separation distance shall not apply to irrigation piping located outside of a building and downstream of the backflow preventer where nonpotable water is used for outdoor applications.

P2910.14 Outdoor outlet access. Deleted.

Silicocks, hose bibs, wall hydrants, yard hydrants and other outdoor outlets supplied by nonpotable water shall be located in a locked vault or shall be operable only by means of a removable key.

SECTION P2911
ON-SITE NONPOTABLE WATER REUSE SYSTEMS

P2911.1 (1302.1) General.
The provisions of this section shall govern the construction, installation, alteration and repair of on-site nonpotable water reuse systems for the collection, storage, treatment and distribution of on-site sources of nonpotable water as permitted by the jurisdiction.

P2911.2 (1302.2) Sources.
On-site nonpotable water reuse systems shall collect waste discharge only from the following sources: bathtubs, showers, lavatories, clothes washers and laundry trays. Water from other approved nonpotable sources including swimming pool backwash operations, air conditioner condensate, rainwater, foundation drain water, fluid cooler discharge water and fire pump test water shall be permitted to be collected for reuse by on-site nonpotable water reuse systems, as approved by the building official and as appropriate for the intended application.

P2911.2.1 (1302.2.1) Prohibited sources.
Reverse osmosis system reject water, water softener backwash water, kitchen sink wastewater, dishwasher wastewater and wastewater containing urine or fecal matter shall not be collected for reuse within an on-site nonpotable water reuse system.

P2911.3 (1302.3) Traps.
Traps serving fixtures and devices discharging waste water to on-site nonpotable water reuse systems shall comply with the Section P3201.2.

P2911.4 (1302.4) Collection pipe.
On-site nonpotable water reuse systems shall utilize drainage piping approved for use within plumbing drainage systems to collect and convey untreated water for reuse. Vent piping approved for use within plumbing venting systems shall be utilized for vents within the gray-water system. Collection and vent piping materials shall comply with Section P3002.
P2911.4.1 (1302.4.1) Installation.
Collection piping conveying untreated water for reuse shall be installed in accordance with Section P3005.

P2911.4.2 (1302.4.2) Joints.
Collection piping conveying untreated water for reuse shall utilize joints approved for use with the distribution piping and appropriate for the intended applications as specified in Section P3002.

P2911.4.3 (1302.4.3) Size.
Collection piping conveying untreated water for reuse shall be sized in accordance with drainage sizing requirements specified in Section P3005.4.

P2911.4.4 (1302.4.4) Labeling and Marking.
Additional marking of collection piping conveying untreated water for reuse shall not be required beyond that required for sanitary drainage, waste and vent piping by the Chapter 30.

P2911.5 (1302.5) Filtration.
Untreated water collected for reuse shall be filtered as required for the intended end use. Filters shall be accessible for inspection and maintenance. Filters shall utilize a pressure gauge or other approved method to provide indication when a filter requires servicing or replacement. Filters shall be installed with shutoff valves immediately upstream and downstream to allow for isolation during maintenance. Non-potable water for use within a building shall be colored blue or green.

P2911.6 (1302.6) Disinfection.
Nonpotable water collected on site for reuse shall be disinfected, treated or both as determined by a registered design professional to provide the quality of water needed for the intended end-use application. Where the intended end-use application does not have requirements for the quality of water, disinfection and treatment of water collected on site for reuse shall not be required. Nonpotable water collected on site containing untreated gray water shall be retained in collection reservoirs for not more than 24 hours.

P2911.6.1 (1302.6.1) Gray water used for fixture flushing.
Gray water used for flushing water closets and urinals shall be disinfected and treated by an on-site water reuse treatment system complying with NSF 350.

P2911.7 (1302.7) Storage tanks.
Storage tanks utilized in on-site nonpotable water reuse systems shall comply with Section P2910.9 and Sections P2911.7.1 through P2911.7.3.

P2911.7.1 (1302.7.1) Location.
Storage tanks shall be located with a minimum horizontal distance between various elements as indicated in Table P2911.7.1.

| LOCATION OF NONPOTABLE WATER REUSE STORAGE TANKS |

2018 North Carolina Residential Code
### TABLE 2904.7 STORAGE TANK INLET AND OUTLET DISTANCES (FEET)

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>MINIMUM HORIZONTAL DISTANCE FROM STORAGE TANK (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical root zone (CRZ) of protected trees</td>
<td>2</td>
</tr>
<tr>
<td>Lot line adjoining private lots</td>
<td>5</td>
</tr>
<tr>
<td>Seepage pits</td>
<td>5</td>
</tr>
<tr>
<td>Septic tanks</td>
<td>5</td>
</tr>
<tr>
<td>Water wells</td>
<td>50</td>
</tr>
<tr>
<td>Streams and lakes</td>
<td>50</td>
</tr>
<tr>
<td>Water service</td>
<td>5</td>
</tr>
<tr>
<td>Public water main</td>
<td>10</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm

P2911.7.2 Inlets.
Storage tank inlets shall be designed to introduce water into the tank with minimum turbulence, and shall be located and designed to avoid agitating the contents of the storage tank.

P2911.7.3 (1302.7.3) Outlets.
Outlets shall be located not less than 4 inches (102 mm) above the bottom of the storage tank, and shall not skim water from the surface.

P2911.8 (1302.8) Valves.
Valves shall be supplied on on-site nonpotable water reuse systems in accordance with Sections P2911.8.1 and P2911.8.2.

P2911.8.1 (1302.8.1) Bypass valve.
One three-way diverter valve certified to NSF 50 or other approved device shall be installed on collection piping upstream of each storage tank, or drainfield, as applicable, to divert untreated on-site reuse sources to the sanitary sewer to allow servicing and inspection of the system. Bypass valves shall be installed downstream of fixture traps and vent connections. Bypass valves shall be labeled to indicate the direction of flow, connection and storage tank or drainfield connection. Bypass valves shall be installed in accessible locations. Two shutoff valves shall not be installed to serve as a bypass valve.

P2911.8.2 (1302.8.2) Backwater valve.
Backwater valves shall be installed on each overflow and tank drain pipe. Backwater valves shall be in accordance with Section P3008.

P2911.9 (1302.9) Pumping and control system.
Mechanical equipment including pumps, valves and filters shall be accessible and removable in order to perform repair, maintenance and cleaning. The minimum flow rate and flow pressure delivered by the pumping system shall be appropriate for the application and in accordance with Section P2903.

P2911.10 (1302.10) Water-pressure-reducing valve or regulator.
Where the water pressure supplied by the pumping system exceeds 80 psi (552 kPa) static, a pressure-reducing valve shall be installed to reduce the pressure in the nonpotable water distribution system piping to 80 psi (552 kPa) static or less. Pressure-reducing valves shall be specified and installed in accordance with Section P2903.3.1.
Exception: Service lines to sill cocks and outside hydrants, and main supply risers where pressure from the mains is reduced to 80 psi (552 kPa) or less at individual fixtures.

P2911.11 (1302.11) Distribution pipe.
Distribution piping utilized in on-site nonpotable water reuse systems shall comply with Sections P2911.11.1 through P2911.11.3.

Exception: Irrigation piping located outside of the building and downstream of a backflow preventer.

P2910.11.1 (1302.11.1) Materials, joints and connections.
Distribution piping shall conform to the standards and requirements specified in Section P2906 for nonpotable water.

P2911.11.2 (1302.11.2) Design.
On-site nonpotable water reuse distribution piping systems shall be designed and sized in accordance with Section P2903 for the intended application.

P2911.11.3 (1302.11.3) Marking.
On-site nonpotable water distribution piping labeling and marking shall comply with Section P2901.2

P2911.12 (1302.12) Tests and inspections.
Tests and inspections shall be performed in accordance with Sections P2911.12.1 through P2911.12.6.

Drain, waste and vent piping used for on-site water reuse systems shall be tested in accordance with Section P2503.

P2911.12.2 (1302.12.2) Storage tank test.
Storage tanks shall be tested with either air or water in accordance with Section P2910.11.

P2911.12.3 (1302.12.3) Water supply system test.
The testing of makeup water supply piping and distribution piping shall be conducted in accordance with Section P2503.7.

P2911.12.4 (1302.12.4) Inspection and testing of backflow prevention assemblies.
Deleted.
The testing of backflow preventers and backwater valves shall be conducted in accordance with Section P2503.8.

P2911.12.5 (1302.12.5) Inspection of vermin and insect protection.
Inlets and vents to the system shall be inspected to verify that each is protected to prevent the entrance of insects and vermin into the storage tank and piping systems in accordance with Section P2910.7.

P2911.12.6 (1302.12.6) Water quality test.
The quality of the water for the intended application shall be verified at the point of use in accordance with the requirements of the jurisdiction.
P2911.13 (1302.13) Operation and maintenance manuals.
Operation and maintenance materials shall be supplied with nonpotable on-site water reuse systems in accordance with Sections P2910.13.1 through P2910.13.4.

A detailed operations and maintenance manual shall be supplied in hard-copy form for each system.

P2911.13.2 (1302.13.2) Schematics.
The manual shall include a detailed system schematic, the location of system components and a list of system components that includes the manufacturers and model numbers of the components.

P2911.13.3 (1302.13.3) Maintenance procedures.
The manual shall provide a schedule and procedures for system components requiring periodic maintenance. Consumable parts including filters shall be noted along with part numbers.

P2911.13.4 (1302.13.4) Operations procedures.
The manual shall include system startup and shutdown procedures. The manual shall include detailed operating procedures for the system.

SECTION P2912
NONPOTABLE RAINWATER COLLECTION AND DISTRIBUTION SYSTEMS

P2912.1 (1303.1) General.
The provisions of this section shall govern the construction, installation, alteration, and repair of rainwater collection and conveyance systems for the collection, storage, treatment and distribution of rainwater for nonpotable applications, as permitted by the jurisdiction.

P2912.2 (1303.2) Collection surface.
Rainwater shall be collected only from above-ground impervious roofing surfaces constructed from approved materials for acceptable uses without treatment listed in Section P2910.2.3 or where additional appropriate treatment is designed by a registered design professional. Collection of water from vehicular parking or pedestrian walkway surfaces shall be prohibited except where the water is used exclusively for landscape irrigation. Overflow and bleed-off pipes from roof-mounted appliances including, but not limited to, evaporative coolers, water heaters and solar water heaters shall not discharge onto rainwater collection surfaces.

P2912.3 (1303.3) Debris excluders.
Downspouts and leaders shall be connected to a roof washer and shall be equipped with a debris excluder or equivalent device to prevent the contamination of collected rainwater with leaves, sticks, pine needles and similar undesirable material. Debris excluders and equivalent devices shall be self-cleaning.

P2912.4 (1303.4) Roof washer.
An amount of rainwater shall be diverted at the beginning of each rain event, and not allowed to enter the storage tank, to wash accumulated debris from the collection surface. The amount of rainfall to be diverted shall be field adjustable as necessary to minimize storage tank water contamination. The roof washer shall not rely on manually operated valves or devices, and shall
operate automatically. Diverted rainwater shall not be drained to the roof surface, and shall be discharged in a manner consistent with the storm water runoff requirements of the jurisdiction. Roof washers shall be accessible for maintenance and service.

**P2912.5 (1303.5) Roof gutters and downspouts.**
Gutters and downspouts shall be constructed of materials that are compatible with the collection surface and the rainwater quality for the desired end use. Joints shall be watertight.

**P2912.5.1 (1303.5.1) Slope.**
Roof gutters, leaders and rainwater collection piping shall slope continuously toward collection inlets and shall be free of leaks. Gutters and downspouts shall have a slope of not less than \(\frac{1}{8}\) inch per foot (10.4 mm/m) along their entire length. Gutters and downspouts shall be installed so that water does not pool at any point.

**Exception:** Siphonic drainage systems installed in accordance with the manufacturer's instructions shall not be required to have a slope.

**P2912.5.2 (1303.5.3) Cleanouts.**
Cleanouts shall be provided in the water conveyance system to allow access to filters, flushes, pipes and downspouts.

**P2912.6 (1303.6) Drainage.**
Water drained from the roof washer (first flush diverter) or debris excluder shall not be drained to the sanitary sewer. Such water shall be diverted from the storage tank and shall discharge to a location that will not cause erosion or damage to property. Roof washers and debris excluders shall be provided with an automatic means of self-draining between rain events and shall not drain onto roof surfaces.

**P2912.7 (1303.7) Collection pipe.**
Rainwater collection and conveyance systems shall utilize drainage piping approved for use within plumbing drainage systems to collect and convey captured rainwater. Vent piping approved for use within plumbing venting systems shall be utilized for vents within the rainwater system. Collection and vent piping materials shall comply with Section P3002.

**P2912.7.1 (1303.7.1) Installation.**
Collection piping conveying captured rainwater shall be installed in accordance with Section P3005.3.

**P2912.7.2 (1303.7.2) Joints.**
Collection piping conveying captured rainwater shall utilize joints approved for use with the distribution piping and appropriate for the intended applications as specified in Section P3003.

**P2912.7.3 (1303.7.3) Size.**
Collection piping conveying captured rainwater shall be sized in accordance with drainage-sizing requirements specified in Section P3005.4.

**P2912.7.4 (1303.7.4) Marking.**
Additional marking of collection piping conveying captured rainwater for reuse shall not be required beyond that required for sanitary drainage, waste, and vent piping by Chapter 30.
P2912.8 (1303.8) Filtration.
Collected rainwater shall be filtered as required for the intended end use. Filters shall be accessible for inspection and maintenance. Filters shall utilize a pressure gauge or other approved method to provide indication when a filter requires servicing or replacement. Filters shall be installed with shutoff valves installed immediately upstream and downstream to allow for isolation during maintenance. Non-potable water for use within a building shall be colored blue or green.

P2912.9 (1303.9) Disinfection.
Where the intended application for rainwater requires disinfection or other treatment or both, it shall be disinfected as needed determined by a registered design professional to ensure that the required water quality is delivered at the point of use.

P2912.10 (1303.10) Storage tanks.
Storage tanks utilized in nonpotable rainwater collection and conveyance systems shall comply with Section P2910.9 and Sections P2912.10.1 through P2912.10.3.

P2912.10.1 (1303.10.1) Location.
Storage tanks shall be located with a minimum horizontal distance between various elements as indicated in Table P2912.10.1.

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>MINIMUM HORIZONTAL DISTANCE FROM STORAGE TANK (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical root zone (CRZ) of protected trees</td>
<td>2</td>
</tr>
<tr>
<td>Lot line adjoining private lots</td>
<td>5</td>
</tr>
<tr>
<td>Seepage pits</td>
<td>5</td>
</tr>
<tr>
<td>Septic tanks</td>
<td>5</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm

P2912.10.2 (1303.10.2) Inlets.
Storage tank inlets shall be designed to introduce collected rainwater into the tank with minimum turbulence, and shall be located and designed to avoid agitating the contents of the storage tank.

P2912.10.3 (1303.10.3) Outlets.
Outlets shall be located not less than 4 inches (102 mm) above the bottom of the storage tank and shall not skim water from the surface.

P2912.11 (1303.11) Valves.
Valves shall be supplied on rainwater collection and conveyance systems in accordance with Sections P2912.11.1 and P2912.11.2.

P2912.11.1 Influent diversion.
A means shall be provided to divert storage tank influent to allow for maintenance and repair of the storage tank system.
P2912.11.2 (1303.11.1) Backwater valve.
Backwater valves shall be installed on each overflow and tank drain pipe. Backwater valves shall be in accordance with Section P3008.

P2912.12 (1303.12) Pumping and control system.
Mechanical equipment including pumps, valves and filters shall be easily accessible and removable in order to perform repair, maintenance and cleaning. The minimum flow rate and flow pressure delivered by the pumping system shall appropriate for the application and in accordance with Section P2903.

P2912.13 (1303.13) Water-pressure-reducing valve or regulator.
Where the water pressure supplied by the pumping system exceeds 80 psi (552 kPa) static, a pressure-reducing valve shall be installed to reduce the pressure in the rainwater distribution system piping to 80 psi (552 kPa) static or less. Pressure-reducing valves shall be specified and installed in accordance with Section P2903.3.1.

Exception: Service lines to sill cocks and outside hydrants, and main supply risers where pressure from the mains is reduced to 80 psi (552 kPa) or less at individual fixtures.

Distribution piping utilized in rainwater collection and conveyance systems shall comply with Sections P2912.14.1 through P2912.14.3.

Exception: Irrigation piping located outside of the building and downstream of a backflow preventer.

Distribution piping shall conform to the standards and requirements specified in Section P2906 for nonpotable water.

Distribution piping systems shall be designed and sized in accordance with the Section P2903 for the intended application.

Nonpotable rainwater distribution piping labeling and marking shall comply with Section P2901.2.

P2912.15 (1303.15) Tests and inspections.
Tests and inspections shall be performed in accordance with Sections P2912.15.1 through P2912.15.8.

P2912.15.1 (1303.15.1) Roof gutter inspection and test. Deleted.
Roof gutters shall be inspected to verify that the installation and slope is in accordance with Section P2912.5.1. Gutters shall be tested by pouring not less than one gallon of water (3.8 L) into the end of the gutter opposite the collection point. The gutter being tested shall not leak and shall not retain standing water.

P2912.15.2 (1303.15.2) Roofwasher test. Deleted.
Roofwashers shall be tested by introducing water into the gutters. Proper diversion of the
first quantity of water in accordance with the requirements of Section P2912.4 shall be verified.

P2912.15.3 (1303.15.3) Collection pipe and vent test.  
Drain, waste and vent piping used for rainwater collection and conveyance systems shall be tested in accordance with Section P2503.

P2912.15.4 (1303.15.4) Storage tank test.  
Storage tanks shall be tested with either air or water in accordance with the Section P2910.11.

P2912.15.5 (1303.15.5) Water supply system test.  
The testing of makeup water supply piping and distribution piping shall be conducted in accordance with Section P2503.7.

P2912.15.6 (1303.15.6) Inspection and testing of backflow prevention assemblies.  
The testing of backflow preventers and backwater valves shall be conducted in accordance with Section P2503.8.

P2912.15.7 (1303.15.7) Inspection of vermin and insect protection.  
Inlets and vents to the system shall be inspected to verify that each is protected to prevent the entrance of insects and vermin into the storage tank and piping systems in accordance with Section P2910.7.

P2912.15.8 (1303.15.8) Water quality test.  
The quality of the water for the intended application shall be verified at the point of use in accordance with the requirements of the jurisdiction.

P2912.16 (1303.16) Operation and maintenance manuals.  
Operation and maintenance manuals shall be supplied with rainwater collection and conveyance systems in accordance with Sections P2912.16.1 through P2912.16.4.

A detailed operations and maintenance manual shall be supplied in hard-copy form for each system.

P2912.16.2 (1303.16.2) Schematics.  
The manual shall include a detailed system schematic, the location of system components and a list of system components that includes the manufacturers and model numbers of the components.

P2912.16.3 (1303.16.3) Maintenance procedures.  
The manual shall provide a maintenance schedule and procedures for system components requiring periodic maintenance. Consumable parts, including filters, shall be noted along with part numbers.

P2912.16.4 (1303.16.4) Operations procedures.  
The manual shall include system startup and shutdown procedures, and detailed operating procedures.
P2913.1 (1304.1) General.
The provisions of this section shall govern the construction, installation, alteration and repair of systems supplying nonpotable reclaimed water.

P2913.2 (1304.2) Water-pressure-reducing valve or regulator.
Where the reclaimed water pressure supplied to the building exceeds 80 psi (552 kPa) static, a pressure-reducing valve shall be installed to reduce the pressure in the reclaimed water distribution system piping to 80 psi (552 kPa) static or less. Pressure-reducing valves shall be specified and installed in accordance with Section P2903.3.1

Exception: Service lines to sill cocks and outside hydrants, and main supply risers where pressure from the mains is reduced to 80 psi (552 kPa) or less at individual fixtures.

P2913.3 (1304.3) Reclaimed water systems.
The design of the reclaimed water systems shall conform to accepted engineering practice.

P2913.3.1 (1304.3.1) Distribution pipe.
Distribution piping shall comply with Sections P2913.3.1.1 through P2913.3.1.3.

Exception: Irrigation piping located outside of the building and downstream of a backflow preventer.

P2913.3.1.1 (1304.3.1.1) Materials, joints and connections.
Distribution piping conveying reclaimed water shall conform to standards and requirements specified in Section P2905 for nonpotable water.

P2913.3.1.2 (1304.3.1.2) Design.
Distribution piping systems shall be designed and sized in accordance with Section P2903 for the intended application.

P2913.3.1.3 (1304.3.1.3) Labeling and marking.
Nonpotable rainwater distribution piping labeling and marking shall comply with Section P2901.2.

P2913.4 (1304.4) Tests and inspections.
Tests and inspections shall be performed in accordance with Sections P2913.4.1 and P2913.4.2.

P2913.4.1 (1304.4.1) Water supply system test.
The testing of makeup water supply piping and reclaimed water distribution piping shall be conducted in accordance with Section P2503.7.

P2913.4.2 (1304.4.2) Inspection and testing of backflow prevention assemblies.
Deleted.
The testing of backflow preventers shall be conducted in accordance with Section P2503.8.
CHAPTER 30
SANITARY DRAINAGE

User note: Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.

The text of this chapter is extracted from the 2018 edition of the North Carolina Plumbing Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Plumbing Code.

SECTION P3001
GENERAL

P3001.1 (701.1) Scope.
The provisions of this chapter shall govern the materials, design, construction and installation of sanitary drainage systems. Plumbing materials shall conform to the requirements of this chapter. The drainage, waste and vent (DWV) system shall consist of piping for conveying wastes from plumbing fixtures, appliances and appurtenances, including fixture traps; above-grade drainage piping; below-grade drains within the building (building drain); below- and above-grade venting systems; and piping to the public sewer or private septic system.

P3001.2 (305.4) Protection from freezing.
No portion of the above-grade DWV system, other than vent terminals, shall be located outside of a building, in attics or crawl spaces, concealed in outside walls, or in any other place subjected to freezing temperatures unless adequate provision is made to protect them from freezing by insulation or heat or both, except in localities having a winter design temperature greater than 32°F (0°C) (ASHRAE 97.5 percent column, winter, see Chapter 3).
No traps of soil or waste pipe shall be installed or permitted outside of a building, or concealed in outside walls or in any place where they may be subjected to freezing temperatures, unless adequate provision is made to protect them from freezing.

Building sewers that connect to private sewage disposal systems shall be installed not less than 3 inches (76.2 mm) below finished grade at the point of septic tank connection. Building sewers shall be installed not less than 3 inches (76.2 mm) below grade.

Note: These provisions are minimum requirements, which have been found suitable for normal weather conditions. Abnormally low temperatures for extended periods may require additional provisions to prevent freezing.

P3001.3 (309.1) Flood-resistant installation.
In flood hazard areas as established by Table R301.2(1), drainage, waste and vent systems shall be located and installed to prevent infiltration of floodwaters into the systems and discharges from the systems into floodwaters.
SECTION P3002
MATERIALS

P3002.1 (702.1) Piping within buildings.
Drain, waste and vent (DWV) piping in buildings shall be as indicated in Tables P3002.1(1) and P3002.1(2) except that galvanized wrought-iron or galvanized steel pipe shall not be used underground and shall be maintained not less than 6 inches (152 mm) above ground. Allowance shall be made for the thermal expansion and contraction of plastic piping.

**TABLE P3002.1(1)**
ABOVE-GROUND DRAINAGE AND VENT PIPE

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters,</td>
<td>ASTM D 2661; ASTM F 628; ASTM F 1488; CSA B181.1</td>
</tr>
<tr>
<td>including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid,</td>
<td></td>
</tr>
<tr>
<td>cellular core or composite wall</td>
<td></td>
</tr>
<tr>
<td>Cast-iron pipe</td>
<td>ASTM A 74; CISPI 301; ASTM A 888</td>
</tr>
<tr>
<td>Copper or copper-alloy pipe</td>
<td>ASTM B 42; ASTM B 43; ASTM B 302</td>
</tr>
<tr>
<td>Copper or copper-alloy tubing (Type K, L, M or DWV)</td>
<td>ASTM B 75; ASTM B 88; ASTM B 251; ASTM B 306</td>
</tr>
<tr>
<td>Galvanized steel pipe</td>
<td>ASTM A 53</td>
</tr>
<tr>
<td>Polyolefin pipe</td>
<td>ASTM F 1412; CSA B181.3</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe in IPS diameters,</td>
<td>ASTM D 2665; ASTM F 891; CSA B181.2; ASTM F 1488</td>
</tr>
<tr>
<td>including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid,</td>
<td></td>
</tr>
<tr>
<td>cellular core or composite wall</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe with a 3.25 inch O.D. and a</td>
<td>ASTM D 2949; ASTM F 1488</td>
</tr>
<tr>
<td>solid, cellular core or composite wall</td>
<td></td>
</tr>
<tr>
<td>Stainless steel drainage systems, Types 304 and 316L</td>
<td>ASME A 112.3.1</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

**TABLE P3002.1(2)**
UNDERGROUND BUILDING DRAINAGE AND VENT PIPE

<table>
<thead>
<tr>
<th>PIPE</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters,</td>
<td>ASTM D 2661; ASTM F 628; ASTM F 1488; CSA B181.1</td>
</tr>
<tr>
<td>including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a</td>
<td></td>
</tr>
<tr>
<td>solid, cellular core or composite wall</td>
<td></td>
</tr>
<tr>
<td>Cast-iron pipe</td>
<td>ASTM A 74; CISPI 301; ASTM A 888</td>
</tr>
<tr>
<td>Copper or copper alloy tubing (Type K, L, M or DWV)</td>
<td>ASTM B 75; ASTM B 88; ASTM B 251; ASTM B 306</td>
</tr>
<tr>
<td>Polyolefin pipe</td>
<td>ASTM F 1412; CSA B181.3</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe in IPS diameters,</td>
<td>ASTM D 2665; ASTM F 891; ASTM F 1488; CSA B181.2</td>
</tr>
<tr>
<td>including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a</td>
<td></td>
</tr>
<tr>
<td>solid, cellular core or composite wall</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe with a 3.25 inch O.D. and a</td>
<td>ASTM D 2949; ASTM F 1488</td>
</tr>
<tr>
<td>solid, cellular core or composite wall</td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
Stainless steel drainage systems, Type 316L | ASME A 112.3.1

For SI: 1 inch = 25.4 mm.

**P3002.2 Building sewer.**

*Building sewer* piping shall be as shown in Table P3002.2. Forced main sewer piping shall conform to one of the standards for ABS plastic pipe, copper or copper-alloy tubing, PVC plastic pipe or pressure-rated pipe indicated in Table P3002.2.

### TABLE P3002.2
**BUILDING SEWER PIPE**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall</td>
<td>ASTM D 2661; ASTM F 628; ASTM F 1488</td>
</tr>
<tr>
<td>Cast-iron pipe</td>
<td>ASTM A 74; ASTM A 888; CISPI 301</td>
</tr>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters, including SDR 42 (PS 20), PS35, SDR 35 (PS 45), PS50, PS100, PS140, SDR 23.5 (PS 150) and PS200; with a solid, cellular core or composite wall</td>
<td>ASTM F 1488; ASTM D 2751</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters, including PS 25, SDR 41 (PS 28), PS 35, SDR 35 (PS 46), PS 50, PS 100, SDR 26 (PS 115), PS140 and PS 200; with a solid, cellular core or composite wall</td>
<td>ASTM F 891; ASTM F 1488; ASTM D 3034; CSA B182.2; CSA B182.4 ANSI/AWWA C900</td>
</tr>
<tr>
<td>Concrete pipe</td>
<td>ASTM C 14; ASTM C 76; CSA A257.1M; CSA A257.2M</td>
</tr>
<tr>
<td>Copper or copper-alloy tubing (Type K or L)</td>
<td>ASTM B 75; ASTM B 88; ASTM B 251</td>
</tr>
<tr>
<td>Ductile iron pipe</td>
<td>ANSI/AWWA C150/A21.50</td>
</tr>
<tr>
<td>Polyethylene (PE) plastic pipe (SDR-PR)</td>
<td>ASTM F 714</td>
</tr>
<tr>
<td>Polyolefin pipe</td>
<td>ASTM F 1412; CSA B181.3</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with solid, cellular core or composite wall</td>
<td>ASTM D 2665; ASTM D 2949; ASTM D 3034; ASTM F 1412; CSA B182.2; CSA B182.4</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe with a 3.25 inch O.D. and a solid, cellular core or composite wall</td>
<td>ASTM D 2949, ASTM F 1488</td>
</tr>
<tr>
<td>Stainless steel drainage systems, Types 304 and 316L</td>
<td>ASME A 112.3.1</td>
</tr>
<tr>
<td>Vitrified clay pipe</td>
<td>ASTM C 425; ASTM C 700</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

**P3002.2.1 (703.1) Building sewer pipe near the water service.**

The proximity of a *building sewer* to a water service shall comply with Section P2905.4.2.

2018 North Carolina Residential Code
P3002.3 Fittings.
Pipe fittings shall be approved for installation with the piping material installed and shall comply with the applicable standards indicated in Table P3002.3. Pipe fittings shall not be solvent cemented inside of plastic pipe.

<table>
<thead>
<tr>
<th>PIPE MATERIAL</th>
<th>FITTING STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters</td>
<td>ASTM D 2661; ASTM D 3311; ASTM F 628; CSA B181.1</td>
</tr>
<tr>
<td>Cast-iron</td>
<td>ASME B 16.4; ASME B 16.12; ASTM A 74; ASTM A 888; CISPI 301</td>
</tr>
<tr>
<td>Acrylonitrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters</td>
<td>ASTM D 2751</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters</td>
<td>ASTM D 3034, ASTM D3139</td>
</tr>
<tr>
<td>Copper or copper alloy</td>
<td>ASME B 16.15; ASME B 16.18; ASME B 16.22; ASME B 16.23; ASME B 16.26; ASME B 16.29</td>
</tr>
<tr>
<td>Gray iron and ductile iron</td>
<td>AWWA C 110/A21.10</td>
</tr>
<tr>
<td>Polyolefin</td>
<td>ASTM F 1412; CSA B181.3</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic in IPS diameters</td>
<td>ASTM D 2665; ASTM D 3311; ASTM F 1866</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe with a 3.25 inch O.D.</td>
<td>ASTM D 2949</td>
</tr>
<tr>
<td>PVC fabricated fittings</td>
<td>ASTM F 1866</td>
</tr>
<tr>
<td>Stainless steel drainage systems, Types 304 and 316L</td>
<td>ASME A 112.3.1</td>
</tr>
<tr>
<td>Vitrified clay</td>
<td>ASTM C 700</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

P3002.3.1 (706.2) Drainage fittings.
Drainage fittings shall have a smooth interior waterway of the same diameter as the piping served. Fittings shall conform to the type of pipe used. Drainage fittings shall not have ledges, shoulders or reductions that can retard or obstruct drainage flow in the piping. Threaded drainage pipe fittings shall be of the recessed drainage type, black or galvanized. Drainage fittings shall be designed to maintain one-fourth unit vertical in 12 units horizontal (2-percent slope) grade. This section shall not be applicable to tubular waste fittings used to convey vertical flow upstream of the trap seal liquid level of a fixture trap.

P3002.4 Other materials.
Sheet lead, lead bends, lead traps and sheet copper shall comply with Sections P3002.4.1 through P3002.4.3.

P3002.4.1 (902.3) Sheet lead.
Sheet lead shall weigh not less than indicated for the following applications:

1. Flashing of vent terminals, 3 psf (15 kg/m²).
2. Prefabricated flashing for vent pipes, $2\frac{1}{2}$ psf (12 kg/m$^2$).

**P3002.4.2 Lead bends and traps.**
Lead bends and lead traps shall be not less than $\frac{1}{8}$-inch (3 mm) wall thickness.

**P3002.4.3 (902.2) Sheet copper.**
Sheet copper shall weigh not less than indicated for the following applications:

1. General use, 12 ounces per square feet (4 kg/m$^2$).
2. Flashing for vent pipes, 8 ounces per square feet (2.5 kg/m$^2$).

**SECTION P3003**
JOINTS AND CONNECTIONS

**P3003.1 Tightness.**
Joints and connections in the DWV system shall be gas tight and water tight for the intended use or pressure required by test.

**P3003.1.1 Threaded joints, general.**
Pipe and fitting threads shall be tapered.

**P3003.2 (707.1) Prohibited joints.**
Running threads and bands shall not be used in the drainage system. Drainage and vent piping shall not be drilled, tapped, burned or welded.

The following types of joints and connections shall be prohibited:

1. Cement or concrete.
2. Mastic or hot-pour bituminous joints.
3. Joints made with fittings not approved for the specific installation.
4. Joints between different diameter pipes made with elastomeric rolling O-rings.
5. Solvent-cement joints between different types of plastic pipe.

**P3003.3 (705.2) ABS plastic.**
Joints between ABS plastic pipe or fittings shall comply with Sections P3003.3.1 through P3003.3.3.

**P3003.3.1 (705.2.1) Mechanical joints.**
Mechanical joints on drainage pipes shall be made with an elastomeric seal conforming to ASTM C 1173, ASTM D 3212 or CSA B602. Mechanical joints shall be installed only in
underground systems unless otherwise approved. Joints shall be installed in accordance with the manufacturer’s instructions.

P3003.3.2 (705.2.2) Solvent cementing.
Joint surfaces shall be clean and free from moisture. Solvent cement that conforms to ASTM D 2235 or CSA B181.1 shall be applied to joint surfaces. The joint shall be made while the cement is wet. Joints shall be made in accordance with ASTM D 2235, ASTM D 2661, ASTM F 628 or CSA B181.1. Solvent-cement joints shall be permitted above or below ground.

P3003.3.3 (705.2.3) Threaded joints.
Threads shall conform to ASME B1.20.1. Schedule 80 or heavier pipe shall be permitted to be threaded with dies specifically designed for plastic pipe. Approved thread lubricant or tape shall be applied on the male threads only.

P3003.4 (705.4) Cast iron.
Joints between cast-iron pipe or fittings shall comply with Sections P3003.4.1 through P3003.4.3.

P3003.4.1 (705.4.1) Caulked joints.
Joints for hub and spigot pipe shall be firmly packed with oakum or hemp. Molten lead shall be poured in one operation to a depth of not less than 1 inch (25 mm). The lead shall not recede more than 1/8 inch (3 mm) below the rim of the hub and shall be caulked tight. Paint, varnish or other coatings shall not be permitted on the jointing material until after the joint has been tested and approved. Lead shall be run in one pouring and shall be caulked tight.

P3003.4.2 (705.4.2) Compression gasket joints.
Compression gaskets for hub and spigot pipe and fittings shall conform to ASTM C 564. Gaskets shall be compressed when the pipe is fully inserted.

P3003.4.3 (705.4.3) Mechanical joint coupling.
Mechanical joint couplings for hubless pipe and fittings shall consist of an elastomeric sealing sleeve and a metallic shield that comply with CISPI 310, ASTM C 1277 or ASTM C 1540. The elastomeric sealing sleeve shall conform to ASTM C 564 or CSA B602 and shall have a center stop. Mechanical joint couplings shall be installed in accordance with the manufacturer’s instructions.

P3003.5 (705.5) Concrete joints.
Joints between concrete pipe and fittings shall be made with an elastomeric seal conforming to ASTM C 443, ASTM C 1173, CSA A257.3M or CSA B602.

P3003.6 (705.6) Copper and copper-alloy pipe and tubing.
Joints between copper or copper-alloy pipe tubing or fittings shall comply with Sections P3003.6.1 through P3003.6.4.

P3003.6.1 (705.6.1) Brazed joints.
All joint surfaces shall be cleaned. An approved flux shall be applied where required. Brazing materials shall have a melting point in excess of 1,000ºF (538ºC). Brazing alloys filler metal shall be in accordance with AWS A5.8.
P3003.6.2 (705.6.2) Mechanical joints.
Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

P3003.6.3 (705.6.3) Soldered joints.
Copper and copper-alloy joints shall be soldered in accordance with ASTM B 828. Cut tube ends shall be reamed to the full inside diameter of the tube end. All joint surfaces shall be cleaned. Fluxes for soldering shall be in accordance with ASTM B 813 and shall become noncorrosive and nontoxic after soldering. The joint shall be soldered with a solder conforming to ASTM B 32.

P3003.6.4 (705.6.4) Threaded joints.
Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

P3003.7 (705.9) Steel.
Joints between galvanized steel pipe or fittings shall comply with Sections P3003.7.1 and P3003.7.2.

P3003.7.1 (705.9.1) Threaded joints.
Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

P3003.7.2 (705.9.2) Mechanical joints.
Joints shall be made with an approved elastomeric seal. Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

P3003.8 (705.10) Lead.
Joints between lead pipe or fittings shall comply with Sections P3003.8.1 and P3003.8.2.

P3003.8.1 (705.10.1) Burned.
Burned joints shall be uniformly fused together into one continuous piece. The thickness of the joint shall be not less than the thickness of the lead being joined. The filler metal shall be of the same material as the pipe.

P3003.8.2 (705.10.2) Wiped.
Joints shall be fully wiped, with an exposed surface on each side of the joint not less than 3/4 inch (19 mm). The joint shall be not less than 3/8 inch (9.5 mm) thick at the thickest point.

P3003.9 (705.11) PVC plastic.
Joints between PVC plastic pipe or fittings shall comply with Sections P3003.9.1 through P3003.9.3.

P3003.9.1 (705.11.1) Mechanical joints.
Mechanical joints on drainage pipe shall be made with an elastomeric seal conforming to ASTM C 1173, ASTM D 3212 or CSA B602. Mechanical joints shall not be installed in above-ground systems, unless otherwise approved. Joints shall be installed in accordance with the manufacturer’s instructions.

P3003.9.2 (705.11.2) Solvent cementing.
Joint surfaces shall be clean and free from moisture. A purple primer or an ultraviolet purple primer that conforms to ASTM F 656 shall be applied. When an ultraviolet primer is used,
the installer shall provide an ultraviolet light to the inspector to be used during the inspection. Solvent cement not purple in color and conforming to ASTM D 2564, CSA B137.3 or CSA B181.2 shall be applied to all joint surfaces. The joint shall be made while the cement is wet, and shall be in accordance with ASTM D 2855. Solvent-cement joints shall be installed above or below ground. Clear primer conforming to ASTM F 656 may be applied to all joint surfaces where the piping is exposed under sinks and in buildings.

Exception: A primer shall not be required where all of the following conditions apply:

1. The solvent cement used is third-party certified as conforming to ASTM D 2564.
2. The solvent cement is used only for joining PVC drain, waste and vent pipe and fittings in non-pressure applications in sizes up to and including 4 inches (102 mm) in diameter.

P3003.9.3 (705.11.3) Threaded joints.
Threads shall conform to ASME B1.20.1. Schedule 80 or heavier pipe shall be permitted to be threaded with dies specifically designed for plastic pipe. Approved thread lubricant or tape shall be applied on the male threads only.

P3003.10 (705.12) Vitrified clay.
Joints between vitrified clay pipe or fittings shall be made with an elastomeric seal conforming to ASTM C 425, ASTM C 1173 or CSA B602.

P3003.11 (705.14) Polyolefin plastic.
Joints between polyolefin plastic pipe and fittings shall comply with Sections P3003.11.1 and P3003.11.2.

P3003.11.1 (705.14.1) Heat-fusion joints.
Heat-fusion joints for polyolefin pipe and tubing joints shall be installed with socket-type heat-fused polyolefin fittings or electrofusion polyolefin fittings. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F 1412 or CSA B181.3.

P3003.11.2 (705.14.2) Mechanical and compression sleeve joints.
Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s instructions.

P3003.12 (705.13) Polyethylene plastic pipe.
Joints between polyethylene plastic pipe and fittings shall be underground and shall comply with Section P3003.12.1 or P3003.12.2.

P3003.12.1 (705.13.1) Heat fusion joints.
Joint surfaces shall be clean and free from moisture. Joint surfaces shall be cut, heated to melting temperature and joined using tools specifically designed for the operation. Joints shall be undisturbed until cool. Joints shall be made in accordance with ASTM D 2657 and the manufacturer’s instructions.

P3003.12.2 (705.13.2) Mechanical joints.
Mechanical joints in drainage piping shall be made with an elastomeric seal conforming to
ASTM C 1173, ASTM D 3212 or CSA B602. Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

P3003.13 (705.16) Joints between different materials.
Joints between different piping materials shall be made with a mechanical joint of the compression or mechanical-sealing type conforming to ASTM C 1173, ASTM C 1460 or ASTM C 1461. Connectors and adapters shall be approved for the application and such joints shall have an elastomeric seal conforming to ASTM C 425, ASTM C 443, ASTM C 564, ASTM C 1440, ASTM D 1869, ASTM F 477, CSA A257.3M or CSA B602, or as required in Sections P3003.13.1 through P3003.13.6. Joints between glass pipe and other types of materials shall be made with adapters having a TFE seal. Joints shall be installed in accordance with the manufacturer’s instructions.

P3003.13.1 (705.16.1) Copper or copper-alloy tubing to cast-iron hub pipe.
Joints between copper or copper-alloy tubing and cast-iron hub pipe shall be made with a copper-alloy ferrule or compression joint. The copper or copper-alloy tubing shall be soldered to the ferrule in an approved manner, and the ferrule shall be joined to the cast-iron hub by a caulked joint or a mechanical compression joint.

P3003.13.2 (705.16.2) Copper or copper-alloy tubing to galvanized steel pipe.
Joints between copper or copper-alloy tubing and galvanized steel pipe shall be made with a copper-alloy fitting or dielectric fitting. The copper tubing shall be soldered to the fitting in an approved manner, and the fitting shall be screwed to the threaded pipe.

P3003.13.3 (705.16.3) Cast-iron pipe to galvanized steel or brass pipe.
Joints between cast-iron and galvanized steel or copper-alloy pipe shall be made by either caulked or threaded joints or with an approved adapter fitting.

P3003.13.4 (705.16.4) Plastic pipe or tubing to other piping material.
Joints between different types of plastic pipe or between plastic pipe and other piping material shall be made with an approved adapter fitting. Joints between plastic pipe and cast-iron hub pipe shall be made by a caulked joint or a mechanical compression joint.

P3003.13.5 (705.16.5) Lead pipe to other piping material.
Joints between lead pipe and other piping shall be made by a wiped joint to a caulking ferrule, soldering nipple, or bushing or shall be made with an approved adapter fitting.

P3003.13.6 (705.16.7) Stainless steel drainage systems to other materials.
Joints between stainless steel drainage systems and other piping materials shall be made with approved mechanical couplings.

P3003.14 (405.4) Joints between drainage piping and water closets.
Joints between drainage piping and water closets or similar fixtures shall be made by means of a closet flange or a waste connector and sealing gasket compatible with the drainage system material, securely fastened to a structurally firm base. Floor outlet fixtures shall be secured to the floor or floor flanges by screws or bolts of corrosion-resistant material. The joint shall be bolted, with an approved gasket flange to fixture connection complying with ASME A112.4.3 or setting compound between the fixture and the closet flange or waste connector and sealing gasket. The waste connector and sealing gasket joint shall comply with the joint-tightness test of ASME A112.4.3 and shall be installed in accordance with the manufacturer’s instructions.
**P3003.14.1 (405.4.1) Floor flanges.**

Floor flanges for water closets or similar fixtures shall be not less than 0.125 inch (3.2 mm) thick for brass, 0.25 inch (6.4 mm) thick for plastic and 0.25 inch (6.4 mm) thick and not less than a 2-inch (51 mm) caulking depth for cast iron or galvanized malleable iron.

Floor flanges of hard lead shall weigh not less than 1 pound, 9 ounces (0.7 kg) and shall be composed of lead alloy with not less than 7.75-percent antimony by weight.

**P3003.14.2 (405.4.3) Securing wall-hung water closet bowls.**

Wall hung water closet bowls shall be supported by a concealed metal carrier that is attached to the building structural members so that strain is not transmitted to the closet connector or any other part of the plumbing system. The carrier shall conform to ASME A112.6.1M or ASME A112.6.2.

**SECTION P3004**

**DETERMINING DRAINAGE Fixture units**

**P3004.1 (709.1) DWV system load.**

The load on DWV-system piping shall be computed in terms of drainage fixture unit (d.f.u.) values in accordance with Table P3004.1.

**TABLE P3004.1 (709.1)**

**DRAINAGE Fixture unit (d.f.u.) VALUES FOR VARIOUS PLUMBING Fixtures**

<table>
<thead>
<tr>
<th>TYPE OF FIXTURE OR GROUP OF FIXTURES</th>
<th>DRAINAGE FIXTURE UNIT VALUE (d.f.u.)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar sink</td>
<td>1</td>
</tr>
<tr>
<td>Bathtub (with or without a shower head or whirlpool attachments)</td>
<td>2</td>
</tr>
<tr>
<td>Bidet</td>
<td>1</td>
</tr>
<tr>
<td>Clothes washer standpipe</td>
<td>2</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>2</td>
</tr>
<tr>
<td>Floor drain (including waste receptors or hub drains for condensate waste)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>2</td>
</tr>
<tr>
<td>Lavatory</td>
<td>1</td>
</tr>
<tr>
<td>Laundry tub</td>
<td>2</td>
</tr>
<tr>
<td>Shower stall</td>
<td>2</td>
</tr>
<tr>
<td>Water closet (1.6 gallons per flush)</td>
<td>3</td>
</tr>
<tr>
<td>Water closet (greater than 1.6 gallons per flush)</td>
<td>4</td>
</tr>
<tr>
<td>Full-bath group with bathtub (with 1.6 gallon per flush water closet, and with or without shower head and/or whirlpool attachment on the bathtub or shower stall)</td>
<td>5</td>
</tr>
<tr>
<td>Full-bath group with bathtub (water closet greater than 1.6 gallon per flush, and with or without shower head and/or whirlpool attachment on the bathtub or shower stall)</td>
<td>6</td>
</tr>
<tr>
<td>Half-bath group (1.6 gallon per flush water closet plus lavatory)</td>
<td>4</td>
</tr>
<tr>
<td>Half-bath group (water closet greater than 1.6 gallon per flush plus lavatory)</td>
<td>5</td>
</tr>
<tr>
<td>Kitchen group (dishwasher and sink with or without food-waste disposer)</td>
<td>2</td>
</tr>
<tr>
<td>Laundry group (clothes washer standpipe and laundry tub)</td>
<td>3</td>
</tr>
</tbody>
</table>

<sup>a</sup> Values rounded to nearest whole number.

<sup>b</sup> Includes condensate and other waste not having a separate discharge fitting.
Multiple-bath groups:
1.5 baths 7
2 baths 8
2.5 baths 9
3 baths 10
3.5 baths 11

For SI: 1 gallon = 3.785 L.

a. For a continuous or semicontinuous flow into a drainage system, such as from a pump or similar device, 1.5 fixture units shall be allowed per gpm of flow. For a fixture not listed, use the highest d.f.u. value for a similar listed fixture.

b. A floor drain itself does not add hydraulic load. Where used as a receptor, the fixture unit value of the fixture discharging into the receptor shall be applicable.

c. Add 2 d.f.u. for each additional full bath.

SECTION P3005
DRAINAGE SYSTEM

P3005.1 Drainage fittings and connections.
Fittings shall be installed to guide sewage and waste in the direction of flow. Changes in direction in drainage piping shall be made by the appropriate use of sanitary tees, wyes, sweeps, bends or by a combination of these drainage fittings in accordance with Table P3005.1. Change in direction by combination fittings, heel or side inlets or increasers shall be installed in accordance with Table P3005.1 and Sections P3005.1.1 through P3005.1.4. based on the pattern of flow created by the fitting. Double sanitary tee patterns shall not receive the discharge of appliances with pumping action discharge.

TABLE P3005.1
FITTINGS FOR CHANGE IN DIRECTION

<table>
<thead>
<tr>
<th>TYPE OF FITTING PATTERN</th>
<th>CHANGE IN DIRECTION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal to c</td>
<td>Vertical to horizontal</td>
</tr>
<tr>
<td></td>
<td>horizontal</td>
<td></td>
</tr>
<tr>
<td>Sixteenth bend</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Eighth bend</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sixth bend</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Quarter bend</td>
<td>X</td>
<td>X^a,d,f</td>
</tr>
<tr>
<td>Short sweep</td>
<td>X</td>
<td>X^a,b</td>
</tr>
<tr>
<td>Long sweep</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sanitary tee</td>
<td>X^c</td>
<td>—</td>
</tr>
<tr>
<td>Wye</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Combination wye and eighth bend</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. The fittings shall only be permitted for a 2-inch or smaller fixture drain. The fittings shall only be permitted for a 2-inch or smaller sink or lavatory fixture drain.

b. Three Two inches and larger.

c. For a limitation on multiple-connection fittings double sanitary tees, see Section P3005.1.1.

d. May be used only within 12 inches below water closet flange measured to centerline of the quarter bend.
e. This fitting shall only be permitted to be used as the first fitting directly behind the fixture for drains 2 inches and smaller, except clothes washers.
f. The heel inlet connection of a quarter bend may be used as a wet or dry vent if the heel inlet connection of the quarter bend is located in the vertical position. The heel or side inlet connection may be used as a wet vent if the quarter bend is located directly below a water closet or other fixture with one integral trap.

P3005.1.1 (706.3) Horizontal to vertical (multiple connection fittings).
Double fittings such as double sanitary tees and tee-wyes or approved multiple connection fittings and back-to-back fixture arrangements that connect two or more branches at the same level shall be permitted as long as directly opposing connections are the same size and the discharge into directly opposing connections is from similar fixture types or fixture groups. Double sanitary tee patterns shall not receive the discharge of back-to-back water closets and fixtures or appliances with pumping action discharge.

Exception: Back-to-back water closet connections to double sanitary tee patterns shall be permitted where the horizontal developed length between the outlet of the water closet and the connection to the double sanitary tee is 18 inches (457 mm) or greater.

P3005.1.2 (706.4) Heel- or side-inlet quarter bends, drainage. Deleted.
Heel-inlet quarter bends shall be an acceptable means of connection, except where the quarter bends serves a water closet. A low heel inlet shall not be used as a wet-vented connection. Side-inlet quarter bends shall be an acceptable means of connection for both drainage, wet venting and stack venting arrangements.

P3005.1.3 Heel- or side-inlet quarter bends, venting.
Heel-inlet or side-inlet quarter bends, or any arrangement of pipe and fittings producing a similar effect, shall be acceptable as a dry vent where the inlet is placed in a vertical position. The inlet is permitted to be placed in a horizontal position only where the entire fitting is part of a dry vent arrangement.

P3005.1.4 (420.4) Water closet connection between flange and pipe.
One-quarter bends 3 inches (76 mm) in diameter shall be acceptable for water closet or similar connections, provided that a 4-inch by 3-inch (102 mm by 76 mm) flange is installed to receive the closet fixture horn. Alternately, a 4-inch by 3-inch (102 mm by 76 mm) elbow shall be acceptable with a 4-inch (102 mm) flange.

P3005.1.5 (704.4) Provisions for future fixtures.
Where drainage has been roughed-in for future fixtures, the drainage unit values of the future fixtures shall be considered in determining the required drain sizes. Such future installations shall be terminated with an accessible permanent plug or cap fitting.

P3005.1.6 (704.2) Change in size.
The size of the drainage piping shall not be reduced in size in the direction of the flow. A 4-inch by 3-inch (102 mm by 76 mm) water closet connection shall not be considered as a reduction in size.

P3005.2 (708.1) Cleanouts required.
Cleanouts shall be provided for drainage piping in accordance with Sections P3005.2.1 through P3005.2.11.

P3005.2.1 (708.1.1) Gravity horizontal drains and building drains.
Horizontal drainage pipes in buildings shall have cleanouts located at intervals of not more
than 100 feet (30 480 mm). **Building drains** shall have cleanouts located at intervals of not more than 100 feet (30 480 mm) except where manholes are used instead of cleanouts, the manholes shall be located at intervals of not more than 400 feet (122 m). The interval length shall be measured from the cleanout or manhole opening, along the **developed length** of the piping to the next drainage fitting providing access for cleaning, the end of the horizontal drain or the end of the **building drain**.

**Exception:** Horizontal fixture drain piping serving a nonremovable trap shall not be required to have a cleanout for the section of piping between the trap and the vent connection for such trap.

P3005.2.2 (708.1.2) **Gravity building sewers.**
**Building sewers** smaller than 8 inches (203 mm) shall have cleanouts located at intervals of not more than 100 feet (30 480 mm). **Building sewers** 8 inches (203 mm) and larger shall have a manhole located not more than 200 feet (60 960 mm) from the junction of the **building drain** and **building sewer** and at intervals of not more than 400 feet (122 m). The interval length shall be measured from the cleanout or manhole opening, along the **developed length** of the piping to the next drainage fitting providing access for cleaning, a manhole or the end of the **building sewer**.

P3005.2.3 (708.1.3) **Building drain and building sewer junction.**
The junction of the **building drain** and the **building sewer** shall be served by a cleanout that is located at the junction or within 10 feet (3048 mm) **developed length** of piping upstream of the junction. For the requirements of this section, removal of a water closet shall not be required to provide cleanout access. There shall be a cleanout at the junction of the building drain and the building sewer. The cleanout shall be outside the building wall and shall be brought up to the finished ground level. An approved two-way cleanout is allowed to be used at this location to serve as a required cleanout for both the building drain and building sewer. The cleanout at the junction of the building drain and building sewer shall not be required if the cleanout on a 3 inch (76 mm) or larger diameter soil stack is located within a **developed length** of not more than 15 feet (4572 mm) from the building drain and building sewer connection and is extended to the outside of the building. The minimum size of the cleanout at the junction of the building drain and building sewer shall comply with Section P3005.2.5.

P3005.2.4 (708.1.4) **Changes of direction.**
Where a horizontal drainage pipe, a **building drain** or a **building sewer** has a change of horizontal direction greater than 45 degrees (0.79 rad), a cleanout shall be installed at the change of direction. Where more than one change of horizontal direction greater than 45 degrees (0.79 rad) occurs within 40 feet (12 192 mm) **developed length** of piping, the cleanout installed for the first change of direction shall serve as the cleanout for all changes in direction within that 40 feet (12 192 mm) **developed length** of piping. One cleanout shall be required for every four horizontal 45 degree (0.79 rad) changes located in series. (A long sweep is equivalent to two 45 degree (0.79 rad) bends.)

P3005.2.5 (708.1.5) **Cleanout size.**
Cleanouts shall be the same size as the piping served by the cleanout, except cleanouts for piping larger than 4 inches (102 mm) need not be larger than 4 inches (102 mm).

**Exceptions:**

2018 North Carolina Residential Code
1. **Cleanouts located on stacks can be one size smaller than the stack size.**
   "P" traps connected to the drainage piping with slip joints or ground joint connections.

2. The size of cleanouts for cast-iron piping can be in accordance with the referenced standards for cast iron fittings as indicated in Table P3002.3. "P" traps into which floor drains, shower drains or tub drains with removable strainers discharge.

3. "P" traps into which the straight-through type waste and overflow discharge with the overflow connecting to the top of the tee.

4. "P" traps into which residential washing machines discharge.

5. Test tees or cleanouts in a vertical pipe.

6. Cleanout near the junction of the building drain and the building sewer which may be rodded both ways.

7. Water closets for the water closet fixture drain only.

8. **Cast-iron cleanout sizing shall be in accordance with referenced standards in Table P3002.3, ASTM A 74 for hub and spigot fittings or ASTM A 888 or CISPI 301 for hubless fittings.**

9. Cleanouts located on stacks can be one size smaller than the stack size.

**P3005.2.6 (708.1.6) Cleanout plugs.**
Cleanout plugs shall be copper alloy, plastic or other approved materials. Cleanout plugs for borosilicate glass piping systems shall be of borosilicate glass. Brass cleanout plugs shall conform to ASTM A74 and shall be limited for use only on metallic piping systems. Plastic cleanout plugs shall conform to the referenced standards for plastic pipe fittings as indicated in Table P3002.3. Cleanout plugs shall have a raised square head, a countersunk square head or a countersunk slot head. Where a cleanout plug will have a trim cover screw installed into the plug, the plug shall be manufactured with a blind end threaded hole for such purpose.

**P3005.2.7 (708.1.7) Manholes.**
Manholes and manhole covers shall be of an approved type. Manholes located inside of a building shall have gas-tight covers that require tools for removal.

**P3005.2.8 (708.1.8) Installation arrangement.**
The installation arrangement of a cleanout shall enable cleaning of drainage piping only in the direction of drainage flow.

**Exceptions:**

1. Test tees serving as cleanouts.
2. A two-way cleanout installation that is approved for meeting the requirements of Section P3005.2.3.

**P3005.2.9 (708.1.9) Required clearance.**
Cleanouts for 6-inch (153 mm) and smaller piping shall be provided with a clearance of not less than 18 inches (457 mm) from, and perpendicular to, the face of the opening to any obstruction. Cleanouts for 8-inch (203 mm) and larger piping shall be provided with a clearance of not less than 36 inches (914 mm) from, and perpendicular to, the face of the opening to any obstruction.

**P3005.2.10 (708.1.10) Cleanout access.**
Required cleanouts shall not be installed in concealed locations. For the purposes of this section, concealed locations include, but are not limited to, the inside of plenums, within walls, within floor/ceiling assemblies, below grade and in crawl spaces where the height from the crawl space floor to the nearest obstruction along the path from the crawl space opening to the cleanout location is less than 24 inches (610 mm). Cleanouts with openings at a finished wall shall have the face of the opening located within \(1\frac{1}{2}\) inches (38 mm) of the finished wall surface. Cleanouts located below grade shall be extended to grade level so that the top of the cleanout plug is at or above grade. A cleanout installed in a floor or walkway that will not have a trim cover installed shall have a counter-sunk plug installed so the top surface of the plug is flush with the finished surface of the floor or walkway.

**P3005.2.10.1 (708.1.10.1) Cleanout plug trim covers.**
Trim covers and access doors for cleanout plugs shall be designed for such purposes. Trim cover fasteners that thread into cleanout plugs shall be corrosion resistant. Cleanout plugs shall not be covered with mortar, plaster or any other permanent material.

**P3005.2.10.2 (708.1.10.2) Floor cleanout assemblies.**
Where it is necessary to protect a cleanout plug from the loads of vehicular traffic, cleanout assemblies in accordance with ASME A112.36.2M shall be installed.

**P3005.2.11 (708.1.11) Prohibited use.**
The use of a threaded cleanout opening to add a fixture or extend piping shall be prohibited except where another cleanout of equal size is installed with the required access and clearance.

**P3005.3 (704.1) Horizontal drainage piping slope.**
Horizontal drainage piping shall be installed in uniform alignment at uniform slopes not less than \(1/4\) unit vertical in 12 units horizontal (2-percent slope) for \(2\frac{1}{2}\) inch (64 mm) diameter and less, and not less than \(1/8\) unit vertical in 12 units horizontal (1-percent slope) for diameters of 3 inches (76 mm) or more.

**P3005.4 (710.1) Drain pipe sizing.**
Drain pipes shall be sized according to drainage fixture unit (d.f.u.) loads. The size of the drainage piping shall not be reduced in size in the direction of flow. The following general procedure is permitted to be used:
1. Draw an isometric layout or riser diagram denoting fixtures on the layout.

2. Assign d.f.u. values to each fixture group plus individual fixtures using Table P3004.1.

3. Starting with the top floor or most remote fixtures, work downstream toward the building drain accumulating d.f.u. values for fixture groups plus individual fixtures for each branch. Where multiple bath groups are being added, use the reduced d.f.u. values in Table P3004.1, which take into account probability factors of simultaneous use.

4. Size branches and stacks by equating the assigned d.f.u. values to pipe sizes shown in Table P3005.4.1.

5. Determine the pipe diameter and slope of the building drain and building sewer based on the accumulated d.f.u. values, using Table P3005.4.2.

**P3005.4.1 Branch and stack sizing.**

Branches and stacks shall be sized in accordance with Table P3005.4.1. Below grade drain pipes shall be not less than \( \frac{1}{2} \) inch (38 mm) in diameter. Drain stacks shall be not smaller than the largest horizontal branch connected.

**Exceptions:**

1. A 4-inch by 3-inch (102 mm by 76 mm) closet bend or flange.

2. A 4-inch (102 mm) closet bend connected to a 3-inch (76 mm) stack tee shall not be prohibited.

**TABLE P3005.4.1**

<table>
<thead>
<tr>
<th>NOMINAL PIPE SIZE (inches)</th>
<th>ANY HORIZONTAL FIXTURE BRANCH ( ^a )</th>
<th>ANY ONE VERTICAL STACK OR DRAIN ( ^b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{1}{4} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \frac{1}{4} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \frac{1}{2} )</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>( \frac{1}{2} )</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>( \frac{1}{2} )</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>( \frac{3}{1} )</td>
<td>20( ^e )</td>
<td>48</td>
</tr>
<tr>
<td>4</td>
<td>160</td>
<td>240</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. \( \frac{1}{4} \)-inch pipe size limited to a single-fixure drain or trap arm. See Table P3201.7.

b. No water closets.

c. No more than three water closets.

d. 50 percent less for circuit-vented fixture branches.
e. Minimum of 2-inch diameter underground.
f. The minimum size of any branches serving a water closet shall be 3 inches.

**P3005.4.2 Building drain and sewer size and slope.**
Pipe sizes and slope shall be determined from Table P3005.4.2 on the basis of drainage load in fixture units (d.f.u.) computed from Table P3004.1.

**TABLE P3005.4.2**
MAXIMUM NUMBER OF FIXTURE UNITS ALLOWED TO BE CONNECTED TO THE BUILDING DRAIN, BUILDING DRAIN BRANCHES OR THE BUILDING SEWER

<table>
<thead>
<tr>
<th>DIAMETER OF PIPE (inches)</th>
<th>SLOPE PER FOOT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/8 inch</td>
</tr>
<tr>
<td>1/2</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>1/2</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>180</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. 1/2-inch pipe size limited to a building drain branch serving not more than two waste fixtures, or not more than one waste fixture if serving a pumped discharge fixture or food waste disposer discharge.
b. No water closets.
c. No building sewer shall be less than 4 inches in size.
d. No more than three water closets.
e. Minimum of 2-inch diameter underground.

**P3005.5 Connections to offsets and bases of stacks.**
Horizontal branches shall connect to the bases of stacks at a point located not less than 10 times the diameter of the drainage stack downstream from the stack. Horizontal branches shall connect to horizontal stack offsets at a point located not less than 10 times the diameter of the drainage stack downstream from the upper stack.

**SECTION P3006**
SIZING OF DRAIN PIPE OFFSETS

**P3006.1 Vertical offsets.**
An offset in a vertical drain, with a change of direction of 45 degrees (0.79 rad) or less from the vertical, shall be sized as a straight vertical drain.

**P3006.2 Horizontal offsets above the lowest branch.**
A stack with an offset of more than 45 degrees (0.79 rad) from the vertical shall be sized as follows:
1. The portion of the stack above the offset shall be sized as for a regular stack based on the total number of fixture units above the offset.

2. The offset shall be sized as for a building drain in accordance with Table P3005.4.2.

3. The portion of the stack below the offset shall be sized as for the offset or based on the total number of fixture units on the entire stack, whichever is larger.

P3006.3 Horizontal offsets below the lowest branch.
In soil or waste stacks below the lowest horizontal branch, a change in diameter shall not be required if the offset is made at an angle not greater than 45 degrees (0.79 rad) from the vertical. If an offset greater than 45 degrees (0.79 rad) from the vertical is made, the offset and stack below it shall be sized as a building drain (see Table P3005.4.2).

SECTION P3007
SUMPS AND EJECTORS

P3007.1 (712.1) Building subdrains.
Building subdrains that cannot be discharged to the sewer by gravity flow shall be discharged into a tightly covered and vented sump from which the liquid shall be lifted and discharged into the building gravity drainage system by automatic pumping equipment or other approved method. In other than existing structures, the sump shall not receive drainage from any piping within the building capable of being discharged by gravity to the building sewer.

P3007.2 (712.2) Valves required.
A check valve, and a full open valve and a means for cleanout located on the discharge side of the check valve shall be installed in the pump or ejector discharge piping between the pump or ejector and the gravity drainage system. Access shall be provided to such valves. Such valves shall be located above the sump cover required by Section P3007.3.2 or, where the discharge pipe from the ejector is below grade, the valves shall be accessibly located outside the sump below grade in an access pit with a removable access cover.

P3007.3 (712.3) Sump design.
The sump pump, pit and discharge piping shall conform to the requirements of Sections P3007.3.1 through P3007.3.5.

P3007.3.1 (712.3.1) Sump pump.
The sump pump capacity and head shall be appropriate to anticipated use requirements.

P3007.3.2 (712.3.2) Sump pit.
The sump pit shall be not less than 18 inches (457 mm) in diameter and 24 inches (610 mm) deep, unless otherwise approved. The pit shall be accessible and located so that drainage flows into the pit by gravity. The sump pit shall be constructed of tile, concrete, steel, plastic or other approved materials. The pit bottom shall be solid and provide permanent support for the pump. The sump pit shall be fitted with a gas-tight removable cover that is installed above grade level or floor level, or not more than 2 inches (51 mm) below grade or floor level. The cover shall be adequate to support anticipated loads in the area of use. The sump pit shall be vented in accordance with Chapter 31.
P3007.3.3 (712.3.3) Discharge pipe and fittings.
Discharge pipe and fittings serving sump pumps and ejectors shall be constructed of materials pressure-rated for not less than the maximum discharge pressure of the pump in accordance with Sections P3007.3.3.1 and P3007.3.3.2 and shall be approved.

P3007.3.3.1 (712.3.3.1) Materials.
Pipe and fitting materials shall be constructed of copper alloy, copper, CPVC, ductile iron, PE, or PVC. Forced main sewer piping shall conform to one of the standards for ABS plastic pipe, copper or copper-alloy tubing, PVC plastic pipe or pressure-rated pipe indicated in Table P3002.2.1, excluding cell-core products.

P3007.3.3.2 (712.3.3.2) Ratings.
Pipe and fittings shall be rated for the maximum system operating pressure and temperature. Pipe fitting materials shall be compatible with the pipe material. Where pipe and fittings are buried in the earth, they shall be suitable for burial.

P3007.3.4 (712.3.4) Maximum effluent level.
The effluent level control shall be adjusted and maintained to at all times prevent the effluent in the sump from rising to within 2 inches (51 mm) of the invert of the gravity drain inlet into the sump.

P3007.3.4.1 (712.3.4.1) Sump alarms.
Sumps that discharge by means of automatic pumping equipment shall be provided with an approved, electrically operated high-water indicating alarm. A remote sensor shall activate the alarm when the fluid level exceeds a preset level that is less than the maximum capacity of the sump. The alarm shall function to provide an audiovisual signal to occupants within the building. Electrical power for the alarm shall be supplied through a branch circuit separate from that supplying the pump motor.

Exception: Sump alarms are not required for single point-of-use sump pumps and macerating toilet systems.

P3007.3.5 (712.3.5) Ejector connection to the drainage system.
Pumps connected to the drainage system shall connect to a building sewer, building drain, soil stack, waste stack or horizontal branch drain. Where the discharge line connects into horizontal drainage piping, the connection shall be made through a wye fitting into the top of the drainage piping and such wye fitting shall be located not less than 10 pipe diameters from the base of any soil stack, waste stack or fixture drain.

P3007.4 (712.4) Sewage pumps and sewage ejectors.
A sewage pump or sewage ejector shall automatically discharge the contents of the sump to the building drainage system. The ejector pump discharge pipe shall not discharge directly into a septic tank. The pumped line shall discharge laterally into a 4-inch (102 mm) gravity line not less than 10 feet (3048 mm) from the connection to the tank through a lateral wye branch.

P3007.5 (712.4.1) Macerating toilet systems and pumped waste systems.
Macerating toilet systems and pumped waste systems shall comply with ASME A112.3.4/CSA B45.9 and shall be installed in accordance with the manufacturer’s instructions.

P3007.6 (712.4.2) Capacity.
Sewage pumps and sewage ejectors shall have the capacity and head for the application
requirements. Pumps and ejectors that receive the discharge of water closets shall be capable of handling spherical solids with a diameter of up to and including 2 inches (51 mm). Other pumps or ejectors shall be capable of handling spherical solids with a diameter of up to and including 1 inch (25.4 mm). The minimum capacity of a pump or ejector based on the diameter of the discharge pipe shall be in accordance with Table 3007.6.

**Exceptions:**

1. Grinder pumps or grinder ejectors that receive the discharge of water closets shall have a discharge opening of not less than \( \frac{1}{4} \) inch (32 mm).

2. Macerating toilet assemblies that serve single water closets shall have a discharge opening of not less than \( \frac{3}{4} \) inch (19 mm).

**TABLE 3007.6 (712.4.2)
MINIMUM CAPACITY OF SEWAGE PUMP OR SEWAGE EJECTOR**

<table>
<thead>
<tr>
<th>DIAMETER OF THE DISCHARGE PIPE (inches)</th>
<th>CAPACITY OF PUMP OR EJECTOR (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>(2^{\frac{1}{2}})</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m.

**SECTION P3008
BACKWATER VALVES**

**P3008.1 (715.1) Sewage backflow.**

Where the flood level rims of plumbing fixtures are below plumbing fixtures are installed on a floor with a finished floor elevation below the elevation of the manhole cover of the next upstream manhole in the public sewer, the fixtures shall be protected by a backwater valve installed in the building drain, branch of the building drain or horizontal branch serving such fixtures. Plumbing fixtures having flood level rims installed on a floor with a finished floor elevation above the elevation of the manhole cover of the next upstream manhole in the public sewer shall not discharge through a backwater valve.

**Exceptions:**

1. In existing buildings, fixtures above the elevation of the manhole cover of the next upstream manhole in the public sewer shall not be prohibited from discharging through a backwater valve.

2. Where the sewer service line ties directly to a manhole, that manhole is considered to be the next upstream manhole.
3. Where hub drains are located in the crawl space for condensate waste, a backwater valve or check valve be installed.

P3008.2 (715.2) Material.
Bearing parts of backwater valves shall be of corrosion-resistant material. Backwater valves shall comply with ASME A112.14.1, CSA B181.1 or CSA B181.2.

P3008.3 (715.3) Seal.
Backwater valves shall be constructed to provide a mechanical seal against backflow.

P3008.4 (715.4) Diameter.
Backwater valves, when fully opened, shall have a capacity not less than that of the pipes in which they are installed.

P3008.5 (715.5) Location.
Backwater valves shall be installed so that the working parts are accessible for service and repair.

P3008.6 (715.6) Crawl spaces.
All hub drains or floor drains installed in crawl spaces shall be protected from backflow into the building by a check valve or back-water valve installed in the lateral serving the said hub drain or floor drain.

SECTION P3009
SUBSURFACE LANDSCAPE IRRIGATION SYSTEMS
Deleted.

P3009.1 Scope.
The provisions of this section shall govern the materials, design, construction and installation of subsurface landscape irrigation systems connected to nonpotable water from on-site water reuse systems.

P3009.2 Materials.
Above-ground drain, waste and vent piping for subsurface landscape irrigation systems shall conform to one of the standards indicated in Table P3002.2(1). Subsurface landscape irrigation, underground building drainage and vent pipe shall conform to one of the standards indicated in Table P3002.1(2).

P3009.3 Tests.
Drain, waste and vent piping for subsurface landscape irrigation systems shall be tested in accordance with Section P2503.

P3009.4 Inspections.
Subsurface landscape irrigation systems shall be inspected in accordance with Section R109.

P3009.5 Disinfection.
Disinfection shall not be required for on-site nonpotable reuse water for subsurface landscape irrigation systems.
P3009.6 Coloring.
On-site nonpotable reuse water used for subsurface landscape irrigation systems shall not be required to be dyed.

P3009.7 Sizing.
The system shall be sized in accordance with the sum of the output of all water sources connected to the subsurface irrigation system. Where gray-water collection piping is connected to subsurface landscape irrigation systems, gray-water output shall be calculated according to the gallons-per-day-per-occupant (liters-per-day-per-occupant) number based on the type of fixtures connected. The gray-water discharge shall be calculated by the following equation:

\[ C = A \times B \]  
(Equation 30-1)

where:

A = Number of occupants:
Number of occupants shall be determined by the actual number of occupants, but not less than two occupants for one bedroom and one occupant for each additional bedroom.

B = Estimated flow demands for each occupant:
25 gallons (94.6 L) per day per occupant for showers, bathtubs and lavatories and 15 gallons (56.7 L) per day per occupant for clothes washers or laundry trays.

C = Estimated gray-water discharge based on the total number of occupants.

P3009.8 Percolation tests.
The permeability of the soil in the proposed absorption system shall be determined by percolation tests or permeability evaluation.

P3009.8.1 Percolation tests and procedures.
Not less than three percolation tests in each system area shall be conducted. The holes shall be spaced uniformly in relation to the bottom depth of the proposed absorption system. More percolation tests shall be made where necessary, depending on system design.

P3009.8.1.1 Percolation test hole.
The test hole shall be dug or bored. The test hole shall have vertical sides and a horizontal dimension of 4 inches to 8 inches (102 mm to 203 mm). The bottom and sides of the hole shall be scratched with a sharp-pointed instrument to expose the natural soil. Loose material shall be removed from the hole and the bottom shall be covered with 2 inches (51 mm) of gravel or coarse sand.

P3009.8.1.2 Test procedure, sandy soils.
The hole shall be filled with clear water to not less than 12 inches (305 mm) above the bottom of the hole for tests in sandy soils. The time for this amount of water to seep away shall be determined, and this procedure shall be repeated if the water from the second filling of the hole seeps away in 10 minutes or less. The test shall proceed as follows: Water shall be added to a point not more than 6 inches (152 mm) above the gravel or coarse sand. Thereupon, from a fixed reference point, water levels shall be measured at 10-minute intervals for a period of 1 hour. Where 6 inches (152 mm) of water seeps away in less than 10 minutes, a shorter interval between measurements shall be used. The water depth shall not exceed 6 inches (152 mm). Where 6 inches...
(152 mm) of water seeps away in less than 2 minutes, the test shall be stopped and a rate of less than 3 minutes per inch (7.2 s/mm) shall be reported. The final water level drop shall be used to calculate the percolation rate. Soils not meeting these requirements shall be tested in accordance with Section P3009.8.1.3.

P3009.8.1.3 Test procedure, other soils. The hole shall be filled with clear water, and a minimum water depth of 12 inches (305 mm) shall be maintained above the bottom of the hole for a 4-hour period by refilling whenever necessary or by use of an automatic siphon. Water remaining in the hole after 4 hours shall not be removed. Thereafter, the soil shall be allowed to swell not less than 16 hours or more than 30 hours. Immediately after the soil swelling period, the measurements for determining the percolation rate shall be made as follows: any soil sloughed into the hole shall be removed and the water level shall be adjusted to 6 inches (152 mm) above the gravel or coarse sand. Thereupon, from a fixed reference point, the water level shall be measured at 30-minute intervals for a period of 4 hours, unless two successive water level drops do not vary by more than \( \frac{1}{16} \) inch (1.59 mm). Not less than three water level drops shall be observed and recorded. The hole shall be filled with clear water to a point not more than 6 inches (152 mm) above the gravel or coarse sand whenever it becomes nearly empty. Adjustments of the water level shall not be made during the three measurement periods except to the limits of the last measured water level drop. When the first 6 inches (152 mm) of water seeps away in less than 30 minutes, the time interval between measurements shall be 10 minutes and the test run for 1 hour. The water depth shall not exceed 5 inches (127 mm) at any time during the measurement period. The drop that occurs during the final measurement period shall be used in calculating the percolation rate.

P3009.8.1.4 Mechanical test equipment. Mechanical percolation test equipment shall be of an approved type.

P3009.8.2 Permeability evaluation. Soil shall be evaluated for estimated percolation based on structure and texture in accordance with accepted soil evaluation practices. Borings shall be made in accordance with Section P3009.8.1.1 for evaluating the soil.

P3009.9 Subsurface landscape irrigation site location. The surface grade of soil absorption systems shall be located at a point lower than the surface grade of any water well or reservoir on the same or adjoining lot. Where this is not possible, the site shall be located so surface water drainage from the site is not directed toward a well or reservoir. The soil absorption system shall be located with a minimum horizontal distance between various elements as indicated in Table P3009.9. Private sewage disposal systems in compacted areas, such as parking lots and driveways, are prohibited. Surface water shall be diverted away from any soil absorption site on the same or neighboring lots.

<table>
<thead>
<tr>
<th>TABLE P3009.9</th>
<th>LOCATION OF SUBSURFACE IRRIGATION SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEMENT</td>
<td>MINIMUM HORIZONTAL DISTANCE</td>
</tr>
<tr>
<td></td>
<td>STORAGE TANK (feet)</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
P3009.10 Installation.
Absorption systems shall be installed in accordance with Sections P3009.10.1 through P3009.10.5 to provide landscape irrigation without surfacing of water.

P3009.10.1 Absorption area.
The total absorption area required shall be computed from the estimated daily gray-water discharge and the design-loading rate based on the percolation rate for the site. The required absorption area equals the estimated gray-water discharge divided by the design loading rate from Table P3009.10.1.

<table>
<thead>
<tr>
<th>PERCOLATION RATE (minutes per inch)</th>
<th>DESIGN LOADING RATE (gallons per square foot per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to less than 10</td>
<td>1.2</td>
</tr>
<tr>
<td>10 to less than 30</td>
<td>0.8</td>
</tr>
<tr>
<td>30 to less than 45</td>
<td>0.72</td>
</tr>
<tr>
<td>45 to 60</td>
<td>0.4</td>
</tr>
</tbody>
</table>

For SI: 1 minute per inch = 25.4 mm, 1 gallon per square foot = 40.7 L/m².

P3009.10.2 Seepage trench excavations.
Seepage trench excavations shall be not less than 1 foot (304 mm) in width and not greater than 5 feet (1524 mm) in width. Trench excavations shall be spaced not less than 2 feet (610 mm) apart. The soil absorption area of a seepage trench shall be computed by using the bottom of the trench area (width) multiplied by the length of pipe. Individual seepage trenches shall be not greater than 100 feet (30,480 mm) in developed length.

P3009.10.3 Seepage bed excavations.
Seepage bed excavations shall be not less than 5 feet (1524 mm) in width and have more than one distribution pipe. The absorption area of a seepage bed shall be computed by using the bottom of the trench area. Distribution piping in a seepage bed shall be uniformly spaced not greater than 5 feet (1524 mm) and not less than 3 feet (914 mm) apart, and greater than 3 feet (914 mm) and not less than 1 foot (305 mm) from the sidewall or headwall.

P3009.10.4 Excavation and construction.
The bottom of a trench or bed excavation shall be level. Seepage trenches or beds shall not
be excavated where the soil is so wet that such material rolled between the hands forms a soil wire. Smeared or compacted soil surfaces in the sidewalls or bottom of seepage trench or bed excavations shall be scarified to the depth of smearing or compaction and the loose material removed. Where rain falls on an open excavation, the soil shall be left until sufficiently dry so a soil wire will not form when soil from the excavation bottom is rolled between the hands. The bottom area shall then be scarified and loose material removed.

**P3009.10.5 Aggregate and backfill.**

Not less than 6 inches (150 mm) in depth of aggregate ranging in size from \(\frac{1}{2}\) to \(\frac{3}{2}\) inches (12.7 mm to 64 mm) shall be laid into the trench below the distribution piping elevation. The aggregate shall be evenly distributed not less than 2 inches (51 mm) in depth over the top of the distribution pipe. The aggregate shall be covered with approved synthetic materials or 9 inches (229 mm) of uncompacted marsh hay or straw. Building paper shall not be used to cover the aggregate. Not less than 9 inches (229 mm) of soil backfill shall be provided above the covering.

**P3009.11 Distribution piping.**

Distribution piping shall be not less than 3 inches (76 mm) in diameter. Materials shall comply with Table P3009.11. The top of the distribution pipe shall be not less than 8 inches (203 mm) below the original surface. The slope of the distribution pipes shall be not less than 2 inches (51 mm) and not greater than 4 inches (102 mm) per 100 feet (30 480 mm).

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene (PE) plastic pipe</td>
<td>ASTM F 405</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe</td>
<td>ASTM D 2729</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) plastic pipe with a 3.5-inch O.D. and solid cellular core or composite wall</td>
<td>ASTM F 1498</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

**P3009.11.1 Joints.**

Joints in distribution pipe shall be made in accordance with Section P3003 of this code.

**SECTION P3010**

REPLACEMENT OF UNDERGROUND SEWERS BY PIPE BURSTING METHODS

**P3010.1 (717.1) General.**

This section shall govern the replacement of existing building sewer piping by pipe-bursting methods.

**P3010.2 (717.2) Applicability.**

The replacement of building sewer piping by pipe bursting methods shall be limited to gravity drainage piping of sizes 6 inches (150 mm) and smaller. The replacement piping shall be of the same nominal size as the existing piping.
P3010.3 (717.3) Preinstallation inspection.
The existing piping sections to be replaced shall be inspected internally by a recorded video camera survey. The survey shall include notations of the position of cleanouts and the depth of connections to the existing piping.

P3010.4 (717.4) Pipe.
The replacement pipe shall be made of a high-density polyethylene (HDPE) that conforms to cell classification number PE3608, PE4608 or PE4710 as indicated in ASTM F 714. The pipe fittings shall be manufactured with an SDR of 17 and in compliance with ASTM F 714.

P3010.5 (717.5) Pipe fittings.
Pipe fittings to be connected to the replacement piping shall be made of high-density polyethylene (HDPE) that conforms to cell classification number PE3608, PE4608 or PE4710 as indicated in ASTM F 714. The pipe fittings shall be manufactured with an SDR of 17 and in compliance with ASTM D 2683.

P3010.6 (717.6) Cleanouts.
Where the existing building sewer did not have cleanouts meeting the requirements of this code, cleanout fittings shall be installed as required by this code.

P3010.7 (717.7) Post-installation inspection.
The completed replacement piping section shall be inspected internally by a recorded video camera survey. The video survey shall be reviewed and approved by the building official prior to pressure testing of the replacement piping system.

P3010.8 (717.8) Pressure testing.
The replacement piping system and the connections to the replacement piping shall be tested in accordance with Section P2503.4.
CHAPTER 31
VENTS

User note: Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.

The text of this chapter is extracted from the 2018 edition of the North Carolina Plumbing Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Plumbing Code.

SECTION P3101
VENT SYSTEMS

P3101.1 (901.1) General.
This chapter shall govern the selection and installation of piping, tubing and fittings for vent systems. This chapter shall control the minimum diameter of vent pipes, circuit vents, branch vents and individual vents, and the size and length of vents and various aspects of vent stacks and stack vents. Additionally, this chapter regulates vent grades and connections, height above fixtures and relief vents for stacks and fixture traps, and the venting of sumps and sewers.

P3101.2 (901.2) Trap seal protection.
The plumbing system shall be provided with a system of vent piping that will allow the admission or emission of air so that the liquid seal of any fixture trap shall not be subjected to a pressure differential of more than 1 inch of water column (249 Pa).

P3101.2.1 (901.2.1) Venting required.
Every trap and trapped fixture shall be vented in accordance with one of the venting methods specified in this chapter. All fixtures discharging downstream from a water closet shall be individually vented except as provided in Section P3107.

P3101.3 (901.4) Use limitations.
The plumbing vent system shall not be used for purposes other than the venting of the plumbing system.

P3101.4 (903.2) Extension outside a structure. Deleted.
In climates where the 97.5-percent value for outside design temperature is 0°F (-18°C) or less (ASHRAE 97.5-percent column, winter, see Chapter 3), vent pipes installed on the exterior of the structure shall be protected against freezing by insulation, heat or both. Vent terminals shall be protected from frost closure in accordance with Section P3103.2.

P3101.5 (309.2) Flood resistance.
In flood hazard areas as established by Table R301.2(1), vents shall be located at or above the elevation required in Section R322.1 (flood hazard areas including A Zones) or R322.2 (coastal
high-hazard areas including V Zones). The plumbing systems, pipes and fixtures shall not be
mounted on or penetrate through walls intended to break away under flood loads.

P3101.6 (901.5) Tests.
The vent system shall be tested in accordance with Section P2503.5.

P3101.7 (902.1) Materials
The materials and methods utilized for the construction and installation of venting systems shall
comply with the applicable provisions of Section P2906.

P3101.7.1 (902.2) Sheet copper.
Sheet copper for vent pipe flashings shall conform to ASTM B 152 and shall weigh not less
than 8 ounces per square foot (2.5 kg/m²).

P3101.7.2 (902.3) Sheet lead.
Sheet lead for vent pipe flashings shall weigh not less than 3 pounds per square foot (15
kg/m²) for field-constructed flashings and not less than 2-1/2 pounds per square foot (12
kg/m²) for prefabricated flashings.

SECTION P3102
VENT STACKS AND STACK VENTS

P3102.1 (904.1) Required vent extension Stack required.
The vent system serving each building drain shall have not less than one vent pipe that extends
to the outdoors. Every building in which plumbing is installed shall have at least one stack the
size of which is not less than one-half of the required diameter of the building drain, and not less
than 2 inches (51 mm) in diameter. Such stack shall run undiminished in size and as directly as
possible from the building drain through to the open air or to a vent header that extends to the
open air.

P3102.1.1 (904.1.1) Connection to drainage system.
A vent stack shall connect to the building drain or to the base of a drainage stack in
accordance with Section P3005.5. A stack vent shall be an extension of the drainage
stack. For townhouses and one- and two-family dwellings, the main vent shall connect to
the building drain, building stack or branch thereof not less than 3 inches (76 mm) in
size.

P3102.2 Installation.
The required vent shall be a dry vent that connects to the building drain or an extension of a
drain that connects to the building drain. Such vent shall not be an island fixture vent as
permitted by Section P3112.

P3102.3 Size.
The required vent shall be sized in accordance with Section P3113.1 based on the required size
of the building drain.

P3102.4 (904.3) Stack vent termination.
Stack vents shall terminate outdoors to the open air or to a stack-type air admittance valve in
accordance with Section P3114.
P3102.5 (904.5) Stack vent headers.
Stack vents connected into a common vent header at the top of the stacks and extending to the open air at one point shall be sized in accordance with the requirements of Section P3113.1. The number of fixture units shall be the sum of all fixture units on all stacks connected thereto, and the developed length shall be the longest vent length from the intersection at the base of the most distant stack to the vent terminal in the open air, as a direct extension of one stack.

SECTION P3103
VENT TERMINALS

P3103.1 (903.1) Roof extension.
Open vent pipes that extend through a roof shall be terminated not less than 6 inches (152 mm) above the roof or 6 inches (152 mm) above the anticipated snow accumulation, whichever is greater. Where a roof is to be used for assembly, as a promenade, observation deck or sunbathing deck or for similar purposes, open vent pipes shall terminate not less than 7 feet (2134 mm) above the roof.

P3103.2 (903.2) Frost closure. Deleted.
Where the 97.5 percent value for outside design temperature is 0°F (−18°C) or less, vent extensions through a roof or wall shall be not less than 3 inches (76 mm) in diameter. Any increase in the size of the vent shall be made not less than 1 foot (304.8 mm) inside the thermal envelope of the building.

P3103.3 (903.3) Flashings and sealing.
The juncture of each vent pipe with the roof line shall be made water tight by an approved flashing. Vent extensions in walls and soffits shall be made weather tight by caulking.

P3103.4 (903.4) Prohibited use.
A vent terminal shall not be used for any purpose other than a vent terminal. Vent terminals shall not be used as a flag pole or to support flag poles, television aerials or similar items, except when the piping has been anchored in an approved manner.

P3103.5 (903.5) Location of vent terminal.
An open vent terminal from a drainage system shall not be located less than 4 feet (1219 mm) directly beneath any door, openable window, or other air intake opening of the building or of an adjacent building, nor shall any such vent terminal be within 10 feet (3048 mm) horizontally of such an opening unless it is not less than 3 feet (914 mm) above the top of such opening. An open vent terminal from a drainage system shall not be located directly beneath any door, openable window, or other air intake opening of the building or of an adjacent building or property line, and any such vent terminal shall not be within 10 feet (3048 mm) horizontally of such an opening unless it is 2 feet (610 mm) or more above the top of such opening.

P3103.6 (903.6) Extension through the wall.
Vent terminals extending through the wall shall terminate not less than 10 feet (3048 mm) from the lot line and 10 feet (3048 mm) above the highest adjacent grade within 10 feet (3048 mm) horizontally of the vent terminal. Vent terminals shall not terminate under the overhang of a structure with soffit vents. Side wall vent terminals shall be protected to prevent birds or rodents from entering or blocking the vent opening.
SECTION P3104 (905)
VENT CONNECTIONS AND GRADES

P3104.1 (905.1) Connection.
Individual branch and circuit vents shall connect to a vent stack, stack vent or extend to the open air.

Exception: Individual, branch and circuit vents shall be permitted to terminate at an air admittance valve in accordance with Section P3114.

P3104.2 (905.2) Grade.
Vent and branch vent pipes shall be graded, connected and supported to allow moisture and condensate to drain back to the soil or waste pipe by gravity.

P3104.3 (905.3) Vent connection to drainage system.
A dry vent connecting to a horizontal drain shall connect above the centerline of the horizontal drain pipe.

P3104.4 (905.4) Vertical rise of vent.
A dry vent shall rise vertically to not less than 6 inches (152 mm) above the flood level rim of the highest trap or trapped fixture being vented.

Exceptions:

1. Vents for interceptors located outdoors.
2. When vents for interceptors are not located near an adjacent wall, the vent must rise 6 inches (152 mm) vertically before turning horizontally and continuing to the nearest wall. For cleaning purposes, a cleanout of the same size as the vent shall be installed.

P3104.5 (905.5) Height above fixtures.
A connection between a vent pipe and a vent stack or stack vent shall be made not less than 6 inches (152 mm) above the flood level rim of the highest fixture served by the vent. Horizontal vent pipes forming branch vents shall be not less than 6 inches (152 mm) above the flood level rim of the highest fixture served.

P3104.6 (905.6) Vent for future fixtures.
Where the drainage piping has been roughed-in for future fixtures, a rough-in connection for a vent, not less than one-half the diameter of the drain, shall be installed. The vent rough-in shall connect to the vent system or shall be vented by other means as provided in this chapter. The connection shall be identified to indicate that the connection is a vent.

SECTION P3105
FIXTURE VENTS

P3105.1 (909.1) Distance of trap from vent.
Each fixture trap shall have a protecting vent located so that the slope and the developed length in the fixture drain from the trap weir to the vent fitting are within the requirements set forth in Table P3105.1.
Exception: The developed length of the fixture drain from the trap weir to the vent fitting for self-siphoning fixtures, such as water closets, shall not be limited.

**TABLE P3105.1**
MAXIMUM DISTANCE OF FIXTURE TRAP FROM VENT

<table>
<thead>
<tr>
<th>SIZE OF TRAP (inches)</th>
<th>SLOPE (inch per foot)</th>
<th>DISTANCE FROM TRAP (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (\frac{1}{4})</td>
<td>(\frac{1}{4})</td>
<td>5</td>
</tr>
<tr>
<td>1 (\frac{1}{2})</td>
<td>(\frac{1}{4})</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>(\frac{1}{4})</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>(\frac{1}{8})</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>(\frac{1}{8})</td>
<td>16</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 inch per foot = 83.3 mm/m.

**P3105.2 (909.2) Fixture drains.**
The total fall in a fixture drain resulting from pipe slope shall not exceed one pipe diameter, nor shall the vent pipe connection to a fixture drain, except for water closets, be below the weir of the trap.

**P3105.3 (909.3) Crown vent prohibited.**
A vent shall not be installed within two pipe diameters of the trap weir.

**SECTION P3106 (910)**
INDIVIDUAL VENT

**P3106.1 (910.1) Individual vent permitted.**
Each trap and trapped fixture shall be permitted to be provided with an individual vent. The individual vent shall connect to the fixture drain of the trap or trapped fixture being vented.

**SECTION P3107**
COMMON VENT

**P3107.1 (911.1) Individual vent as common vent.**
An individual vent shall be permitted to vent two traps or trapped fixtures as a common vent. The traps or trapped fixtures being common vented shall be located on the same floor level.

**P3107.2 (911.2) Connection at the same level.**
Where the fixture drains being common vented connect at the same level, the vent connection shall be at the interconnection of the fixture drains or downstream of the interconnection.
P3107.3 (911.3) Connection at different levels.
Where the fixture drains connect at different levels, the vent shall connect as a vertical extension of the vertical drain. The vertical drain pipe connecting the two fixture drains shall be considered the vent for the lower fixture drain, and shall be sized in accordance with Table P3107.3. The upper fixture shall not be a water closet or clothes washer.

<table>
<thead>
<tr>
<th>PIPE SIZE (inches)</th>
<th>MAXIMUM DISCHARGE FROM UPPER FIXTURE DRAIN (d.f.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1\frac{1}{2}$</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>$2\frac{1}{2}$ to 3</td>
<td>6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

SECTION P3108
WET VENTING

P3108.1 (912.1) Horizontal wet vent permitted.
Any combination of fixtures within two bathroom groups located on the same floor level shall be permitted to be vented by a horizontal wet vent. The wet vent shall be considered the vent for the fixtures and shall extend from the connection of the dry vent along the direction of the flow in the drain pipe to the most downstream fixture drain connection. Each fixture drain shall connect horizontally to the horizontal branch being wet vented or shall have a dry vent. Each wet-vented fixture drain shall connect independently to the horizontal wet vent. Only the fixtures within the bathroom groups shall connect to the wet-vented horizontal branch drain. Any additional fixtures shall discharge downstream of the horizontal wet vent. A residential clothes washer drain line shall not be used as a wet vent.

P3108.2 (912.2) Dry vent connection.
The required dry-vent connection for wet-vented systems shall comply with Sections P3108.2.1 and P3108.2.2.

P3108.2.1 (912.2.1) Horizontal wet vent.
The dry-vent connection for a horizontal wet-vent system shall be an individual vent or a common vent for any bathroom group fixture, except an emergency floor drain. Where the dry vent connects to a water closet fixture drain, the drain shall connect horizontally to the horizontal wet vent system. Not more than one wet-vented fixture drain shall discharge upstream of the dry-vented fixture drain connection.

P3108.2.2 (912.2.2) Vertical wet vent.
The dry-vent connection for a vertical wet-vent system shall be an individual vent or common vent for the most upstream fixture drain.

P3108.3 (912.3) Size.
Horizontal and vertical wet vents shall be not less than the size as specified in Table P3108.3,
based on the fixture unit discharge to the wet vent. The dry vent serving the wet vent shall be sized based on the largest required diameter of pipe within the wet-vent system served by the dry vent.

**TABLE P3108.3**
**WET VENT SIZE**

<table>
<thead>
<tr>
<th>WET VENT PIPE SIZE</th>
<th>FIXTURE UNIT LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(inches)</td>
<td>(d.f.u.)</td>
</tr>
<tr>
<td>1 1/2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2 1/2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

**P3108.4 (912.1.1) Vertical wet vent permitted.**
A combination of fixtures located on the same floor level shall be permitted to be vented by a vertical wet vent. The vertical wet vent shall be considered the vent for the fixtures and shall extend from the connection of the dry vent down to the lowest fixture drain connection. Each wet-vented fixture shall connect independently to the vertical wet vent. All water closet drains shall connect at the same elevation. Other fixture drains shall connect above or at the same elevation as the water closet fixture drains. The dry vent connection to the vertical wet vent shall be an individual or common vent serving one or two fixtures.

**P3108.5 Trap weir to wet vent distances.**
The maximum developed length of wet-vented fixture drains shall comply with Table P3105.1.

**SECTION P3109 (913) WASTE STACK VENT**

**P3109.1 (913.1) Waste stack vent permitted.**
A waste stack shall be considered a vent for all of the fixtures discharging to the stack where installed in accordance with the requirements of this section.

**P3109.2 (913.2) Stack installation.**
The waste stack shall be vertical, and both horizontal and vertical offsets shall be prohibited between the lowest fixture drain connection and the highest fixture drain connection to the stack. Every fixture drain shall connect separately to the waste stack. The stack shall not receive the discharge of water closets or urinals.

**P3109.3 (913.3) Stack vent.**
A stack vent shall be installed for the waste stack. The size of the stack vent shall be not less than the size of the waste stack. Offsets shall be permitted in the stack vent and shall be located not less than 6 inches (152 mm) above the flood level of the highest fixture, and shall be in accordance with Section P3104.5. The stack vent shall be permitted to connect with other stack vents and vent stacks in accordance with Section P3113.3.
P3109.4 (913.4) Waste stack size.
The waste stack shall be sized based on the total discharge to the stack and the discharge within a branch interval in accordance with Table P3109.4. The waste stack shall be the same size throughout the length of the waste stack.

<table>
<thead>
<tr>
<th>STACK SIZE (inches)</th>
<th>MAXIMUM NUMBER OF FIXTURE UNITS (d.f.u.)</th>
<th>Total discharge into one branch interval</th>
<th>Total discharge for stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2 1/2</td>
<td>No limit</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>No limit</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>No limit</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

SECTION P3110 (914) CIRCUIT VENTING

P3110.1 (914.1) Circuit vent permitted.
Not greater than eight fixtures connected to a horizontal branch drain shall be permitted to be circuit vented. Each fixture drain shall connect horizontally to the horizontal branch being circuit vented. The horizontal branch drain shall be classified as a vent from the most downstream fixture drain connection to the most upstream fixture drain connection to the horizontal branch.

P3110.1.1 (914.1.1) Multiple circuit-vented branches.
Circuit-vented horizontal branch drains are permitted to be connected together. Each group of a maximum of eight fixtures shall be considered a separate circuit vent and shall conform to the requirements of this section.

P3110.2 (914.2) Vent connection.
The circuit vent connection shall be located between the two most upstream fixture drains. The vent shall connect to the horizontal branch and shall be installed in accordance with Section P3104. The circuit vent pipe shall not receive the discharge of any soil or waste.

P3110.3 (914.3) Slope and size of horizontal branch.
The slope of the vent section of the horizontal branch drain shall be not greater than one unit vertical in 12 units horizontal (8-percent slope). The entire length of the vent section of the horizontal branch drain shall be sized for the total drainage discharge to the branch in accordance with Table P3005.4.1. Drainage discharge dfu values for horizontal fixture branches shall be reduced 50% in Table P3005.4.1 for circuit vented fixture branches.

P3110.4 (914.5) Additional fixtures.
Fixtures, other than the circuit vented fixtures shall be permitted to discharge, to the horizontal
branch drain. Such fixtures shall be located on the same floor as the circuit vented fixtures and shall be either individually or common vented.

SECTION P3111
COMBINATION WASTE AND VENT SYSTEM

P3111.1 Type of fixtures.
A combination waste and vent system shall not serve fixtures other than floor drains, sinks and lavatories. A combination waste and vent system shall not receive the discharge of a food waste disposer.

P3111.2 Installation.
The only vertical pipe of a combination waste and vent system shall be the connection between the fixture drain and the horizontal combination waste and vent pipe. The vertical distance shall be not greater than 8 feet (2438 mm).

P3111.2.1 Slope.
The horizontal combination waste and vent pipe shall have a slope of not greater than \( \frac{1}{2} \) unit vertical in 12 units horizontal (4-percent slope). The minimum slope shall be in accordance with Section P3005.3.

P3111.2.2 Connection.
The combination waste and vent system shall be provided with a dry vent connected at any point within the system or the system shall connect to a horizontal drain that serves vented fixtures located on the same floor. Combination waste and vent systems connecting to building drains receiving only the discharge from one or more stacks shall be provided with a dry vent. The vent connection to the combination waste and vent pipe shall extend vertically to a point not less than 6 inches (152 mm) above the flood level rim of the highest fixture being vented before offsetting horizontally.

P3111.2.3 Vent size.
The vent shall be sized for the total fixture unit load in accordance with Section P3113.1.

P3111.2.4 Fixture branch or drain.
The fixture branch or fixture drain shall connect to the combination waste and vent within a distance specified in Table P3105.1. The combination waste and vent pipe shall be considered the vent for the fixture.

P3111.3 Size.
The size of a combination drain and vent pipe shall be not less than that specified in Table 3111.3. The horizontal length of a combination drain and vent system shall be unlimited.

<table>
<thead>
<tr>
<th>DIAMETER PIPE (inches)</th>
<th>MAXIMUM NUMBER OF FIXTURE UNITS (d.f.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Connecting to a horizontal branch or stack</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
SECTION P3112 (916)
ISLAND FIXTURE VENTING

P3112.1 (916.1) Limitation.
Island fixture venting shall not be permitted for fixtures other than sinks and lavatories. Kitchen sinks with a dishwasher waste connection, a food waste disposer, or both, in combination with the kitchen sink waste, shall be permitted to be vented in accordance with this section.

P3112.2 (916.2) Vent connection.
The island fixture vent shall connect to the fixture drain as required for an individual or common vent. The vent shall rise vertically to above the drainage outlet of the fixture being vented before offsetting horizontally or vertically downward. The vent or branch vent for multiple island fixture vents shall extend not less than 6 inches (152 mm) above the highest island fixture being vented before connecting to the outside vent terminal.

P3112.3 (916.3) Vent installation below the fixture flood level rim.
The vent located below the flood level rim of the fixture being vented shall be installed as required for drainage piping in accordance with Chapter 30, except for sizing. The vent shall be sized in accordance with Section P3113.1. The lowest point of the island fixture vent shall connect full size to the drainage system. The connection shall be to a vertical drain pipe or to the top half of a horizontal drain pipe. Cleanouts shall be provided in the island fixture vent to permit rodding of all vent piping located below the flood level rim of the fixtures. Rodding in both directions shall be permitted through a cleanout.

SECTION P3113
VENT PIPE SIZING

P3113.1 (906.1) Size of vents.
The required diameter of individual vents, branch vents, circuit vents, vent stacks and stack vents shall be not less than one-half the required diameter of the drain served. The required size of the drain shall be determined in accordance with Chapter 30. Vent pipes shall be not less than 1\(\frac{1}{4}\) inches (32 mm) in diameter. Vents exceeding 40 feet (12 192 mm) in developed length shall be increased by one nominal pipe size for the entire developed length of the vent pipe.

P3113.2 (906.3) Developed length.
The developed length of individual, branch, and circuit vents shall be measured from the farthest point of vent connection to the drainage system, to the point of connection to the vent stack, stack vent or termination outside of the building.

P3113.3 (906.4) Branch vents.
Where branch vents are connected to a common branch vent, the common branch vent shall be sized in accordance with this section, based on the size of the common horizontal drainage

For SI: 1 inch = 25.4 mm.
branch that is or would be required to serve the total drainage fixture unit (d.f.u.) load being vented.

**P3113.4 (906.5) Sump vents.**
Sump vent sizes shall be determined in accordance with Sections P3113.4.1 and P3113.4.2.

**P3113.4.1 (906.5.1) Sewage pumps and sewage ejectors other than pneumatic.**
Drainage piping below sewer level shall be vented in the same manner as that of a gravity system. Building sump vent sizes for sumps with sewage pumps or sewage ejectors, other than pneumatic, shall be determined in accordance with Table P3113.4.1. An open vent terminal from a drainage system shall not be located directly beneath any door, openable window, or other air intake opening of the building or of an adjacent building or property line, and any such vent terminal shall not be within 10 feet (3048 mm) horizontally of such an opening unless it is at least 2 feet (610 mm) above the top of such opening.

**TABLE P3113.4.1**
SIZE AND LENGTH OF SUMP VENTS

<table>
<thead>
<tr>
<th>DISCHARGE CAPACITY OF PUMP (gpm)</th>
<th>MAXIMUM DEVELOPED LENGTH OF VENT (feet)¹</th>
<th>Diameter of vent (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 / 4</td>
<td>1 / 2</td>
</tr>
<tr>
<td>10</td>
<td>No limit</td>
<td>No limit</td>
</tr>
<tr>
<td>20</td>
<td>270</td>
<td>No limit</td>
</tr>
<tr>
<td>40</td>
<td>72</td>
<td>160</td>
</tr>
<tr>
<td>60</td>
<td>31</td>
<td>75</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute (gpm) = 3.785 L/m.

a. Developed length plus an appropriate allowance for entrance losses and friction caused by fittings, changes in direction and diameter. Suggested allowances shall be obtained from NBS Monograph 31 or other approved sources. An allowance of 50 percent of the developed length shall be assumed if a more precise value is not available.

b. Actual values greater than 500 feet.

**P3113.4.2 (906.5.2) Pneumatic sewage ejectors.**
The air pressure relief pipe from a pneumatic sewage ejector shall be connected to an independent vent stack terminating as required for vent extensions through the roof. The relief pipe shall be sized to relieve air pressure inside the ejector to atmospheric pressure, but shall be not less than 1 1/4 inches (32 mm) in size.

**SECTION P3114 (918)**
AIR ADMITTANCE VALVES

**P3114.1 (918.1) General.**
Vent systems using air admittance valves shall comply with this section. Individual and branch-type air admittance valves shall conform to ASSE 1051. Stack-type air admittance valves shall conform to ASSE 1050.
P3114.2 (918.2) Installation.
The valves shall be installed in accordance with the requirements of this section and the manufacturer's instructions. *Air admittance valves* shall be installed after the DWV testing required by Section P2503.5.1 or P2503.5.2 has been performed.

P3114.3 (918.3) Where permitted.
Individual vents, branch vents, circuit vents and stack vents shall be permitted to terminate with a connection to an *air admittance valve*. Individual and branch type air admittance valves shall vent only fixtures that are on the same floor level and connect to a horizontal branch drain.

P3114.4 (918.4) Location.
Individual and branch *air admittance valves* shall be located not less than 4 inches (102 mm) above the horizontal branch drain or *fixture drain* being vented. Stack-type air admittance valves shall be located not less than 6 inches (152 mm) above the flood level rim of the highest fixture being vented. The *air admittance valve* shall be located within the maximum *developed length* permitted for the vent. The *air admittance valve* shall be installed not less than 6 inches (152 mm) above insulation materials where installed in *attics*.

P3114.5 (918.5) Access and ventilation.
Access shall be provided to *air admittance valves*. Such valves shall be installed in a location that allows air to enter the valve.

P3114.6 (918.6) Size.
The *air admittance valve* shall be rated for the size of the vent to which the valve is connected.

P3114.7 (918.7) Vent required.
Within each plumbing system, not less than one stack vent or a vent stack shall extend outdoors to the open air.

P3114.8 (918.8) Prohibited installations.
*Air admittance valves* shall not be used to vent sumps or tanks except where the vent system for the sump or tank has been designed by an engineer. *Air admittance valves* shall not be located in spaces utilized as supply or return air plenums.
CHAPTER 32
TRAPS

User note: Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.

The text of this chapter is extracted from the 2018 edition of the North Carolina Plumbing Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Plumbing Code.

SECTION P3201 (1002)
FIXTURE TRAPS

P3201.1 (1002.2) Design of traps.
Traps shall be of standard design, shall have smooth uniform internal waterways, shall be self-cleaning and shall not have interior partitions except where integral with the fixture. Traps shall be constructed of lead, cast iron, copper or copper alloy or approved plastic. Copper or copper alloy traps shall be not less than No. 20 gage (0.8 mm) thickness. Solid connections, slip joints and couplings shall be permitted to be used on the trap inlet, trap outlet, or within the trap seal. Slip joints shall be accessible.

P3201.2 (1002.4) Trap seals.
Each fixture trap shall have a liquid seal of not less than 2 inches (51 mm) and not more than 4 inches (102 mm).

Exception: Trap seal protection for waste receptors or hub drains used for condensate waste shall be by the use of a deep seal trap.

P3201.2.1 (1002.4.1) Trap seal protection.
Traps seals of emergency floor drain traps and traps subject to evaporation shall be protected by one of the methods in Sections P3201.2.1.1 through P3201.2.1.4.

P3201.2.1.1 (1002.4.1) Potable water-supplied trap seal primer valve.
A potable water-supplied trap seal primer valve shall supply water to the trap. Water-supplied trap seal primer valves shall conform to ASSE 1018. The discharge pipe from the trap seal primer valve shall connect to the trap above the trap seal on the inlet side of the trap.

P3201.2.1.2 (1002.4.2) Reclaimed or gray-water-supplied trap seal primer valve.
A reclaimed or gray-water-supplied trap seal primer valve shall supply water to the trap. Water-supplied trap seal primer valves shall conform to ASSE 1018. The quality of reclaimed or gray water supplied to trap seal primer valves shall be in accordance with the requirements of the manufacturer of the trap seal primer valve. The discharge pipe
from the trap seal primer valve shall connect to the trap above the trap seal on the inlet side of the trap.

P3201.2.1.3 (1002.4.3) Waste-water-supplied trap primer device. 
A waste-water-supplied trap primer device shall supply water to the trap. Waste-water-supplied trap primer devices shall conform to ASSE 1044. The discharge pipe from the trap seal primer device shall connect to the trap above the trap seal on the inlet side of the trap.

P3201.2.1.4 (1002.4.4) Barrier-type trap seal protection device. Deleted.
A barrier-type trap seal protection device shall protect the floor drain trap seal from evaporation. Barrier-type floor drain trap seal protection devices shall conform to ASSE 1072. The devices shall be installed in accordance with the manufacturer’s instructions.

P3201.3 (1002.7) Trap setting and protection. 
Traps shall be set level with respect to their water seals and shall be protected from freezing. Trap seals shall be protected from siphonage, aspiration or back pressure by an approved system of venting (see Section P3101).

P3201.4 (1002.6) Building traps. 
Building traps shall be prohibited.

P3201.5 (1002.3) Prohibited trap designs. 
The following types of traps are prohibited:

1. Bell traps.
2. Separate fixture traps with interior partitions, except those lavatory traps made of plastic, stainless steel or other corrosion-resistant material.
3. “S” traps.
4. Drum traps.
5. Trap designs with moving parts.

P3201.6 (1002.1) Number of fixtures per trap. 
Each plumbing fixture shall be separately trapped by a water seal trap. The vertical distance from the fixture outlet to the trap weir shall not exceed 24 inches (610 mm) and the horizontal distance shall not exceed 30 inches (762 mm) measured from the center line of the fixture outlet to the centerline of the inlet of the trap. The height of a clothes washer standpipe above a trap shall conform to Section P2706.1.2. Fixtures shall not be double trapped.

Exceptions:

1. Fixtures that have integral traps.
2. A single trap shall be permitted to serve two or three like fixtures limited to kitchen sinks, laundry tubs and lavatories. Such fixtures shall be adjacent to each other and located in the same room with a continuous waste arrangement. The trap shall be
installed at the center fixture where three fixtures are installed. Common trapped fixture outlets shall be not more than 30 inches (762 mm) apart.

3. Connection of a laundry tray waste line into a standpipe for the automatic clothes-washer drain shall be permitted in accordance with Section P2706.1.2.1.

**P3201.7 Size of fixture traps.**

Trap sizes for plumbing fixtures shall be as indicated in Table P3201.7. Where the tailpiece of a plumbing fixture is larger than that indicated in Table P3201.7, the trap size shall be the same nominal size as the fixture tailpiece. A trap shall not be larger than the drainage pipe into which the trap discharges.

**TABLE P3201.7**

<table>
<thead>
<tr>
<th>PLUMBING FIXTURE</th>
<th>TRAP SIZE MINIMUM (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathtub (with or without shower head and/or whirlpool attachments)</td>
<td>1 1/2</td>
</tr>
<tr>
<td>Bidet</td>
<td>1 1/4</td>
</tr>
<tr>
<td>Clothes washer standpipe</td>
<td>2</td>
</tr>
<tr>
<td>Dishwasher (on separate trap)</td>
<td>1 1/2</td>
</tr>
<tr>
<td>Floor drain</td>
<td>2</td>
</tr>
<tr>
<td>Kitchen sink (one or two traps, with or without dishwasher and food waste disposer)</td>
<td>1 1/2</td>
</tr>
<tr>
<td>Laundry tub (one or more compartments)</td>
<td>1 3/4</td>
</tr>
<tr>
<td>Lavatory</td>
<td>1 3/4</td>
</tr>
<tr>
<td>Shower (based on the total flow rate through showerheads and bodysprays)</td>
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<tr>
<td>Flow rate:</td>
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<tr>
<td>5.7 gpm and less</td>
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</tr>
<tr>
<td>More than 5.7 gpm up to 12.3 gpm</td>
<td>2</td>
</tr>
<tr>
<td>More than 12.3 gpm up to 25.8 gpm</td>
<td>3</td>
</tr>
<tr>
<td>More than 25.8 gpm up to 55.6 gpm</td>
<td>4</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
CHAPTER 33
STORM DRAINAGE

Deleted

User note: Code change proposals to this chapter will be considered by the IRC—Plumbing and Mechanical Code Development Committee during the 2015 (Group A) Code Development Cycle. See explanation on page xvii.

SECTION P3301
GENERAL

P3301.1 Scope.
The provisions of this chapter shall govern the materials, design, construction and installation of storm drainage.

SECTION P3302
SUBSOIL DRAINS

P3302.1 Subsoil drains.
Subsoil drains shall be open-jointed, horizontally split or perforated pipe conforming to one of the standards listed in Table P3302.1. Such drains shall be not less than 4 inches (102 mm) in diameter. Where the building is subject to backwater, the subsoil drain shall be protected by an accessibly located backwater valve. Subsoil drains shall discharge to a trapped area drain, sump, dry well or approved location above ground. The subsoil sump shall not be required to have either a gas-tight cover or a vent. The sump and pumping system shall comply with Section P3303.

TABLE P3302.1
SUBSOIL DRAIN PIPE

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast-iron pipe</td>
<td>ASTM A 74; ASTM A 888; CISPI 301</td>
</tr>
<tr>
<td>Polyethylene (PE) plastic pipe</td>
<td>ASTM F 405; CSA B182.1; CSA B182.6; CSA B182.8</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC) Plastic pipe (type sewer pipe, SDR 35, PS25, PS50 or PS100)</td>
<td>ASTM D 2729; ASTM D3034; ASTM F 891; CSA B182.2; CSA B182.4</td>
</tr>
<tr>
<td>Stainless steel drainage systems, Type 316L</td>
<td>ASME A112.3.1</td>
</tr>
<tr>
<td>Vitrified clay pipe</td>
<td>ASTM C 4; ASTM C 700</td>
</tr>
</tbody>
</table>

SECTION P3303
SUMPS AND PUMPING SYSTEMS

P3303.1 Pumping system.
The sump pump, pit and discharge piping shall conform to Sections P3303.1.1 through P3303.1.4.
**P3303.1.1 Pump capacity and head.**
The sump pump shall be of a capacity and head appropriate to anticipated use requirements.

**P3303.1.2 Sump pit.**
The sump pit shall be not less than 18 inches (457 mm) in diameter and 24 inches (610 mm) deep, unless otherwise approved. The pit shall be accessible and located so that all drainage flows into the pit by gravity. The sump pit shall be constructed of tile, steel, plastic, cast-iron, concrete or other approved material, with a removable cover adequate to support anticipated loads in the area of use. The pit floor shall be solid and provide permanent support for the pump.

**P3303.1.3 Electrical.**
Electrical outlets shall meet the requirements of Chapters 34 through 43.

**P3303.1.4 Piping.**
Discharge piping shall meet the requirements of Sections P3002.1, P3002.2, P3002.3 and P3003. Discharge piping shall include an accessible full flow check valve. Pipe and fittings shall be the same size as, or larger than, the pump discharge tapping.
Part VIII—Electrical

CHAPTER 34

GENERAL REQUIREMENTS

Deleted. See the North Carolina Electrical Code.

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SECTION E3401
GENERAL

E3401.1 Applicability.
The provisions of Chapters 34 through 43 shall establish the general scope of the electrical system and equipment requirements of this code. Chapters 34 through 43 cover those wiring methods and materials most commonly encountered in the construction of one- and two-family dwellings and structures regulated by this code. Other wiring methods, materials and subject matter covered in NFPA 70 are also allowed by this code.

E3401.2 Scope.
Chapters 34 through 43 shall cover the installation of electrical systems, equipment and components indoors and outdoors that are within the scope of this code, including services, power distribution systems, fixtures, appliances, devices and appurtenances. Services within the scope of this code shall be limited to 120/240-volt, 0–400-ampere, single-phase systems. These chapters specifically cover the equipment, fixtures, appliances, wiring methods and materials that are most commonly used in the construction or alteration of one- and two-family dwellings and accessory structures regulated by this code. The omission from these chapters of any material or method of construction provided for in the referenced standard NFPA 70 shall not be construed as prohibiting the use of such material or method of construction. Electrical systems, equipment or components not specifically covered in these chapters shall comply with the applicable provisions of NFPA 70.

E3401.3 Not covered.
Chapters 34 through 43 do not cover the following:

1. Installations, including associated lighting, under the exclusive control of communications utilities and electric utilities.

2. Services over 400 amperes.

E3401.4 Additions and alterations.
Any addition or alteration to an existing electrical system shall be made in conformity to the provisions of Chapters 34 through 43. Where additions subject portions of existing systems to loads exceeding those permitted herein, such portions shall be made to comply with Chapters 34 through 43.

SECTION E3402
BUILDING STRUCTURE PROTECTION
**E3402.1 Drilling and notching.**
Wood-framed structural members shall not be drilled, notched or altered in any manner except as provided for in this code.

**E3402.2 Penetrations of fire-resistance-rated assemblies.**
Electrical installations in hollow spaces, vertical shafts and ventilation or air-handling ducts shall be made so that the possible spread of fire or products of combustion will not be substantially increased. Electrical penetrations into or through fire-resistance-rated walls, partitions, floors or ceilings shall be protected by approved methods to maintain the fire-resistance rating of the element penetrated. Penetrations of fire-resistance-rated walls shall be limited as specified in Section R317.3. (300.21)

**E3402.3 Penetrations of firestops and draftstops.**
Penetrations through fire blocking and draftstopping shall be protected in an approved manner to maintain the integrity of the element penetrated.

**SECTION E3403**
**INSPECTION AND APPROVAL**

**E3403.1 Approval.**
Electrical materials, components and equipment shall be approved. (110.2)

**E3403.2 Inspection required.**
New electrical work and parts of existing systems affected by new work or alterations shall be inspected by the building official to ensure compliance with the requirements of Chapters 34 through 43.

**E3403.3 Listing and labeling.**
Electrical materials, components, devices, fixtures and equipment shall be listed for the application, shall bear the label of an approved agency and shall be installed, and used, or both, in accordance with the manufacturer's installation instructions. [110.3(B)]

**SECTION E3404**
**GENERAL EQUIPMENT REQUIREMENTS**

**E3404.1 Voltagess.**
Throughout Chapters 34 through 43, the voltage considered shall be that at which the circuit operates. (110.4)

**E3404.2 Interrupting rating.**
Equipment intended to interrupt current at fault levels shall have a minimum interrupting rating of 10,000 amperes. Equipment intended to interrupt current at levels other than fault levels shall have an interrupting rating at nominal circuit voltage of not less than the current that must be interrupted. (110.9)

**E3404.3 Circuit characteristics.**
The overcurrent protective devices, total impedance, equipment short-circuit current ratings and other characteristics of the circuit to be protected shall be so selected and coordinated as to permit the circuit protective devices that are used to clear a fault to do so without extensive damage to the electrical equipment of the circuit. This fault shall be assumed to be either
between two or more of the circuit conductors or between any circuit conductor and the equipment grounding conductors permitted in Section E3908.8. Listed equipment applied in accordance with its listing shall be considered to meet the requirements of this section. (110.10)

**E3404.4 Enclosure types.**

Enclosures, other than surrounding fences or walls, of panelboards, meter sockets, enclosed switches, transfer switches, circuit breakers, pullout switches and motor controllers, rated not over 600 volts nominal and intended for such locations, shall be marked with an enclosure-type number as shown in Table E3404.4.

Table E3404.4 shall be used for selecting these enclosures for use in specific locations other than hazardous (classified) locations. The enclosures are not intended to protect against conditions such as condensation, icing, corrosion, or contamination that might occur within the enclosure or enter through the conduit or unsealed openings. (110.28)

**TABLE E3404.4 (Table 110.28)**  
**ENCLOSURE SELECTION**

| PROVIDES A DEGREE OF PROTECTION AGAINST THE FOLLOWING ENVIRONMENTAL CONDITIONS | FOR OUTDOOR USE
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| PROVIDES A DEGREE OF PROTECTION AGAINST THE FOLLOWING ENVIRONMENTAL CONDITIONS | FOR INDOOR USE
<table>
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<td>Settling airborne dust, lint, fibers and flings</td>
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<td>Hosedown and splashing water</td>
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<td>Oil and coolant seepage</td>
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<td>Oil or coolant spraying and splashing</td>
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<td>Prolonged submersion</td>
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</tbody>
</table>

a.—— Mechanism shall be operable when ice covered.
Note 1: The term raintight is typically used in conjunction with Enclosure Types 3, 3S, 3SX, 3X, 4, 4X, 6 and 6P. The term rainproof is typically used in conjunction with Enclosure Types 3R and 3RX. The term watertight is typically used in conjunction with Enclosure Types 4, 4X, 6 and 6P. The term driptight is typically used in conjunction with Enclosure Types 2, 5, 12, 12K and 13. The term dusttight is typically used in conjunction with Enclosure Types 3, 3S, 3SX, 3X, 5, 12, 12K and 13.

Note 2: Ingress protection (IP) ratings are found in ANSI/NEMA 60529, Degrees of Protection Provided by Enclosures. IP ratings are not a substitute for enclosure type ratings.

E3404.5 Protection of equipment.
Equipment not identified for outdoor use and equipment identified only for indoor use, such as “dry locations,” “indoor use only” “damp locations,” or enclosure Type 1, 2, 5, 12, 12K and/or 13, shall be protected against damage from the weather during construction. (110.11)

E3404.6 Unused openings.
Unused openings, other than those intended for the operation of equipment, those intended for mounting purposes, and those permitted as part of the design for listed equipment, shall be closed to afford protection substantially equivalent to the wall of the equipment. Where metallic plugs or plates are used with nonmetallic enclosures they shall be recessed at least $\frac{1}{4}$ inch (6.4 mm) from the outer surface of the enclosure. [110.12(A)]

E3404.7 Integrity of electrical equipment.
Internal parts of electrical equipment, including busbars, wiring terminals, insulators and other surfaces, shall not be damaged or contaminated by foreign materials such as paint, plaster, cleaners or abrasives, and corrosive residues. There shall not be any damaged parts that might adversely affect safe operation or mechanical strength of the equipment such as parts that are broken; bent; cut; deteriorated by corrosion, chemical action, or overheating. Foreign debris shall be removed from equipment. [110.12(B)]

E3404.8 Mounting.
Electrical equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into masonry, concrete, plaster, or similar materials shall not be used. [110.13(A)]

E3404.9 Energized parts guarded against accidental contact.
Approved enclosures shall guard energized parts that are operating at 50 volts or more against accidental contact. [110.27(A)]

E3404.10 Prevent physical damage.
In locations where electrical equipment is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage. [110.27(B)]

E3404.11 Equipment identification.
The manufacturer’s name, trademark or other descriptive marking by which the organization responsible for the product can be identified shall be placed on all electric equipment. Other markings shall be provided that indicate voltage, current, wattage or other ratings as specified elsewhere in Chapters 34 through 43. The marking shall have the durability to withstand the environment involved. [110.21(A)]

E3404.12 Field-applied hazard markings.
Where caution, warning, or danger signs or labels are required by this code, the labels shall meet the following requirements:
1. The marking shall adequately warn of the hazard using effective words, colors, or symbols or combinations of such.

2. Labels shall be permanently affixed to the equipment or wiring method.

3. Labels shall not be hand written except for portions of labels or markings that are variable, or that could be subject to changes. Labels shall be legible.

4. Labels shall be of sufficient durability to withstand the environment involved. [110.21(B)]

**E3404.13 Identification of disconnecting means.**
Each disconnecting means shall be legibly marked to indicate its purpose, except where located and arranged so that the purpose is evident. The marking shall have the durability to withstand the environment involved. [110.22(A)]

**SECTION E3405**
**EQUIPMENT LOCATION AND CLEARANCES**

**E3405.1 Working space and clearances.**
Access and working space shall be provided and maintained around all electrical equipment to permit ready and safe operation and maintenance of such equipment in accordance with this section and Figure E3405.1. (110.26)
a. Equipment, piping and ducts foreign to the electrical installation shall not be placed in the shaded areas extending from the floor to a height of 6 feet above the panelboard enclosure, or to the structural ceiling, whichever is lower.
b. The working space shall be clear and unobstructed from the floor to a height of 6.5 feet or the height of the equipment, whichever is greater.
c. The working space shall not be designated for storage.
d. Panelboards, service equipment and similar enclosures shall not be located in bathrooms, toilet rooms, clothes closets or over the steps of a stairway.
e. Such work spaces shall be provided with artificial lighting where located indoors and shall not be controlled by automatic means only.

FIGURE E3405.1  Working Space and Clearances

**E3405.2 Working clearances for energized equipment and panelboards.**
Except as otherwise specified in Chapters 34 through 43, the dimension of the working space in the direction of access to panelboards and live parts of other equipment likely to require examination, adjustment, servicing or maintenance while energized shall be not less than 36 inches (914 mm) in depth. Distances shall be measured from the energized parts where such parts are exposed or from the enclosure front or opening where such parts are enclosed. In addition to the 36-inch dimension (914 mm), the work space shall not be less than 30 inches (762 mm) wide in front of the electrical equipment and not less than the width of such equipment. The work space shall be clear and shall extend from the floor or platform to a height of 6.5 feet (1981 mm) or the height of the equipment, whichever is greater. In all cases, the work space shall allow at least a 90-degree (1.57 rad) opening of equipment doors or hinged panels. Equipment associated with the electrical installation located above or below the electrical equipment shall be permitted to extend not more than 6 inches (152 mm) beyond the front of the electrical equipment. [110.26(A)(1), (2), (3)]

**Exceptions:**

1. In existing dwelling units, service equipment and panelboards that are not rated in excess of 200 amperes shall be permitted in spaces where the height of the working space is less than 6.5 feet (1981 mm). [110.26(A)(3) Exception No. 1]

2. Meters that are installed in meter sockets shall be permitted to extend beyond the other equipment. Meter sockets shall not be exempt from the requirements of this section. [110.26(A)(3) Exception No. 2]

**E3405.3 Indoor dedicated panelboard space.**
The indoor space equal to the width and depth of the panelboard and extending from the floor to a height of 6 feet (1829 mm) above the panelboard, or to the structural ceiling, whichever is lower, shall be dedicated to the electrical installation. Piping, ducts, leak protection apparatus and other equipment foreign to the electrical installation shall not be installed in such dedicated space. The area above the dedicated space shall be permitted to contain foreign systems, provided that protection is installed to avoid damage to the electrical equipment from condensation, leaks and breaks in such foreign systems (see Figure E3405.1).

**Exception:** Suspended ceilings with removable panels shall be permitted within the 6-foot (1829 mm) dedicated space.

**E3405.4 Outdoor dedicated panelboard space.**
The outdoor space equal to the width and depth of the panelboard, and extending from grade to
a height of 6 feet (1.8 m) above the panelboard, shall be dedicated to the electrical installation. Piping and other equipment foreign to the electrical installation shall not be located in this zone.

**E3405.5 Location of working spaces and equipment.**
Required working space shall not be designated for storage. Panelboards and overcurrent protection devices shall not be located in clothes closets, in bathrooms, or over the steps of a stairway. [110.26(B), 240.24(D), (E), (F)]

**E3405.6 Access and entrance to working space.**
Access shall be provided to the required working space. [110.26(C)(1)]

**E3405.7 Illumination.**
Artificial illumination shall be provided for all working spaces for service equipment and panelboards installed indoors and shall not be controlled by automatic means only. Additional lighting outlets shall not be required where the work space is illuminated by an adjacent light source or as permitted by Exception 1 of Section E3903.2 for switched receptacles. [110.26(D)]

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**SECTION E3406**
**ELECTRICAL CONDUCTORS AND CONNECTIONS**

**E3406.1 General.**
This section provides general requirements for conductors, connections and splices. These requirements do not apply to conductors that form an integral part of equipment, such as motors, appliances and similar equipment, or to conductors specifically provided for elsewhere in Chapters 34 through 43. (310.1)

**E3406.2 Conductor material.**
Conductors used to conduct current shall be of copper except as otherwise provided in Chapters 34 through 43. Where the conductor material is not specified, the material and the sizes given in these chapters shall apply to copper conductors. Where other materials are used, the conductor sizes shall be changed accordingly. (110.5)

**E3406.3 Minimum size of conductors.**
The minimum size of conductors for feeders and branch circuits shall be 14 AWG copper and 12 AWG aluminum. The minimum size of service conductors shall be as specified in Chapter 36. The minimum size of Class 2 remote control, signaling and power-limited circuits conductors shall be as specified in Chapter 43. [310.106(A)]

**E3406.4 Stranded conductors.**
Where installed in raceways, conductors 8 AWG and larger shall be stranded. A solid 8 AWG conductor shall be permitted to be installed in a raceway only to meet the requirements of Sections E3610.2 and E4204. [310.106(C)]

**E3406.5 Individual conductor insulation.**
Except where otherwise permitted in Sections E3605.1 and E3908.9, and E4303, current-carrying conductors shall be insulated. Insulated conductors shall have insulation types identified as RHH, RHW, RHW-2, THHN, THHW, THW, THW-2, THWN, THWN-2, TW, UF, USE, USE-2, XHHW or XHHW-2. Insulation types shall be approved for the application. [310.106(C), 310.104]
E3406.6 Conductors in parallel.
Circuit conductors that are connected in parallel shall be limited to sizes 1/0 AWG and larger. Conductors in parallel shall: be of the same length; consist of the same conductor material; be the same circular mil area and have the same insulation type. Conductors in parallel shall be terminated in the same manner. Where run in separate raceways or cables, the raceway or cables shall have the same physical characteristics. Where conductors are in separate raceways or cables, the same number of conductors shall be used in each raceway or cable. [310.10(H)]

E3406.7 Conductors of the same circuit.
All conductors of the same circuit and, where used, the grounded conductor and all equipment grounding conductors and bonding conductors shall be contained within the same raceway, cable or cord. [300.3(B)]

E3406.8 Aluminum and copper connections.
Terminals and splicing connectors shall be identified for the material of the conductors joined. Conductors of dissimilar metals shall not be joined in a terminal or splicing connector where physical contact occurs between dissimilar conductors such as copper and aluminum, copper and copper-clad aluminum, or aluminum and copper-clad aluminum, except where the device is listed for the purpose and conditions of application. Materials such as inhibitors and compounds shall be suitable for the application and shall be of a type that will not adversely affect the conductors, installation or equipment. (110.14)

E3406.9 Fine stranded conductors.
Connectors and terminals for conductors that are more finely stranded than Class B and Class C stranding as shown in Table E3406.9, shall be identified for the specific conductor class or classes. (110.14)

**TABLE E3406.9 (Chapter 9, Table 10)**

<table>
<thead>
<tr>
<th>CONDUCTOR SIZE</th>
<th>NUMBER OF STRANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Copper</td>
</tr>
<tr>
<td>AWG or kcmil</td>
<td>Class-B</td>
</tr>
<tr>
<td>24-30</td>
<td>0.20-0.05</td>
</tr>
<tr>
<td>22</td>
<td>0.32</td>
</tr>
<tr>
<td>20</td>
<td>0.52</td>
</tr>
<tr>
<td>18</td>
<td>0.82</td>
</tr>
<tr>
<td>16</td>
<td>1.3</td>
</tr>
<tr>
<td>14-2</td>
<td>2.1-33.6</td>
</tr>
<tr>
<td>14-0</td>
<td>42.4-107</td>
</tr>
<tr>
<td>250-500</td>
<td>127-253</td>
</tr>
<tr>
<td>600-1000</td>
<td>304-508</td>
</tr>
<tr>
<td>1250-1500</td>
<td>635-759</td>
</tr>
<tr>
<td>1750-2000</td>
<td>886-1016</td>
</tr>
</tbody>
</table>

a. Number of strands vary.
b. Aluminum 14 AWG (2.1 mm²) is not available.
c. With the permission of Underwriters Laboratories, Inc., this material is reproduced from UL Standard 486A-B, Wire Connectors, which is copyrighted by Underwriters Laboratories, Inc., Northbrook, Illinois. While use of this
E3406.10 Terminals.
Connection of conductors to terminal parts shall be made without damaging the conductors and shall be made by means of pressure connectors, including set screw type, by means of splices to flexible leads, or for conductor sizes of 10 AWG and smaller, by means of wire binding screws or studs and nuts having upturned lugs or the equivalent. Terminals for more than one conductor and terminals for connecting aluminum conductors shall be identified for the application. [110.14(A)]

E3406.11 Splices.
Conductors shall be spliced or joined with splicing devices listed for the purpose. Splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device listed for the purpose. Wire connectors or splicing means installed on conductors for direct burial shall be listed for such use. [110.14(B)]

E3406.11.1 Continuity.
Conductors in raceways shall be continuous between outlets, boxes, and devices and shall be without splices or taps in the raceway.

Exception: Splices shall be permitted within surface-mounted raceways that have a removable cover. [300.13(A)]

E3406.11.2 Device connections.
The continuity of a grounded conductor in multiwire branch circuits shall not be dependent on connection to devices such as receptacles and lampholders. The arrangement of grounding connections shall be such that the disconnection or the removal of a receptacle, luminaire or other device fed from the box does not interfere with or interrupt the grounding continuity. [300.13(B)]

E3406.11.3 Length of conductor for splice or termination.
Where conductors are to be spliced, terminated or connected to fixtures or devices, a minimum length of 6 inches (152 mm) of free conductor shall be provided at each outlet, junction or switch point. The required length shall be measured from the point in the box where the conductor emerges from its raceway or cable sheath. Where the opening to an outlet, junction or switch point is less than 8 inches (200 mm) in any dimension, each conductor shall be long enough to extend at least 3 inches (75 mm) outside of such opening. (300.14)

E3406.12 Grounded conductor continuity.
The continuity of a grounded conductor shall not depend on connection to a metallic enclosure, raceway or cable armor. [200.2(B)]

E3406.13 Connection of grounding and bonding equipment.
The connection of equipment grounding conductors, grounding electrode conductors and bonding jumpers shall be in accordance with Sections E3406.13.1 and E3406.13.2.

E3406.13.1 Permitted methods.
Equipment grounding conductors, grounding electrode conductors, and bonding jumpers shall be connected by one or more of the following means:
1. Listed pressure connectors.
2. Terminal bars.
3. Pressure connectors listed as grounding and bonding equipment.
4. Exothermic welding process.
5. Machine screw-type fasteners that engage not less than two threads or are secured with a nut.
6. Thread-forming machine screws that engage not less than two threads in the enclosure.
7. Connections that are part of a listed assembly.
8. Other listed means. [250.8 (A)]

**E3406.13.2 Methods not permitted.**
Connection devices or fittings that depend solely on solder shall not be used. [250.8 (B)]

**SECTION E3407**
CONDUCTOR AND TERMINAL IDENTIFICATION

**E3407.1 Grounded conductors.**
Insulated grounded conductors of sizes 6 AWG or smaller shall be identified by a continuous white or gray outer finish or by three continuous white or gray stripes on other than green insulation along the entire length of the conductors. Conductors of sizes 4 AWG or larger shall be identified either by a continuous white or gray outer finish or by three continuous white or gray stripes on other than green insulation along its entire length or at the time of installation by a distinctive white or gray marking at its terminations. This marking shall encircle the conductor or insulation. [200.6 (A) & (B)]

**E3407.2 Equipment grounding conductors.**
Equipment grounding conductors of sizes 6 AWG and smaller shall be identified by a continuous green color or a continuous green color with one or more yellow stripes on the insulation or covering, except where bare. Conductors with insulation or individual covering that is green, green with one or more yellow stripes, or otherwise identified as permitted by this section shall not be used for ungrounded or grounded circuit conductors. (250.119)

Equipment grounding conductors 4 AWG and larger AWG that are not identified as required for conductors of sizes 6 AWG and smaller shall, at the time of installation, be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is accessible, except where such conductors are bare.

The required identification for conductors 4 AWG and larger shall encircle the conductor and shall be accomplished by one of the following:
1. Stripping the insulation or covering from the entire exposed length.

2. Coloring the exposed insulation or covering green at the termination.

3. Marking the exposed insulation or covering with green tape or green adhesive labels at the termination. [250.119(A)]

Exceptions:

1. Conductors 4 AWG and larger shall not be required to be identified in conduit bodies that do not contain splices or unused hubs. [250.119(A)(1) Exception]

2. Power-limited, Class 2 or Class 3 circuit cables containing only circuits operating at less than 50 volts shall be permitted to use a conductor with green insulation for other than equipment grounding purposes. [250.119 Exception No. 1]

E3407.3 Ungrounded conductors.
Insulation on the ungrounded conductors shall be a continuous color other than white, gray and green. [310.110(C)]

Exception: An insulated conductor that is part of a cable or flexible cord assembly and that has a white or gray finish or a finish marking with three continuous white or gray stripes shall be permitted to be used as an ungrounded conductor where it is permanently reidentified to indicate its use as an ungrounded conductor by marking tape, painting, or other effective means at all terminations and at each location where the conductor is visible and accessible. Identification shall encircle the insulation and shall be a color other than white, gray, and green. [200.7(C)(1)]

Where used for single-pole, 3-way or 4-way switch loops, the reidentified conductor with white or gray insulation or three continuous white or gray stripes shall be used only for the supply to the switch, not as a return conductor from the switch to the outlet. [200.7(C)(2)]

E3407.4 Identification of terminals.
Terminals for attachment to conductors shall be identified in accordance with Sections E3407.4.1 and E3407.4.2.

E3407.4.1 Device terminals.
All devices excluding panelboards, provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have terminals properly marked for identification, except where the terminal intended to be connected to the grounded conductor is clearly evident. [200.10(A)]

Exception: Terminal identification shall not be required for devices that have a normal current rating of over 30 amperes, other than polarized attachment caps and polarized receptacles for attachment caps as required in Section E3407.4.2. [200.10(A) Exception]

E3407.4.2 Receptacles, plugs and connectors.
Receptacles, polarized attachment plugs and cord connectors for plugs and polarized plugs shall have the terminal intended for connection to the grounded (white) conductor identified. Identification shall be by a metal or metal coating substantially white in color or by the word...
“white” or the letter “W” located adjacent to the identified terminal. Where the terminal is not visible, the conductor entrance hole for the connection shall be colored white or marked with the word “white” or the letter “W.” [200.10(B)]
CHAPTER 35
ELECTRICAL DEFINITIONS

Deleted. See the North Carolina Electrical Code.

SECTION E3501
GENERAL

E3501.1 Scope.
This chapter contains definitions that shall apply only to the electrical requirements of Chapters 34 through 43. Unless otherwise expressly stated, the following terms shall, for the purpose of this code, have the meanings indicated in this chapter. Words used in the present tense include the future; the singular number includes the plural and the plural the singular. Where terms are not defined in this section and are defined in Section R202 of this code, such terms shall have the meanings ascribed to them in that section. Where terms are not defined in these sections, they shall have their ordinarily accepted meanings or such as the context implies.

ACCESSIBLE. (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation or other effective means.

ACCESSIBLE. (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building.

ACCESSIBLE, READILY. Capable of being reached quickly for operation, renewal or inspections, without requiring those to whom ready access is requisite to take actions such as to use tools, to climb over or remove obstacles or to resort to portable ladders, etc.

AMPACITY. The maximum current in amperes that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

APPLIANCE. Utilization equipment, normally built in standardized sizes or types, that is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, etc.

APPROVED. Acceptable to the authority having jurisdiction.

ARC-FAULT CIRCUIT INTERRUPTER. A device intended to provide protection from the effects of arc-faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc-fault is detected.

ATTACHMENT PLUG (PLUG CAP) (PLUG). A device that, by insertion into a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

AUTOMATIC. Performing a function without the necessity of human intervention.
BATHROOM. An area, including a basin, with one or more of the following: a toilet, a urinal, a tub, a shower, a bidet, or similar plumbing fixture.

BONDED (BONDING). Connected to establish electrical continuity and conductivity.

BONDING CONDUCTOR OR JUMPER. A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.

BONDING JUMPER (EQUIPMENT). The connection between two or more portions of the equipment grounding conductor.

BONDING JUMPER, MAIN. The connection between the grounded circuit conductor and the equipment grounding conductor at the service.

BONDING JUMPER, SUPPLY-SIDE. A conductor installed on the supply side of a service or within a service equipment enclosure(s) that ensures the required electrical conductivity between metal parts required to be electrically connected.

BRANCH CIRCUIT. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

BRANCH CIRCUIT, APPLIANCE. A branch circuit that supplies energy to one or more outlets to which appliances are to be connected, and that has no permanently connected luminaires that are not a part of an appliance.

BRANCH CIRCUIT, GENERAL PURPOSE. A branch circuit that supplies two or more receptacle outlets or outlets for lighting and appliances.

BRANCH CIRCUIT, INDIVIDUAL. A branch circuit that supplies only one utilization equipment.

BRANCH CIRCUIT, MULTIWIRE. A branch circuit consisting of two or more ungrounded conductors having voltage difference between them, and a grounded conductor having equal voltage difference between it and each ungrounded conductor of the circuit, and that is connected to the neutral or grounded conductor of the system.

CABINET. An enclosure designed either for surface or flush mounting and provided with a frame, mat or trim in which a swinging door or doors are or may be hung.

CIRCUIT BREAKER. A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

CLOTHES CLOSET. A nonhabitable room or space intended primarily for storage of garments and apparel.

CONCEALED. Rendered inaccessible by the structure or finish of the building.

CONDUCTOR. Bare. A conductor having no covering or electrical insulation whatsoever.
Covered. A conductor encased within material of composition or thickness that is not recognized by this code as electrical insulation.

Insulated. A conductor encased within material of composition and thickness that is recognized by this code as electrical insulation.

CONDUIT BODY. A separate portion of a conduit or tubing system that provides access through a removable cover(s) to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system. Boxes such as FS and FD or larger cast or sheet metal boxes are not classified as conduit bodies.

CONNECTOR, PRESSURE (SOLDERLESS). A device that establishes a connection between two or more conductors or between one or more conductors and a terminal by means of mechanical pressure and without the use of solder.

CONTINUOUS LOAD. A load where the maximum current is expected to continue for 3 hours or more.

COOKING UNIT, COUNTER-MOUNTED. A cooking appliance designed for mounting in or on a counter and consisting of one or more heating elements, internal wiring and built-in or separately mountable controls.

COPPER-CLAD ALUMINUM CONDUCTORS. Conductors drawn from a copper-clad aluminum rod with the copper metallurgically bonded to an aluminum core. The copper forms a minimum of 10 percent of the cross-sectional area of a solid conductor or each strand of a stranded conductor.

CUTOUT BOX. An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper (see “Cabinet”).

DEAD FRONT. Without live parts exposed to a person on the operating side of the equipment.

DEMAND FACTOR. The ratio of the maximum demand of a system, or part of a system, to the total connected load of a system or the part of the system under consideration.

DEVICE. A unit of an electrical system that carries or controls electrical energy as its principal function.

DISCONNECTING MEANS. A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

DWELLING.

Dwelling unit. A single unit, providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking and sanitation.

One-family dwelling. A building consisting solely of one dwelling unit.

Two-family dwelling. A building consisting solely of two dwelling units.
**EFFECTIVE GROUND-FAULT CURRENT PATH.** An intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground-fault detectors.

**ENCLOSED.** Surrounded by a case, housing, fence or walls that will prevent persons from accidentally contacting energized parts.

**ENCLOSURE.** The case or housing of apparatus, or the fence or walls surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage.

**ENERGIZED.** Electrically connected to, or is, a source of voltage.

**EQUIPMENT.** A general term including material, fittings, devices, appliances, luminaires, apparatus, machinery and the like used as a part of, or in connection with, an electrical installation.

**EXPOSED.** (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person.

**EXPOSED.** (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access.

**EXTERNALLY OPERABLE.** Capable of being operated without exposing the operator to contact with live parts.

**FEEDER.** All circuit conductors between the service equipment, or the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device.

**FITTING.** An accessory such as a locknut, bushing or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

**GROUND.** The earth.

**GROUNDED (GROUNDING).** Connected (connecting) to ground or to a conductive body that extends the ground connection.

**GROUNDED, EFFECTIVELY.** Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazards to connected equipment or to persons.

**GROUNDED CONDUCTOR.** A system or circuit conductor that is intentionally grounded.

**GROUNDING CONDUCTOR, EQUIPMENT (EGC).** The conductive path(s) that provides a ground-fault current path and connects normally noncurrent-carrying metal parts of equipment together and, to the system grounded conductor, the grounding electrode conductor or both.

**GROUNDING ELECTRODE.** A conducting object through which a direct connection to earth is established.
GROUNDING ELECTRODE CONDUCTOR. A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

GROUND-FAULT CIRCUIT-INTERRUPTER. A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the value for a Class A device.

GROUND-FAULT CURRENT PATH. An electrically conductive path from the point of a ground fault on a wiring system through normally non-current-carrying conductors, equipment, or the earth to the electrical supply source.

Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; and the earth itself.

GUARDED. Covered, shielded, fenced, enclosed or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.

IDENTIFIED. (As applied to equipment.) Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular code requirement.

INTERRUPTING RATING. The highest current at rated voltage that a device is identified to interrupt under standard test conditions.

INTERSYSTEM BONDING TERMINATION. A device that provides a means for connecting intersystem bonding conductors for communications systems to the grounding electrode system.

ISOLATED. (As applied to location.) Not readily accessible to persons unless special means for access are used.

KITCHEN. An area with a sink and permanent provisions for food preparation and cooking.

LABELED. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

LIGHTING OUTLET. An outlet intended for the direct connection of a lampholder or luminaire.

LIGHTING TRACK (Track Lighting). A manufactured assembly designed to support and energize luminaires that are capable of being readily repositioned on the track. Its length can be altered by the addition or subtraction of sections of track.
LISTED. Equipment, materials or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states either that the equipment, material or services meets identified standards or has been tested and found suitable for a specified purpose.

LIVE PARTS. Energized conductive components.

LOCATION, DAMP. Location protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture.

LOCATION, DRY. A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

LOCATION, WET. Installations underground or in concrete slabs or masonry in direct contact with the earth and locations subject to saturation with water or other liquids, such as vehicle-washing areas, and locations exposed to weather.

LUMINAIRE. A complete lighting unit consisting of a light source such as a lamp or lamps together with the parts designed to position the light source and connect it to the power supply. A luminaire can include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire.

MULTIOUTLET ASSEMBLY. A type of surface, or flush, or freestanding raceway; designed to hold conductors and receptacles, assembled in the field or at the factory.

NEUTRAL CONDUCTOR. The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.

NEUTRAL POINT. The common point on a wye-connection in a polyphase system or midpoint on a single-phase, 3-wire system, or midpoint of a single-phase portion of a 3-phase delta system, or a midpoint of a 3-wire, direct-current system.

OUTLET. A point on the wiring system at which current is taken to supply utilization equipment.

OVERCURRENT. Any current in excess of the rated current of equipment or the ampacity of a conductor. Such current might result from overload, short circuit or ground fault.

OVERLOAD. Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

PANELBOARD. A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat or power circuits, designed to be placed in a cabinet or cutout box placed in or against a wall, partition or other support and accessible only from the front.
PLENUM. A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.

POWER OUTLET. An enclosed assembly that may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means, intended to supply and control power to mobile homes, recreational vehicles or boats, or to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

PREMISES WIRING (SYSTEM). Interior and exterior wiring, including power, lighting, control and signal circuit wiring together with all of their associated hardware, fittings and wiring devices, both permanently and temporarily installed. This includes wiring from the service point or power source to the outlets and wiring from and including the power source to the outlets where there is no service point. Such wiring does not include wiring internal to appliances, luminaires, motors, controllers, and similar equipment.

QUALIFIED PERSON. One who has the skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved.

RACEWAY. An enclosed channel of metallic or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this code.

RAINFOOD. Constructed, protected or treated so as to prevent rain from interfering with the successful operation of the apparatus under specified test conditions.

RAIN-TIGHT. Constructed or protected so that exposure to a beating rain will not result in the entrance of water under specified test conditions.

RECEPTACLE. A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

RECEPTACLE OUTLET. An outlet where one or more receptacles are installed.

SERVICE. The conductors and equipment for delivering energy from the serving utility to the wiring system of the premises served.

SERVICE CABLE. Service conductors made up in the form of a cable.

SERVICE CONDUCTORS. The conductors from the service point to the service disconnecting means.

SERVICE CONDUCTORS, OVERHEAD. The overhead conductors between the service point and the first point of connection to the service-entrance conductors at the building or other structure.

SERVICE CONDUCTORS, UNDERGROUND. The underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside of the building wall.
SERVICE DROP. The overhead service conductors between the utility electric supply system and the service point.

SERVICE-ENTRANCE CONDUCTORS, OVERHEAD SYSTEM. The service conductors between the terminals of the service equipment and a point usually outside of the building, clear of building walls, where joined by tap or splice to the service drop or overhead service conductors.

SERVICE-ENTRANCE CONDUCTORS, UNDERGROUND SYSTEM. The service conductors between the terminals of the service equipment and the point of connection to the service lateral or underground service conductors.

SERVICE EQUIPMENT. The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s), and their accessories, connected to the load end of the service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.

SERVICE LATERAL. The underground service conductors between the electric utility supply system and the service point.

SERVICE POINT. The point of connection between the facilities of the serving utility and the premises wiring.

STRUCTURE. That which is built or constructed.

SWITCHES.

General-use switch. A switch intended for use in general distribution and branch circuits. It is rated in amperes and is capable of interrupting its rated current at its rated voltage.

General-use snap switch. A form of general-use switch constructed so that it can be installed in device boxes or on box covers or otherwise used in conjunction with wiring systems recognized by this code.

Isolating switch. A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating and is intended to be operated only after the circuit has been opened by some other means.

Motor-circuit switch. A switch, rated in horsepower that is capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

UNGROUNDED. Not connected to ground or to a conductive body that extends the ground connection.

UTILIZATION EQUIPMENT. Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting or similar purposes.

VENTILATED. Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes or vapors.
**VOLTAGE (OF A CIRCUIT).** The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned.

**VOLTAGE, NOMINAL.** A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

**VOLTAGE TO GROUND.** For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded. For ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

**WATERTIGHT.** Constructed so that moisture will not enter the enclosure under specified test conditions.

**WEATHERPROOF.** Constructed or protected so that exposure to the weather will not interfere with successful operation.
CHAPTER 36
SERVICES

Deleted. See the North Carolina Electrical Code.

SECTION E3601
GENERAL SERVICES

E3601.1 Scope.
This chapter covers service conductors and equipment for the control and protection of services and their installation requirements. (230.1)

E3601.2 Number of services.
One- and two-family dwellings shall be supplied by only one service. (230.2)

E3601.3 One building or other structure not to be supplied through another.
Service conductors supplying a building or other structure shall not pass through the interior of another building or other structure. (230.3)

E3601.4 Other conductors in raceway or cable.
Conductors other than service conductors shall not be installed in the same service raceway or service cable. (230.7)

Exceptions:

1. Grounding electrode conductors and equipment bonding jumpers or conductors.
2. Load management control conductors having overcurrent protection.

E3601.5 Raceway seal.
Where a service raceway enters from an underground distribution system, it shall be sealed in accordance with Section E3803.6. (230.8)

E3601.6 Service disconnect required.
Means shall be provided to disconnect all conductors in a building or other structure from the service entrance conductors. (230.70)

E3601.6.1 Marking of service equipment and disconnects.
Service disconnects shall be permanently marked as a service disconnect. [230.70(B)]

E3601.6.2 Service disconnect location.
The service disconnecting means shall be installed at a readily accessible location either outside of a building or inside nearest the point of entrance of the service conductors. Service disconnecting means shall not be installed in bathrooms. Each occupant shall have access to the disconnect serving the dwelling unit in which they reside. [230.70(A)(1), 230.72(C)]
E3601.7 Maximum number of disconnects.
The service disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure or in a group of separate enclosures. [230.71(A)]

SECTION E3602
SERVICE SIZE AND RATING

E3602.1 Ampacity of ungrounded conductors.
Ungrounded service conductors shall have an ampacity of not less than the load served. For one-family dwellings, the ampacity of the ungrounded conductors shall be not less than 100 amperes, 3 wire. For all other installations, the ampacity of the ungrounded conductors shall be not less than 60 amperes. [230.42(B), 230.79(C) & (D)]

E3602.2 Service load.
The minimum load for ungrounded service conductors and service devices that serve 100 percent of the dwelling unit load shall be computed in accordance with Table E3602.2. Ungrounded service conductors and service devices that serve less than 100 percent of the dwelling unit load shall be computed as required for feeders in accordance with Chapter 37. [220.82(A)]

TABLE E3602.2
MINIMUM SERVICE LOAD CALCULATION [220.82(B) & (C)]

<table>
<thead>
<tr>
<th>LOADS AND PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 volt-amperes per square foot of floor area for general lighting and general use receptacle outlets.</td>
</tr>
<tr>
<td>Plus</td>
</tr>
<tr>
<td>1,500 volt-amperes multiplied by total number of 20-ampere-rated small appliance and laundry circuits.</td>
</tr>
<tr>
<td>Plus</td>
</tr>
<tr>
<td>The nameplate volt-ampere rating of all fastened-in-place, permanently connected or dedicated circuit-supplied appliances such as ranges, ovens, cooking units, clothes dryers not connected to the laundry branch circuit and water heaters.</td>
</tr>
<tr>
<td>Apply the following demand factors to the above subtotal:</td>
</tr>
<tr>
<td>The minimum subtotal for the loads above shall be 100 percent of the first 10,000 volt-amperes of the sum of the above loads plus 40 percent of any portion of the sum that is in excess of 10,000 volt-amperes.</td>
</tr>
<tr>
<td>Plus the largest of the following:</td>
</tr>
<tr>
<td>One hundred percent of the nameplate rating(s) of the air-conditioning and cooling equipment.</td>
</tr>
<tr>
<td>One hundred percent of the nameplate rating(s) of the heat pump where a heat pump is used without any supplemental electric heating.</td>
</tr>
<tr>
<td>One hundred percent of the nameplate rating of the electric thermal storage and other heating systems where the usual load is expected to be continuous at the full nameplate value. Systems qualifying under this selection shall not be figured under any other category in this table.</td>
</tr>
<tr>
<td>One hundred percent of nameplate rating of the heat pump compressor and sixty-five percent of the supplemental electric heating load for central electric space heating systems, if the heat pump compressor is prevented from operating at the same time as the supplementary heat, the compressor load does not need to be added to the supplementary heat load for the total central electric space heating load.</td>
</tr>
<tr>
<td>Sixty-five percent of nameplate rating(s) of electric space-heating units if less than four separately controlled units.</td>
</tr>
<tr>
<td>Forty percent of nameplate rating(s) of electric space-heating units of four or more separately controlled units.</td>
</tr>
</tbody>
</table>
The minimum total load in amperes shall be the volt-ampere sum calculated above divided by 240 volts.

**E3602.2.1 Services under 100 amperes.**
Services that are not required to be 100 amperes shall be sized in accordance with Chapter 37, [230.42(A), (B), and (C)].

**E3602.3 Rating of service disconnect.**
The combined rating of all individual service disconnects serving a single dwelling unit shall be not less than the load determined from Table E3602.2 and shall be not less than as specified in Section E3602.1. (230.79 & 230.80)

**E3602.4 Voltage rating.**
Systems shall be three-wire, 120/240-volt, single-phase with a grounded neutral. [220.82(A)]

**SECTION E3603**
**SERVICE, FEEDER AND GROUNDING ELECTRODE-CONDUCTOR SIZING**

**E3603.1 Grounded and ungrounded service conductor size.**
Service and feeder conductors supplied by a single-phase, 120/240-volt system shall be sized in accordance with Sections E3603.1.1 through E3603.1.4 and Table 3705.1.

**E3603.1.1**
For a service rated at 100 through 400 amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family dwelling, shall have an ampacity of not less than 83 percent of the service rating.

**E3603.1.2**
For a feeder rated at 100 through 400 amperes, the feeder conductors supplying the entire load associated with a one-family dwelling, or the feeder conductors supplying the entire load associated with an individual dwelling unit in a two-family dwelling, shall have an ampacity of not less than 83 percent of the feeder rating.

**E3603.1.3**
A feeder for an individual dwelling unit shall not be required to have an ampacity greater than that specified in Sections E3603.1.1 and E3603.1.2.

**E3603.1.4**
The grounded conductor ampacity shall be not less than the maximum unbalance of the load and the size of the grounded conductor shall be not smaller than the required minimum grounding electrode conductor size specified in Table E3603.4. [310.15(B)(7)]

**E3603.2 Ungrounded service conductors for accessory buildings and structures.**
Ungrounded conductors for other than dwelling units shall have an ampacity of not less than 60 amperes and shall be sized as required for feeders in Chapter 37. [230.79(D)]

**Exceptions:**
1. For limited loads of a single branch circuit, the service conductors shall have an ampacity of not less than 15 amperes. [230.79(A)]

2. For loads consisting of not more than two two-wire branch circuits, the service conductors shall have an ampacity of not less than 30 amperes. [230.79(C)]

E3603.3 Overload protection.
Each ungrounded service conductor shall have overload protection. (230.90)

E3603.3.1 Ungrounded conductor.
Overload protection shall be provided by an overcurrent device installed in series with each ungrounded service conductor. The overcurrent device shall have a rating or setting not higher than the allowable service or feeder rating specified in Section E3603.1. A set of fuses shall be considered to be all of the fuses required to protect all of the ungrounded conductors of a circuit. Single pole circuit breakers, grouped in accordance with Section E3601.7, shall be considered as one protective device. [230.90(A)]

Exception: Two to six circuit breakers or sets of fuses shall be permitted as the overcurrent device to provide the overload protection. The sum of the ratings of the circuit breakers or fuses shall be permitted to exceed the ampacity of the service conductors provided that the calculated load does not exceed the ampacity of the service conductors. [230.90(A) Exception No. 3]

E3603.3.2 Not in grounded conductor.
Overcurrent devices shall not be connected in series with a grounded service conductor except where a circuit breaker is used that simultaneously opens all conductors of the circuit. [230.90(B)]

E3603.3.3 Location.
The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto. (230.91)

E3603.4 Grounding electrode conductor size.
The grounding electrode conductors shall be sized based on the size of the service entrance conductors as required in Table E3603.4. (250.66)

<table>
<thead>
<tr>
<th>SIZE OF LARGEST UNGROUND SERVICE-ENTRANCE CONDUCTOR OR EQUIVALENT AREA FOR PARALLEL CONDUCTORS (AWG/kcmil)</th>
<th>SIZE OF GROUNDING ELECTRODE CONDUCTOR (AWG/kcmil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Aluminum or copper-clad aluminum</td>
</tr>
<tr>
<td>2 or smaller</td>
<td>1/0 or smaller</td>
</tr>
<tr>
<td>1 or 1/0</td>
<td>2/0 or 3/0</td>
</tr>
<tr>
<td>2/0 or 3/0</td>
<td>4/0 or 250</td>
</tr>
<tr>
<td>Over 3/0 through 350</td>
<td>Over 250 through 500</td>
</tr>
</tbody>
</table>
a. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.
b. Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.
c. Where protected by a ferrous metal raceway, grounding electrode conductors shall be electrically bonded to the ferrous metal raceway at both ends. [250.64(E)(1)]
d. An 8 AWG grounding electrode conductor shall be protected with rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride (Type PVC) nonmetallic conduit, rigid thermosetting resin (Type RTRC) nonmetallic conduit, electrical metallic tubing or cable armor. [250.64(B)]
e. Where not protected, 6 AWG grounding electrode conductor shall closely follow a structural surface for physical protection. The supports shall be spaced not more than 24 inches on center and shall be within 12 inches of any enclosure or termination. [250.64(B)]
f. Where the sole grounding electrode system is a ground rod or pipe as covered in Section E3608.3, the grounding electrode conductor shall not be required to be larger than 6 AWG copper or 4 AWG aluminum. Where the sole grounding electrode system is the footing steel as covered in Section E3608.1.2, the grounding electrode conductor shall not be required to be larger than 4 AWG copper conductor. [250.66(A) and (B)]

E3603.5 Temperature limitations.
Except where the equipment is marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table E3705.1. [110.14(C)(1)]

SECTION E3604
OVERHEAD SERVICE AND SERVICE-ENTRANCE CONDUCTOR INSTALLATION

E3604.1 Clearances on buildings.
Open conductors and multiconductor cables without an overall outer jacket shall have a clearance of not less than 3 feet (914 mm) from the sides of doors, porches, decks, stairs, ladders, fire escapes and balconies, and from the sides and bottom of windows that open. See Figure E3604.1. [230.9(A)]
FIGURE E3604.1
CLEARANCES FROM BUILDING OPENINGS

E3604.2 Vertical clearances.
Overhead service conductors shall not have ready access and shall comply with Sections E3604.2.1 and E3604.2.2. (230.24)

E3604.2.1 Above roofs.
Conductors shall have a vertical clearance of not less than 8 feet (2438 mm) above the roof surface. The vertical clearance above the roof level shall be maintained for a distance of not less than 3 feet (914 mm) in all directions from the edge of the roof. See Figure E3604.2.1. (230.24(A))

Exceptions:

1. Conductors above a roof surface subject to pedestrian traffic shall have a vertical clearance from the roof surface in accordance with Section E3604.2.2. [230.24(A) Exception No. 1]

2. Where the roof has a slope of 4 inches (102 mm) in 12 inches (305 mm), or greater, the minimum clearance shall be 3 feet (914 mm). [230.24(A) Exception No. 2]
3. The minimum clearance above only the overhanging portion of the roof shall not be less than 18 inches (457 mm) where not more than 6 feet (1829 mm) of overhead service conductor length passes over 4 feet (1219 mm) or less of roof surface measured horizontally and such conductors are terminated at a through-the-roof raceway or approved support. [230.24(A) Exception No. 3]

4. The requirement for maintaining the vertical clearance for a distance of 3 feet (914 mm) from the edge of the roof shall not apply to the final conductor span where the service drop is attached to the side of a building. [230.24(A) Exception No. 4]

5. Where the voltage between conductors does not exceed 300 and the roof area is guarded or isolated, a reduction in clearance to 3 feet (914 mm) shall be permitted. [230.24(A) Exception No. 5]
1. For conductors supported on and cabled together with a grounded bare messenger wire, the minimum vertical clearance shall be 10 feet (3048 mm) at the electric service entrance to buildings, at the lowest point of the drip loop of the building electric entrance, and above areas or sidewalks accessed by pedestrians only. Such clearance shall be measured from final grade or other accessible surfaces.

2. Twelve feet (3658 mm)—over residential property and driveways.

3. Eighteen feet (5486 mm)—over public streets, alleys, roads or parking areas subject to truck traffic. \[230.24(B)(1), (2), and (4)\]

E3604.3 Point of attachment.
The point of attachment of the overhead service conductors to a building or other structure shall provide the minimum clearances as specified in Sections E3604.1 through E3604.2.2. The point of attachment shall be not less than 10 feet (3048 mm) above finished grade. (230.26)

E3604.4 Means of attachment.
Multiconductor cables used for overhead service conductors shall be attached to buildings or other structures by fittings approved for the purpose. (230.27)

E3604.5 Service masts as supports.
A service mast used for the support of service-drop or overhead service conductors shall comply with Sections E3604.5.1 and E3604.5.2. Only power service-drop or overhead-service conductors shall be attached to a service mast.

E3504.5.1 Strength.
The service mast shall be of adequate strength or shall be supported by braces or guys to safely withstand the strain imposed by the service-drop or overhead service conductors. Hubs intended for use with a conduit that serves as a service mast shall be identified for use with service-entrance equipment.

E3604.5.2 Attachment.
Service-drop or overhead service conductors shall not be attached to a service mast at a point between a coupling and a weatherhead or the end of the conduit, where the coupling is located above the last point of securement of the building or other structure or is located above the building or other structure. \[230.28(A) & (B)\]

E3604.6 Supports over buildings.
Service conductors passing over a roof shall be securely supported. Where practicable, such supports shall be independent of the building. (230.29)

SECTION E3605
SERVICE-ENTRANCE CONDUCTORS

E3605.1 Insulation of service-entrance conductors.
Service-entrance conductors entering or on the exterior of buildings or other structures shall be insulated in accordance with Section E3406.5. (230.41)

Exceptions:
1. A copper grounded conductor shall not be required to be insulated where it is:
   1.1. In a raceway or part of a service cable assembly,
   1.2. Directly buried in soil of suitable condition, or
   1.3. Part of a cable assembly listed for direct burial without regard to soil conditions.

2. An aluminum or copper-clad aluminum grounded conductor shall not be required to be insulated where part of a cable or where identified for direct burial or utilization in underground raceways. (230.41 Exception)

E3605.2 Wiring methods for services.
Service-entrance wiring methods shall be installed in accordance with the applicable requirements in Chapter 38. (230.43)

E3605.3 Spliced conductors.
Service-entrance conductors shall be permitted to be spliced or tapped. Splices shall be made in enclosures or, if directly buried, with listed underground splice kits. Conductor splices shall be made in accordance with Chapters 34, 37, 38 and 39. (230.33, 230.46)

E3605.4 Protection of underground service entrance conductors.
Underground service-entrance conductors shall be protected against physical damage in accordance with Chapter 38. (230.32)

E3605.5 Protection of all other service cables.
Above-ground service-entrance cables, where subject to physical damage, shall be protected by one or more of the following: rigid metal conduit, intermediate metal conduit, Schedule 80 PVC conduit, electrical metallic tubing or other approved means. [230.50(1)]

E3605.6 Locations exposed to direct sunlight.
Insulated conductors and cables used where exposed to direct rays of the sun shall comply with one of the following:

1. The conductors and cables shall be listed, or listed and marked, as being sunlight resistant.

2. The conductors and cables are covered with insulating material, such as tape or sleeving, that is listed, or listed and marked, as being sunlight resistant. [310.10(D)]

E3605.7 Mounting supports.
Service-entrance cables shall be supported by straps or other approved means within 12 inches (305 mm) of every service head, gooseneck or connection to a raceway or enclosure and at intervals not exceeding 30 inches (762 mm). [230.51(A)]

E3605.8 Raceways to drain.
Where exposed to the weather, raceways enclosing service-entrance conductors shall be suitable for use in wet locations and arranged to drain. Where embedded in masonry, raceways shall be arranged to drain. (230.53)
E3605.9 Overhead service locations.
Connections at service heads shall be in accordance with Sections E3605.9.1 through E3605.9.7. (230.54)

E3605.9.1 Rain-tight service head.
Service raceways shall be equipped with a service head at the point of connection to service-drop or overhead conductors. The service head shall be listed for use in wet locations. [230.54(A)]

E3605.9.2 Service cable, service head or gooseneck.
Service entrance cable shall be equipped with a service head or shall be formed into a gooseneck in an approved manner. The service head shall be listed for use in wet locations. [230.54(B)]

E3605.9.3 Service-head location.
Service heads, and goosenecks in service entrance cables, shall be located above the point of attachment of the service-drop or overhead service conductors to the building or other structure. [230.54(C)]

Exception: Where it is impracticable to locate the service head or gooseneck above the point of attachment, the service head or gooseneck location shall be not more than 24 inches (610 mm) from the point of attachment. [230.54(C) Exception]

E3605.9.4 Separately bushed openings.
Service heads shall have conductors of different potential brought out through separately bushed openings. [230.54(E)]

E3605.9.5 Drip loops.
Drip loops shall be formed on individual conductors. To prevent the entrance of moisture, service-entrance conductors shall be connected to the service-drop or overhead conductors either below the level of the service head or below the level of the termination of the service-entrance cable sheath. [230.54(F)]

E3605.9.6 Conductor arrangement.
Service-entrance and overhead service conductors shall be arranged so that water will not enter service raceways or equipment. [230.54(G)]

E3605.9.7 Secured.
Service-entrance cables shall be held securely in place. [230.54(D)]

SECTION E3606
SERVICE EQUIPMENT—GENERAL

E3606.1 Service equipment enclosures.
Energized parts of service equipment shall be enclosed. (230.62)
E3606.2 Working space.
The working space in the vicinity of service equipment shall be not less than that specified in Chapter 34. (110.26)

E3606.3 Available short-circuit current.
Service equipment shall be suitable for the maximum fault current available at its supply terminals, but not less than 10,000 amperes. (110.9)

E3606.4 Marking.
Service equipment shall be marked to identify it as being suitable for use as service equipment. Service equipment shall be listed. Individual meter socket enclosures shall not be considered as service equipment. (230.66)

SECTION E3607
SYSTEM GROUNDING

E3607.1 System service ground.
The premises wiring system shall be grounded at the service with a grounding electrode conductor connected to a grounding electrode system as required by this code. Grounding electrode conductors shall be sized in accordance with Table E3603.4. [250.20(B)(1) and 250.24(A)]

E3607.2 Location of grounding electrode conductor connection.
The grounding electrode conductor shall be connected to the grounded service conductor at any accessible point from the load end of the overhead service conductors, service drop, underground service conductors, or service lateral to and including the terminal or bus to which the grounded service conductor is connected at the service disconnecting means. A grounding connection shall not be made to any grounded circuit conductor on the load side of the service disconnecting means, except as provided in Section E3607.3.2. [250.24(A)(1) and (A)(5)]

E3607.3 Buildings or structures supplied by feeder(s) or branch circuit(s).
Buildings or structures supplied by feeder(s) or branch circuit(s) shall have a grounding electrode or grounding electrode system installed in accordance with Section E3608. The grounding electrode conductor(s) shall be connected in a manner specified in Section E3607.3.1 or, for existing premises wiring systems only, Section E3607.3.2. Where there is no existing grounding electrode, the grounding electrode(s) required in Section E3608 shall be installed. [250.32(A)]

Exception: A grounding electrode shall not be required where only one branch circuit, including a multiwire branch circuit, supplies the building or structure and the branch circuit includes an equipment grounding conductor for grounding the noncurrent-carrying parts of all equipment. For the purposes of this section, a multiwire branch circuit shall be considered as a single branch circuit. [250.32(A) Exception]

E3607.3.1 Equipment grounding conductor.
An equipment grounding conductor as described in Section E3908 shall be run with the supply conductors and connected to the building or structure disconnecting means and to the grounding electrode(s). The equipment grounding conductor shall be used for grounding or bonding of equipment, structures or frames required to be grounded or bonded. The...
equipment grounding conductor shall be sized in accordance with Section E3908.12. Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s). [250.32(B) and Table 250.122]  

**E3607.3.2 Grounded conductor, existing premises.**

For installations made in compliance with previous editions of this code that permitted such connection and where an equipment grounding conductor is not run with the supply conductors to the building or structure, there are no continuous metallic paths bonded to the grounding system in both buildings or structures involved, and ground fault protection of equipment has not been installed on the supply side of the feeder(s), the grounded conductor run with the supply to the buildings or structure shall be connected to the building or structure disconnecting means and to the grounding electrode(s) and shall be used for grounding or bonding of equipment, structures, or frames required to be grounded or bonded. Where used for grounding in accordance with this provision, the grounded conductor shall be not smaller than the larger of:

1. That required by Section E3704.3.

2. That required by Section E3908.12. [250.32(B)(1) Exception]

**E3607.4 Grounding electrode conductor.**

A grounding electrode conductor shall be used to connect the equipment grounding conductors, the service equipment enclosures, and the grounded service conductor to the grounding electrode(s). This conductor shall be sized in accordance with Table E3603.4. [250.24(D)]

**E3607.5 Main bonding jumper.**

An unspliced main bonding jumper shall be used to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor of the system within the enclosure for each service disconnect. [250.24(B)]

**E3607.6 Common grounding electrode.**

Where an ac system is connected to a grounding electrode in or at a building or structure, the same electrode shall be used to ground conductor enclosures and equipment in or on that building or structure. Where separate services, feeders or branch circuits supply a building and are required to be connected to a grounding electrode(s), the same grounding electrode(s) shall be used. Two or more grounding electrodes that are effectively bonded together shall be considered as a single grounding electrode system. (250.58)

**SECTION E3608**  
**GROUNDING ELECTRODE SYSTEM**

**E3608.1 Grounding electrode system.**

All electrodes specified in Sections E3608.1.1, E3608.1.2, E3608.1.3, E3608.1.4 E3608.1.5 and E3608.1.6 that are present at each building or structure served shall be bonded together to form the grounding electrode system. Where none of these electrodes are present, one or more of the electrodes specified in Sections E3608.1.3, E3608.1.4, E3608.1.5 and E3608.1.6 shall be installed and used. (250.50)
Exception: Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system where the steel reinforcing bars or rods are not accessible for use without disturbing the concrete. (250.50 Exception)

E3608.1.1 Metal underground water pipe.
A metal underground water pipe that is in direct contact with the earth for 10 feet (3048 mm) or more, including any well casing effectively bonded to the pipe and that is electrically continuous, or made electrically continuous by bonding around insulating joints or insulating pipe to the points of connection of the grounding electrode conductor and the bonding conductors, shall be considered as a grounding electrode (see Section E3608.1).

E3608.1.1.1 Interior metal water piping.
Interior metal water piping located more than 5 feet (1524 mm) from the entrance to the building shall not be used as a conductor to interconnect electrodes that are part of the grounding electrode system. [250.68(C)(1)]

E3608.1.1.2 Installation.
Continuity of the grounding path or the bonding connection to interior piping shall not rely on water meters, filtering devices and similar equipment. A metal underground water pipe shall be supplemented by an additional electrode of a type specified in Sections E3608.1.2 through E3608.1.6. The supplemental electrode shall be bonded to the grounding electrode conductor, the grounded service entrance conductor, a nonflexible grounded service raceway, any grounded service enclosure or to the equipment grounding conductor provided in accordance with Section E3607.3.1. Where the supplemental electrode is a rod, pipe or plate electrode in accordance with Section E3608.1.4 or E3608.1.5, it shall comply with Section E3608.4.

Where the supplemental electrode is a rod, pipe or plate electrode in accordance with Section E3608.1.4 or E3608.1.5, that portion of the bonding jumper that is the sole connection to the supplemental grounding electrode shall not be required to be larger than 6 AWG copper or 4 AWG aluminum wire. [250.53(D) and (E)]

E3608.1.2 Concrete-encased electrode.
A concrete-encased electrode consisting of at least 20 feet (6096 mm) of either of the following shall be considered as a grounding electrode:

1. One or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods not less than \( \frac{1}{2} \) inch (13 mm) in diameter, installed in one continuous 20-foot (6096 mm) length, or if in multiple pieces connected together by the usual steel tie wires, exothermic welding, welding, or other effective means to create a 20-foot (6096 mm) or greater length.

2. A bare copper conductor not smaller than 4 AWG.

Metallic components shall be encased by at least 2 inches (51 mm) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth.
Where multiple concrete-encased electrodes are present at a building or structure, only one shall be required to be bonded into the grounding electrode system. [250.52(A)(3)]

E3608.1.3 Ground rings.
A ground ring encircling the building or structure, in direct contact with the earth at a depth below the earth’s surface of not less than 30 inches (762 mm), consisting of at least 20 feet (6096 mm) of bare copper conductor not smaller than 2 AWG shall be considered as a grounding electrode. [250.52(A)(4)]

E3608.1.4 Rod and pipe electrodes.
Rod and pipe electrodes not less than 8 feet (2438 mm) in length and consisting of the following materials shall be considered as a grounding electrode:

1. Grounding electrodes of pipe or conduit shall not be smaller than trade size $\frac{3}{4}$ (metric designator 21) and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

2. Rod-type grounding electrodes of stainless steel and copper or zinc-coated steel shall be at least $\frac{5}{8}$ inch (15.9 mm) in diameter unless listed. [250.52(A)(5)]

E3608.1.4.1 Installation.
The rod and pipe electrodes shall be installed such that at least 8 feet (2438 mm) of length is in contact with the soil. They shall be driven to a depth of not less than 8 feet (2438 mm) except that, where rock bottom is encountered, electrodes shall be driven at an oblique angle not to exceed 45 degrees (0.79 rad) from the vertical or shall be buried in a trench that is at least 30 inches (762 mm) deep. The upper end of the electrodes shall be flush with or below ground level except where the aboveground end and the grounding electrode conductor attachment are protected against physical damage. [250.53(G)]

E3608.1.5 Plate electrodes.
A plate electrode that exposes not less than 2 square feet ($0.186 \text{ m}^2$) of surface to exterior soil shall be considered as a grounding electrode. Electrodes of bare or conductively coated iron or steel plates shall be at least $\frac{1}{4}$ inch (6.4 mm) in thickness. Solid, uncoated electrodes of nonferrous metal shall be at least 0.06 inch (1.5 mm) in thickness. Plate electrodes shall be installed not less than 30 inches (762 mm) below the surface of the earth. [250.52(A)(7)]

E3608.1.6 Other electrodes.
In addition to the grounding electrodes specified in Sections E3608.1.1 through E3608.1.5, other listed grounding electrodes shall be permitted. [250.52(A)(6)]

E3608.2 Bonding jumper.
The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system shall be installed in accordance with Sections E3610.2, and E3610.3, shall be sized in accordance with Section E3603.4, and shall be connected in the manner specified in Section E3611.1. [250.53(C)
E3608.3 Rod, pipe and plate electrode requirements.
Where practicable, rod, pipe and plate electrodes shall be embedded below permanent moisture level. Such electrodes shall be free from nonconductive coatings such as paint or enamel. Where more than one such electrode is used, each electrode of one grounding system shall be not less than 6 feet (1829 mm) from any other electrode of another grounding system. Two or more grounding electrodes that are effectively bonded together shall be considered as a single grounding electrode system. That portion of a bonding jumper that is the sole connection to a rod, pipe or plate electrode shall not be required to be larger than 6 AWG copper or 4 AWG aluminum wire. [250.53(A)(1), 250.53(B), 250.53(C)]

E3608.4 Supplemental electrode required.
A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in Sections E3608.1.2 through E3608.1.6. The supplemental electrode shall be bonded to one of the following:

1. A rod, pipe, or plate electrode.
2. A grounding electrode conductor.
3. A grounded service entrance conductor.
4. A nonflexible grounded service raceway.
5. A grounded service enclosure.

Where multiple rod, pipe, or plate electrodes are installed to meet the requirements of this section, they shall not be less than 6 feet (1829 mm) apart. [250.53(A)(2) and (A)(3)]

Exception: Where a single rod, pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less, the supplemental electrode shall not be required. [250.53(A)(2) Exception]

E3608.5 Aluminum electrodes.
Aluminum electrodes shall not be permitted. [250.52(B)(2)]

E3608.6 Metal underground gas piping system.
A metal underground gas piping system shall not be used as a grounding electrode. [250.52(B)(1)]

SECTION E3609
BONDING

E3609.1 General.
Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed. (250.90)
E3609.2 Bonding of equipment for services.
The noncurrent-carrying metal parts of the following equipment shall be effectively bonded together:

1. Raceways or service cable armor or sheath that enclose, contain, or support service conductors.

2. Service enclosures containing service conductors, including meter fittings, and boxes, interposed in the service raceway or armor. [250.92(A)]

E3609.3 Bonding for other systems.
An intersystem bonding termination for connecting intersystem bonding conductors required for other systems shall be provided external to enclosures at the service equipment or metering equipment enclosure and at the disconnecting means for any additional buildings or structures. The intersystem bonding termination shall comply with all of the following:

1. It shall be accessible for connection and inspection.

2. It shall consist of a set of terminals with the capacity for connection of not less than three intersystem bonding conductors.

3. It shall not interfere with opening of the enclosure for a service, building or structure disconnecting means, or metering equipment.

4. Where located at the service equipment, it shall be securely mounted and electrically connected to an enclosure for the service equipment, to the meter enclosure, or to an exposed nonflexible metallic service raceway, or shall be mounted at one of these enclosures and connected to the enclosure or to the grounding electrode conductor with a 6 AWG or larger copper conductor.

5. Where located at the disconnecting means for a building or structure, it shall be securely mounted and electrically connected to the metallic enclosure for the building or structure disconnecting means, or shall be mounted at the disconnecting means and connected to the metallic enclosure or to the grounding electrode conductor with a 6 AWG or larger copper conductor.

6. It shall be listed as grounding and bonding equipment. [250.94]

E3609.4 Method of bonding at the service.
Bonding jumpers meeting the requirements of this chapter shall be used around impaired connections, such as reducing washers or oversized, concentric, or eccentric knockouts. Standard locknuts or bushings shall not be the only means for the bonding required by this section but shall be permitted to be installed to make mechanical connections of raceways. Electrical continuity at service equipment, service raceways and service conductor enclosures shall be ensured by one or more of the methods specified in Sections E3609.4.1 through E3609.4.4.

E3609.4.1 Grounded service conductor.
Equipment shall be bonded to the grounded service conductor in a manner provided in this code.
**E3609.4.2 Threaded connections.**
Equipment shall be bonded by connections using threaded couplings or threaded hubs on enclosures. Such connections shall be made wrench tight.

**E3609.4.3 Threadless couplings and connectors.**
Equipment shall be bonded by threadless couplings and connectors for metal raceways and metal-clad cables. Such couplings and connectors shall be made wrench tight. Standard locknuts or bushings shall not be used for the bonding required by this section.

**E3609.4.4 Other devices.**
Equipment shall be bonded by other listed devices, such as bonding type locknuts, bushings and bushings with bonding jumpers. [250.92(B)]

**E3609.5 Sizing supply-side bonding jumper and main bonding jumper.**
The bonding jumper shall not be smaller than the sizes shown in Table E3603.4 for grounding electrode conductors. Where the service entrance conductors are paralleled in two or more raceways or cables, and an individual supply-side bonding jumper is used for bonding these raceways or cables, the supply-side bonding jumper for each raceway or cable shall be selected from Table E3603.4 based on the size of the ungrounded supply conductors in each raceway or cable. A single supply-side bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with Table E3603.4 based on the largest set of parallel ungrounded supply conductors. [250.102(C)]

**E3609.6 Metal water piping bonding.**
The metal water piping system shall be bonded to the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor where of sufficient size, or to the one or more grounding electrodes used. The bonding jumper shall be sized in accordance with Table E3603.4. The points of attachment of the bonding jumper(s) shall be accessible. [250.104(A) and 250.104(A)(1)]

**E3609.7 Bonding other metal piping.**
Where installed in or attached to a building or structure, metal piping systems, including gas piping, capable of becoming energized shall be bonded to the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor where of sufficient size, or to the one or more grounding electrodes used. The bonding conductor(s) or jumper(s) shall be sized in accordance with Table E3908.12 using the rating of the circuit capable of energizing the piping. The equipment grounding conductor for the circuit that is capable of energizing the piping shall be permitted to serve as the bonding means. The points of attachment of the bonding jumper(s) shall be accessible. [250.104(B)]

**SECTION E3610**

**GROUNDING ELECTRODE CONDUCTORS**

**E3610.1 Continuous.**
The grounding electrode conductor shall be installed in one continuous length without splices or joints and shall run to any convenient grounding electrode available in the grounding electrode system where the other electrode(s), if any, are connected by bonding jumpers in accordance with Section E3608.2, or to one or more grounding electrode(s) individually. The grounding
electrode conductor shall be sized for the largest grounding electrode conductor required among all of the electrodes connected to it. [250.64(C)]

Exception: Splicing of the grounding electrode conductor by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process shall not be prohibited. [250.64(C)(1)]

**E3610.2 Securing and protection against physical damage.**
Where exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. Grounding electrode conductors shall be permitted to be installed on or through framing members. A 4 AWG or larger conductor shall be protected where exposed to physical damage. A 6 AWG grounding conductor that is free from exposure to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection where it is and securely fastened to the construction; otherwise, it shall be in rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride (PVC), nonmetallic conduit, reinforced thermosetting resin (RTRC) nonmetallic conduit, electrical metallic tubing or cable armor. Grounding electrode conductors smaller than 6 AWG shall be in rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride (PVC) nonmetallic conduit, reinforced thermosetting resin (RTRC) nonmetallic conduit, electrical metallic tubing or cable armor. Grounding electrode conductors and grounding electrode bonding jumpers shall not be required to comply with Section E3803. [250.64(B)]

Bare aluminum or copper-clad aluminum grounding electrode conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum or copper-clad aluminum grounding electrode conductors shall not be installed within 18 inches (457 mm) of the earth. [250.64(A)]

**E3610.3 Raceways and enclosures for grounding electrode conductors.**
Ferrous metal raceways and enclosures for grounding electrode conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened to the ground clamp or fitting. Nonferrous metal raceways and enclosures shall not be required to be electrically continuous. Ferrous metal raceways and enclosures shall be bonded at each end of the raceway or enclosure to the grounding electrode or to the grounding electrode conductor. Bonding methods in compliance with Section E3609.4 for installations at service equipment locations and with E3609.4.2 through E3609.4.4 for other than service equipment locations shall apply at each end and to all intervening ferrous raceways, boxes, and enclosures between the cabinets or equipment and the grounding electrode. The bonding jumper for a grounding electrode conductor raceway shall be the same size or larger than the required enclosed grounding electrode conductor.

Where a raceway is used as protection for a grounding conductor, the installation shall comply with the requirements of Chapter 38. [250.64(E)(4)]

**E3610.4 Prohibited use.**
An equipment grounding conductor shall not be used as a grounding electrode conductor. (250.121)

Exception: A wire-type equipment grounding conductor shall be permitted to serve as both an equipment grounding conductor and a grounding electrode conductor where installed in accordance with the applicable requirements for both the equipment grounding conductor.
and the grounding electrode conductor in Chapters 36 and 39. Where used as a grounding electrode conductor, the wire-type equipment grounding conductor shall be installed and arranged in a manner that will prevent objectionable current. [250.121 Exception, 250.6(A)]

SECTION E3611

GROUNDING-ELECTRODE-CONDUCTOR

CONNECTION TO THE GROUNDING ELECTRODES

E3611.1 Methods of grounding conductor connection to electrodes.
The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps or other listed means. Connections depending on solder shall not be used. Ground clamps shall be listed for the materials of the grounding electrode and the grounding electrode conductor and, where used on pipe, rod or other buried electrodes, shall also be listed for direct soil burial or concrete encasement. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting unless the clamp or fitting is listed for multiple conductors. One of the methods indicated in the following items shall be used:

1. A pipe fitting, pipe plug or other approved device screwed into a pipe or pipe fitting.

2. A listed bolted clamp of cast bronze or brass, or plain or malleable iron.

3. For indoor communications purposes only, a listed sheet metal strap-type ground clamp having a rigid metal base that seats on the electrode and having a strap of such material and dimensions that it is not likely to stretch during or after installation.

4. Other equally substantial approved means. (250.70)

E3611.2 Accessibility.
All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to the grounding electrodes that are not buried or concrete encased shall be accessible. [250.68(A) and 250.68(A) Exception]

E3611.3 Effective grounding path.
The connection of the grounding electrode conductor or bonding jumper shall be made in a manner that will ensure a permanent and effective grounding path. Where necessary to ensure effective grounding for a metal piping system used as a grounding electrode, effective bonding shall be provided around insulated joints and sections and around any equipment that is likely to be disconnected for repairs or replacement. Bonding jumpers shall be of sufficient length to permit removal of such equipment while retaining the integrity of the grounding path. [250.68(B)]

E3611.4 Interior metal water piping.
Where grounding electrode conductors and bonding jumpers are connected to interior metal water piping as a means to extend the grounding electrode conductor connection to an electrode(s), such piping shall be located not more than 5 feet (1524 mm) from the point of entry into the building.
Where interior metal water piping is used as a conductor to interconnect electrodes that are part of the grounding electrode system, such piping shall be located not more than 5 feet (1524 mm) from the point of entry into the building. [250.68(C)(1)]

E3611.5 Protection of ground clamps and fittings.
Ground clamps or other fittings shall be approved for applications without protection or shall be protected from physical damage by installing them where they are not likely to be damaged or by enclosing them in metal, wood or equivalent protective coverings. (250.10)

E3611.6 Clean surfaces.
Nonconductive coatings (such as paint, enamel and lacquer) on equipment to be grounded shall be removed from threads and other contact surfaces to ensure good electrical continuity or shall be connected by fittings that make such removal unnecessary. (250.12)
CHAPTER 37
BRANCH CIRCUIT AND FEEDER REQUIREMENTS

Deleted. See the North Carolina Electrical Code.

SECTION E3701
GENERAL

E3701.1 Scope.
This chapter covers branch circuits and feeders and specifies the minimum required branch
circuits, the allowable loads and the required overcurrent protection for branch circuits and
feeders that serve less than 100 percent of the total dwelling unit load. Feeder circuits that serve
100 percent of the dwelling unit load shall be sized in accordance with the procedures in
Chapter 36. [310.15(B)(7)(2)]

E3701.2 Branch-circuit and feeder ampacity.
Branch-circuit and feeder conductors shall have ampacities not less than the maximum load to
be served. Where a branch circuit or a feeder supplies continuous loads or any combination of
continuous and noncontinuous loads, the minimum branch-circuit or feeder conductor size,
before the application of any adjustment or correction factors, shall have an allowable ampacity
equal to or greater than the noncontinuous load plus 125 percent of the continuous load.
[210.19(A)(1)(a) and 215.2(A)(1)(a)]

Exception: The grounded conductors of feeders that are not connected to an overcurrent
device shall be permitted to be sized at 100 percent of the continuous and noncontinuous
load. [215.1(A)(1) Exception No. 2]

E3701.3 Selection of ampacity.
Where more than one calculated or tabulated ampacity could apply for a given circuit length, the
lowest value shall be used. [310.15(A)(2)]

Exception: Where two different ampacities apply to adjacent portions of a circuit, the higher
ampacity shall be permitted to be used beyond the point of transition, a distance equal to 10
feet (3048 mm) or 10 percent of the circuit length figured at the higher ampacity, whichever
is less. [310.15(A)(2) Exception]

E3701.4 Branch circuits with more than one receptacle.
Conductors of branch circuits supplying more than one receptacle for cord-and-plug-connected
portable loads shall have ampacities of not less than the rating of the branch circuit.
[210.19(A)(2)]

E3701.5 Multiwire branch circuits.
All conductors for multiwire branch circuits shall originate from the same panelboard or similar
distribution equipment. Except where all ungrounded conductors are opened simultaneously by
the branch-circuit overcurrent device, multiwire branch circuits shall supply only line-to-neutral
loads or only one appliance. [210.4(A) and 210.4(C)]
**E3701.5.1 Disconnecting means.**
Each multiwire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates. [210.4(B)]

**E3701.5.2 Grouping.**
The ungrounded and grounded circuit conductors of each multiwire branch circuit shall be grouped by cable ties or similar means in at least one location within the panelboard or other point of origination. [210.4(D)]

Exception: Grouping shall not be required where the circuit conductors enter from a cable or raceway unique to the circuit, thereby making the grouping obvious, or where the conductors are identified at their terminations with numbered wire markers corresponding to their appropriate circuit number. [210.4(D) Exception].

**SECTION E3702**
**BRANCH CIRCUIT RATINGS**

**E3702.1 Branch-circuit voltage limitations.**
The voltage ratings of branch circuits that supply luminaires or receptacles for cord-and-plug-connected loads of up to 1,400 volt-amperes or of less than \( \frac{1}{4} \) horsepower (0.186 kW) shall be limited to a maximum rating of 120 volts, nominal, between conductors.

Branch circuits that supply cord-and-plug-connected or permanently connected utilization equipment and appliances rated at over 1,440 volt-amperes or \( \frac{1}{4} \) horsepower (0.186 kW) and greater shall be rated at 120 volts or 240 volts, nominal. [210.6(A), (B), and (C)]

**E3702.2 Branch-circuit ampere rating.**
Branch circuits shall be rated in accordance with the maximum allowable ampere rating or setting of the overcurrent protection device. The rating for other than individual branch circuits shall be 15, 20, 30, 40 and 50 amperes. Where conductors of higher ampacity are used, the ampere rating or setting of the specified over-current device shall determine the circuit rating. (210.3)

**E3702.3 Fifteen- and 20-ampere branch circuits.**
A 15- or 20-ampere branch circuit shall be permitted to supply lighting units, or other utilization equipment, or a combination of both. The rating of any one cord-and-plug-connected utilization equipment not fastened in place shall not exceed 80 percent of the branch-circuit ampere rating. The total rating of utilization equipment fastened in place, other than luminaires, shall not exceed 50 percent of the branch-circuit ampere rating where lighting units, cord-and-plug-connected utilization equipment not fastened in place, or both, are also supplied. [210.23(A)(1) and (2)]

**E3702.4 Thirty-ampere branch circuits.**
A 30-ampere branch circuit shall be permitted to supply fixed utilization equipment. A rating of any one cord-and-plug-connected utilization equipment shall not exceed 80 percent of the branch-circuit ampere rating. [210.23(B)]
E3702.5 Branch circuits serving multiple loads or outlets.
General-purpose branch circuits shall supply lighting outlets, appliances, equipment or receptacle outlets, and combinations of such. Multioutlet branch circuits serving lighting or receptacles shall be limited to a maximum branch-circuit rating of 20 amperes. [210.23(A), (B), and (C)]

E3702.6 Branch circuits serving a single motor.
Branch-circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating. [430.22(A)]

E3702.7 Branch circuits serving motor-operated and combination loads.
For circuits supplying loads consisting of motor operated utilization equipment that is fastened in place and that has a motor larger than 1/8 horsepower (0.093 kW) in combination with other loads, the total calculated load shall be based on 125 percent of the largest motor load plus the sum of the other loads. [220.18(A)]

E3702.8 Branch-circuit inductive and LED lighting loads.
For circuits supplying luminaires having ballasts or LED drivers, the calculated load shall be based on the total ampere ratings of such units and not on the total watts of the lamps. [220.18(B)]

E3702.9 Branch-circuit load for ranges and cooking appliances.
It shall be permissible to calculate the branch-circuit load for one range in accordance with Table E3704.2(2). The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance. The branch-circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens all supplied from a single branch circuit and located in the same room shall be calculated by adding the nameplate ratings of the individual appliances and treating the total as equivalent to one range. (220.55 Note 4)

E3702.9.1 Minimum branch circuit for ranges.
Ranges with a rating of 8.75 kVA or more shall be supplied by a branch circuit having a minimum rating of 40 amperes. [210.19(A)(3)]

E3702.10 Branch circuits serving heating loads.
Electric space-heating and water-heating appliances shall be considered to be continuous loads. Branch circuits supplying two or more outlets for fixed electric space-heating equipment shall be rated 15, 20, 25 or 30 amperes. [424.3(A)]

E3702.11 Branch circuits for air-conditioning and heat pump equipment.
The ampacity of the conductors supplying multimotor and combination load equipment shall be not less than the minimum circuit ampacity marked on the equipment. The branch-circuit overcurrent device rating shall be the size and type marked on the appliance. [440.4(B), 440.35, 440.62(A)]

E3702.12 Branch circuits serving room air conditioners.
A room air conditioner shall be considered as a single motor unit in determining its branch-circuit requirements where all the following conditions are met:

1. It is cord- and attachment plug-connected.
2. The rating is not more than 40 amperes and 250 volts; single-phase.

3. Total rated load current is shown on the room air-conditioner nameplate rather than individual motor currents.

4. The rating of the branch-circuit short-circuit and ground-fault protective device does not exceed the ampacity of the branch-circuit conductors, or the rating of the branch-circuit conductors, or the rating of the receptacle, whichever is less. [440.62(A)]

E3702.12.1 Where no other loads are supplied.
The total marked rating of a cord- and attachment plug-connected room air conditioner shall not exceed 80 percent of the rating of a branch circuit where no other appliances are also supplied. [440.62(B)]

E3702.12.2 Where lighting units or other appliances are also supplied.
The total marked rating of a cord- and attachment plug-connected room air conditioner shall not exceed 50 percent of the rating of a branch circuit where lighting or other appliances are also supplied. Where the circuitry is interlocked to prevent simultaneous operation of the room air conditioner and energization of other outlets on the same branch circuit, a cord- and attachment plug-connected room air conditioner shall not exceed 80 percent of the branch-circuit rating. [440.62(C)]

E3702.13 Electric vehicle branch circuit.
Outlets installed for the purpose of charging electric vehicles shall be supplied by a separate branch circuit. Such circuit shall not supply other outlets. (210.17)

E3702.14 Branch-circuit requirement—summary.
The requirements for circuits having two or more outlets, or receptacles, other than the receptacle circuits of Sections E3703.2, E3703.3 and E3703.4, are summarized in Table E3702.14. Branch circuits in dwelling units shall supply only loads within that dwelling unit or loads associated only with that dwelling unit. Branch circuits installed for the purpose of lighting, central alarm, signal, communications or other purposes for public or common areas of a two-family dwelling shall not be supplied from equipment that supplies an individual dwelling unit. (210.24 and 210.25)

| TABLE E3702.14 (Table 210.24) |
|---------------------------------|---|---|---|
| BRANCH-CIRCUIT REQUIREMENTS-SUMMARY<sup>a,b</sup> |
| CIRCUIT RATING                   | 15 amp | 20 amp | 30 amp |
| Conductors: Minimum size (AWG) circuit conductors | 14 | 12 | 10 |
| Maximum overcurrent-protection device rating Ampere rating | 15 | 20 | 30 |
| Outlet devices: Lampholders permitted Receptacle rating (amperes) Any-type 15 maximum Any-type 15 or 20 N/A 30 |
SECTION E3703
REQUIRED BRANCH CIRCUITS

E3703.1 Branch circuits for heating.
Central heating equipment other than fixed electric space heating shall be supplied by an individual branch circuit. Permanently connected air conditioning equipment, and auxiliary equipment directly associated with the central heating equipment such as pumps, motorized valves, humidifiers and electrostatic air cleaners, shall not be prohibited from connecting to the same branch circuit as the central heating equipment. (422.12 and 422.12 Exceptions No. 1 and No. 2)

E3703.2 Kitchen and dining area receptacles.
A minimum of two 20-ampere-rated branch circuits shall be provided to serve all wall and floor receptacle outlets located in the kitchen, pantry, breakfast area, dining area or similar area of a dwelling. The kitchen countertop receptacles shall be served by a minimum of two 20-ampere-rated branch circuits, either or both of which shall also be permitted to supply other receptacle outlets in the same kitchen, pantry, breakfast and dining area including receptacle outlets for refrigeration appliances. [210.11(C)(1) and 210.52(B)(1) and (B)(2)]

Exception: The receptacle outlet for refrigeration appliances shall be permitted to be supplied from an individual branch circuit rated 15 amperes or greater. [210.52(B)(1) Exception No. 2]

E3703.3 Laundry circuit.
A minimum of one 20-ampere-rated branch circuit shall be provided for receptacles located in the laundry area and shall serve only receptacle outlets located in the laundry area. [210.11(C)(2)]

E3703.4 Bathroom branch circuits.
A minimum of one 20-ampere branch circuit shall be provided to supply bathroom receptacle outlet(s). Such circuits shall have no other outlets. [210.11(C)(3)]

Exception: Where the 20-ampere circuit supplies a single bathroom, outlets for other equipment within the same bathroom shall be permitted to be supplied in accordance with Section E3702. [210.11(C)(3) Exception]

E3703.5 Number of branch circuits.
The minimum number of branch circuits shall be determined from the total calculated load and the size or rating of the circuits used. The number of circuits shall be sufficient to supply the load served. In no case shall the load on any circuit exceed the maximum specified by Section E3702. [210.11(A)]

E3703.6 Branch-circuit load proportioning.
Where the branch-circuit load is calculated on a volt-amperes-per-square-foot (m²) basis, the wiring system, up to and including the branch-circuit panelboard(s), shall have the capacity to
serve not less than the calculated load. This load shall be evenly proportioned among multioutlet branch circuits within the panelboard(s). Branch-circuit overcurrent devices and circuits shall only be required to be installed to serve the connected load. [210.11(B)]

SECTION E3704
FEEDER REQUIREMENTS

E3704.1 Conductor-size.
Feeder conductors that do not serve 100 percent of the dwelling unit load and branch-circuit conductors shall be of a size sufficient to carry the load as determined by this chapter. Feeder conductors shall not be required to be larger than the service-entrance conductors that supply the dwelling unit. The load for feeder conductors that serve as the main power feeder to a dwelling unit shall be determined as specified in Chapter 36 for services. [310.15(B)(7)(2) and (3)]

E3704.2 Feeder loads.
The minimum load in volt-amperes shall be calculated in accordance with the load calculation procedure prescribed in Table E3704.2(1). The associated table demand factors shall be applied to the actual load to determine the minimum load for feeders. (220.40)

TABLE E3704.2(1)
(Table 220.12, 220.14, Table 220.42, 220.50, 220.51, 220.52, 220.53, 220.54, 220.55, and 220.60)
FEEDER LOAD CALCULATION

<table>
<thead>
<tr>
<th>LOAD CALCULATION PROCEDURE</th>
<th>APPLIED DEMAND-FACtor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting and receptacles: A unit load of not less than 3 VA per square foot of total floor area shall constitute the lighting and 120-volt, 15- and 20-ampere general use receptacle load. 1,500 VA shall be added for each 20-ampere branch-circuit serving receptacles in the kitchen, dining room, pantry, breakfast area and laundry area.</td>
<td>100 percent of first 3,000 VA or less and 35 percent of that in excess of 3,000 VA.</td>
</tr>
<tr>
<td><strong>Plus</strong></td>
<td></td>
</tr>
<tr>
<td>Appliances and motors: The nameplate rating load of all fastened-in-place appliances other than dryers, ranges, air-conditioning and space-heating equipment.</td>
<td>100 percent of load for three or less appliances. 75 percent of load for four or more appliances.</td>
</tr>
<tr>
<td><strong>Plus</strong></td>
<td></td>
</tr>
<tr>
<td>Fixed motors: Full-load current of motors plus 25 percent of the full load current of the largest motor.</td>
<td></td>
</tr>
<tr>
<td><strong>Plus</strong></td>
<td></td>
</tr>
<tr>
<td>Electric clothes dryer: The dryer load shall be 5,000 VA for each dryer circuit or the nameplate rating load of each dryer, whichever is greater.</td>
<td></td>
</tr>
<tr>
<td><strong>Plus</strong></td>
<td></td>
</tr>
<tr>
<td>Cooking appliances: The nameplate rating of ranges, wall-mounted ovens, counter-mounted cooking units and other cooking appliances rated in excess of 1.75 kVA shall be summed.</td>
<td>Demand factors shall be as allowed by Table E3704.2(2).</td>
</tr>
<tr>
<td><strong>Plus the largest of either the heating or cooling load</strong></td>
<td></td>
</tr>
<tr>
<td>Largest of the following two selections:</td>
<td></td>
</tr>
<tr>
<td>1. 100 percent of the nameplate rating(s) of the air conditioning and cooling, including heat pump</td>
<td></td>
</tr>
</tbody>
</table>
compressors.

100 percent of the fixed electric space heating.

For SI: 1 square foot = 0.0929 m².

### TABLE E3704.2(2) (220.55 and Table 220.55)
**DEMAND LOADS FOR ELECTRIC RANGES, WALL-MOUNTED OVENS, COUNTER-MOUNTED COOKING UNITS AND OTHER COOKING APPLIANCES OVER 1 \(/4\) kVA RATING**

<table>
<thead>
<tr>
<th>NUMBER OF APPLIANCES</th>
<th>MAXIMUM DEMAND Column A maximum 12 kVA rating</th>
<th>DEMAND FACTORS (percent) Column B less than (1 \slash 2) kVA rating</th>
<th>Column C 3 (1 \slash 2) to 8 (3 \slash 4) kVA rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Column B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8 kVA</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>11 kVA</td>
<td>75</td>
<td>65</td>
</tr>
</tbody>
</table>

a. Column A shall be used in all cases except as provided for in Footnote d.
b. For ranges all having the same rating and individually rated more than 12 kVA but not more than 27 kVA, the maximum demand in Column A shall be increased 5 percent for each additional kVA of rating or major fraction thereof by which the rating of individual ranges exceeds 12 kVA.
c. For ranges of unequal ratings and individually rated more than 8.75 kVA, but none exceeding 27 kVA, an average value of rating shall be computed by adding together the ratings of all ranges to obtain the total connected load (using 12 kVA for any ranges rated less than 12 kVA) and dividing by the total number of ranges; and then the maximum demand in Column A shall be increased 5 percent for each kVA or major fraction thereof by which this average value exceeds 12 kVA.
d. Over 1.75 kVA through 8.75 kVA. As an alternative to the method provided in Column A, the nameplate ratings of all ranges rated more than 1.75 kVA but not more than 8.75 kVA shall be added and the sum shall be multiplied by the demand factor specified in Column B or C for the given number of appliances.

### E3704.3 Feeder neutral load.
The feeder neutral load shall be the maximum unbalance of the load determined in accordance with this chapter. The maximum unbalanced load shall be the maximum net calculated load between the neutral and any one ungrounded conductor. For a feeder or service supplying electric ranges, wall-mounted ovens, counter-mounted cooking units and electric dryers, the maximum unbalanced load shall be considered as 70 percent of the load on the ungrounded conductors. [220.61(A) and (B)]

### E3704.4 Lighting and general use receptacle load.
A unit load of not less than 3 volt-amperes shall constitute the minimum lighting and general use receptacle load for each square foot of floor area (33 VA for each square meter of floor area). The floor area for each floor shall be calculated from the outside dimensions of the building. The calculated floor area shall not include open porches, garages, or unused or unfinished spaces not adaptable for future use. [220.12, Table 220.12, and 220.14(J)]

### E3704.5 Ampacity and calculated loads.
The calculated load of a feeder shall be not less than the sum of the loads on the branch circuits supplied, as determined by Section E3704, after any applicable demand factors permitted by Section E3704 have been applied. (220.40)
E3704.6 Equipment grounding conductor.
Where a feeder supplies branch circuits in which equipment grounding conductors are required, the feeder shall include or provide an equipment grounding conductor that is one or more or a combination of the types specified in Section E3908.8, to which the equipment grounding conductors of the branch circuits shall be connected. Where the feeder supplies a separate building or structure, the requirements of Section E3607.3.1 shall apply. (215.6)

SECTION E3705
CONDUCTOR SIZING
AND OVERCURRENT PROTECTION

E3705.1 General.
Ampacities for conductors shall be determined based in accordance with Table E3705.1 and Sections E3705.2 and E3705.3. [310.15(A)]

<table>
<thead>
<tr>
<th>CONDUCTOR SIZE</th>
<th>CONDUCTOR TEMPERATURE RATING</th>
<th>CONDUCTOR SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60°C</td>
<td>75°C</td>
</tr>
<tr>
<td>AWG kcmil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TW, UF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14^a</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>12^a</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>10^a</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>8^a</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>6^a</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>4^a</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>3^a</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>2^a</td>
<td>95</td>
<td>115</td>
</tr>
<tr>
<td>1^a</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>1/0</td>
<td>125</td>
<td>150</td>
</tr>
<tr>
<td>2/0</td>
<td>145</td>
<td>175</td>
</tr>
<tr>
<td>3/0</td>
<td>165</td>
<td>200</td>
</tr>
<tr>
<td>4/0</td>
<td>185</td>
<td>230</td>
</tr>
<tr>
<td>250</td>
<td>215</td>
<td>255</td>
</tr>
<tr>
<td>300</td>
<td>240</td>
<td>285</td>
</tr>
<tr>
<td>350</td>
<td>260</td>
<td>310</td>
</tr>
<tr>
<td>400</td>
<td>280</td>
<td>335</td>
</tr>
<tr>
<td>500</td>
<td>320</td>
<td>380</td>
</tr>
</tbody>
</table>
E3705.2 Correction factor for ambient temperatures.
For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities specified in Table E3705.1 by the appropriate correction factor shown in Table E3705.2. [310.15(B)(2)]

**TABLE E3705.2** [Table 310.15(B)(2)(a)]  
**Ambient Temperature Correction Factors**

For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities specified in the ampacity tables by the appropriate correction factor shown below.

<table>
<thead>
<tr>
<th>Ambient Temperature (°C)</th>
<th>Temperature Rating of Conductor</th>
<th>60°C</th>
<th>75°C</th>
<th>90°C</th>
<th>Ambient Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 or less</td>
<td></td>
<td>1.29</td>
<td>1.20</td>
<td>1.15</td>
<td>50 or less</td>
</tr>
<tr>
<td>11-15</td>
<td></td>
<td>1.22</td>
<td>1.15</td>
<td>1.12</td>
<td>51-59</td>
</tr>
<tr>
<td>16-20</td>
<td></td>
<td>1.15</td>
<td>1.11</td>
<td>1.08</td>
<td>60-68</td>
</tr>
<tr>
<td>21-25</td>
<td></td>
<td>1.08</td>
<td>1.05</td>
<td>1.04</td>
<td>69-77</td>
</tr>
<tr>
<td>26-30</td>
<td></td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>78-86</td>
</tr>
<tr>
<td>31-35</td>
<td></td>
<td>0.91</td>
<td>0.94</td>
<td>0.96</td>
<td>87-95</td>
</tr>
<tr>
<td>36-40</td>
<td></td>
<td>0.82</td>
<td>0.88</td>
<td>0.91</td>
<td>96-104</td>
</tr>
<tr>
<td>41-45</td>
<td></td>
<td>0.71</td>
<td>0.82</td>
<td>0.87</td>
<td>105-113</td>
</tr>
<tr>
<td>46-50</td>
<td></td>
<td>0.58</td>
<td>0.75</td>
<td>0.82</td>
<td>114-122</td>
</tr>
<tr>
<td>51-55</td>
<td></td>
<td>0.41</td>
<td>0.67</td>
<td>0.76</td>
<td>123-131</td>
</tr>
<tr>
<td>56-60</td>
<td></td>
<td>—</td>
<td>0.58</td>
<td>0.74</td>
<td>132-140</td>
</tr>
<tr>
<td>61-65</td>
<td></td>
<td>—</td>
<td>0.47</td>
<td>0.66</td>
<td>141-149</td>
</tr>
<tr>
<td>66-70</td>
<td></td>
<td>—</td>
<td>0.33</td>
<td>0.58</td>
<td>150-158</td>
</tr>
<tr>
<td>71-75</td>
<td></td>
<td>—</td>
<td>—</td>
<td>0.50</td>
<td>159-167</td>
</tr>
<tr>
<td>76-80</td>
<td></td>
<td>—</td>
<td>—</td>
<td>0.41</td>
<td>168-176</td>
</tr>
<tr>
<td>81-85</td>
<td></td>
<td>—</td>
<td>—</td>
<td>0.29</td>
<td>177-185</td>
</tr>
</tbody>
</table>

E3705.3 Adjustment factor for conductor proximity.
Where the number of current-carrying conductors in a raceway or cable exceeds three, or where single conductors or multiconductor cables are stacked or bundled for distances greater than 24 inches (610 mm) without maintaining spacing and are not installed in raceways, the allowable ampacity of each conductor shall be reduced as shown in Table E3705.3. [310.15(B)(3)]

**Exceptions:**

1. Adjustment factors shall not apply to conductors in nipples having a length not exceeding 24 inches (610 mm). [310.15(B)(3)(2)]
2. Adjustment factors shall not apply to underground conductors entering or leaving an outdoor trench if those conductors have physical protection in the form of rigid metal conduit, intermediate metal conduit, or rigid nonmetallic conduit having a length not exceeding 10 feet (3048 mm) and the number of conductors does not exceed four. [310.15(B)(3)(3)]

3. Adjustment factors shall not apply to type AC cable or to type MC cable without an overall outer jacket meeting all of the following conditions:

3.1. Each cable has not more than three current-carrying conductors.

3.2. The conductors are 12 AWG copper.

3.3. Not more than 20 current-carrying conductors are bundled, stacked or supported on bridle rings. [310.15(B)(3)(4)]

4. An adjustment factor of 60 percent shall be applied to Type AC cable and Type MC cable where all of the following conditions apply:

4.1. The cables do not have an overall outer jacket.

4.2. The number of current-carrying conductors exceeds 20.

4.3. The cables are stacked or bundled longer than 24 inches (607 mm) without spacing being maintained. [310.15(B)(3)(5)]

### TABLE E3705.3 [Table 310.15(B)(3)(a)]
CONDUCTOR PROXIMITY ADJUSTMENT FACTORS

<table>
<thead>
<tr>
<th>NUMBER OF CURRENT-CARRYING CONDUCTORS IN CABLE OR RACEWAY</th>
<th>PERCENT OF VALUES IN TABLE E3705.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-6</td>
<td>80</td>
</tr>
<tr>
<td>7-9</td>
<td>70</td>
</tr>
<tr>
<td>10-20</td>
<td>60</td>
</tr>
<tr>
<td>21-30</td>
<td>45</td>
</tr>
<tr>
<td>31-40</td>
<td>40</td>
</tr>
<tr>
<td>41 and above</td>
<td>35</td>
</tr>
</tbody>
</table>

### E3705.4 Temperature limitations.
The temperature rating associated with the ampacity of a conductor shall be so selected and coordinated to not exceed the lowest temperature rating of any connected termination, conductor or device. Conductors with temperature ratings higher than specified for terminations shall be permitted to be used for ampacity adjustment, correction, or both. Except where the equipment is marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table E3705.1. [110.14(C)]

### E3705.4.1 Conductors rated 60°C.
Except where the equipment is marked otherwise, termination provisions of equipment for circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors, shall be used only for one of the following:
1. Conductors rated 60°C (140°F);

2. Conductors with higher temperature ratings, provided that the ampacity of such conductors is determined based on the 60°C (140°F) ampacity of the conductor size used;

3. Conductors with higher temperature ratings where the equipment is listed and identified for use with such conductors; or

4. For motors marked with design letters B, C, or D conductors having an insulation rating of 75°C (167°F) or higher shall be permitted to be used provided that the ampacity of such conductors does not exceed the 75°C (167°F) ampacity.

E3705.4.2 Conductors rated 75°C.
Termination provisions of equipment for circuits rated over 100 amperes, or marked for conductors larger than 1 AWG, shall be used only for:

1. Conductors rated 75°C (167°F).

2. Conductors with higher temperature ratings provided that the ampacity of such conductors does not exceed the 75°C (167°F) ampacity of the conductor size used, or provided that the equipment is listed and identified for use with such conductors.

E3705.4.3 Separately installed pressure connectors.
Separately installed pressure connectors shall be used with conductors at the ampacities not exceeding the ampacity at the listed and identified temperature rating of the connector.

E3705.4.4 Conductors of Type NM cable.
Conductors in NM cable assemblies shall be rated at 90°C (194°F). Types NM, NMC, and NMS cable identified by the markings NM-B, NMC-B, and NMS-B meet this requirement. The allowable ampacity of Types NM, NMC, and NMS cable shall not exceed that of 60°C (140°F) rated conductors and shall comply with Section E3705.1 and Table E3705.5.3. The 90°C (194°F) rating shall be permitted to be used for ampacity adjustment and calculations provided that the final corrected or adjusted ampacity does not exceed that for a 60°C (140°F) rated conductor. Where more than two NM cables containing two or more current-carrying conductors are installed, without maintaining spacing between the cables, through the same opening in wood framing that is to be sealed with thermal insulation, caulk or sealing foam, the allowable ampacity of each conductor shall be adjusted in accordance with Table E3705.3. Where more than two NM cables containing two or more current-carrying conductors are installed in contact with thermal insulation without maintaining spacing between cables, the allowable ampacity of each conductor shall be adjusted in accordance with Table E3705.3. (334.80 and 334.112)

E3705.4.5 Conductors of Type SE cable.
Where used as a branch circuit or feeder wiring method within the interior of a building and installed in thermal insulation, the ampacity of the conductors in Type SE cable assemblies
shall be in accordance with the 60°C (140°F) conductor temperature rating. The maximum conductor temperature rating shall be permitted to be used for ampacity adjustment and correction purposes, provided that the final derated ampacity does not exceed that for a 60°C (140°F) rated conductor. [338.10(B)(4)(a)]

E3705.5 Overcurrent protection required.
All ungrounded branch-circuit and feeder conductors shall be protected against overcurrent by an overcurrent device installed at the point where the conductors receive their supply. Overcurrent devices shall not be connected in series with a grounded conductor. Overcurrent protection and allowable loads for branch circuits and for feeders that do not serve as the main power feeder to the dwelling unit load shall be in accordance with this chapter.

Branch-circuit conductors and equipment shall be protected by overcurrent protective devices having a rating or setting not exceeding the allowable ampacity specified in Table E3705.1 and Sections E3705.2, E3705.3 and E3705.4 except where otherwise permitted or required in Sections E3705.5.1 through E3705.5.3. [240.4, 240.21, and 310.15(B)(7)(2)]

E3705.5.1 Cords.
Cords shall be protected in accordance with Section E3909.2. [240.5(B)]

E3705.5.2 Overcurrent devices of the next higher rating.
The next higher standard overcurrent device rating, above the ampacity of the conductors being protected, shall be permitted to be used, provided that all of the following conditions are met:

1. The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord- and plug-connected portable loads.

2. The ampacity of conductors does not correspond with the standard ampere rating of a fuse or a circuit-breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).

3. The next higher standard device rating does not exceed 400 amperes. [240.4(B)]

E3705.5.3 Small conductors.
Except as specifically permitted by Section E3705.5.4, the rating of overcurrent protection devices shall not exceed the ratings shown in Table E3705.5.3 for the conductors specified therein. [240.4(D)]

<table>
<thead>
<tr>
<th>Table E3705.5.3 [240.4(D)]</th>
<th>OVERCURRENT-PROTECTION RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (AWG)</td>
<td>Maximum overcurrent- protection-device rating (amps)</td>
</tr>
<tr>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
</tr>
</tbody>
</table>
The maximum overcurrent-protection-device rating shall not exceed the conductor allowable ampacity determined by the application of the correction and adjustment factors in accordance with Sections E3705.2 and E3705.3.

**E3705.5.4 Air-conditioning and heat pump equipment.**
Air-conditioning and heat pump equipment circuit conductors shall be permitted to be protected against overcurrent in accordance with Section E3702.11. [240.4(G)]

**E3705.6 Fuses and fixed trip circuit breakers.**
The standard ampere ratings for fuses and inverse time circuit breakers shall be considered 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350 and 400 amperes. [240.6]

**E3705.7 Location of overcurrent devices in or on premises.**
Overcurrent devices shall:

1. Be readily accessible. [240.24(A)]
2. Not be located where they will be exposed to physical damage. [240.24(C)]
3. Not be located where they will be in the vicinity of easily ignitable material such as in clothes closets. [240.24(D)]
4. Not be located in bathrooms. [240.24(E)]
5. Not be located over steps of a stairway.
6. Be installed so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 6 feet 7 inches (2007 mm) above the floor or working platform. [240.24(A)]

**Exceptions:**

1. This section shall not apply to supplementary overcurrent protection that is integral to utilization equipment. [240.24(A)(2)]
2. Overcurrent devices installed adjacent to the utilization equipment that they supply shall be permitted to be accessible by portable means. [240.24(A)(4)]

**E3705.8 Ready access for occupants.**
Each occupant shall have ready access to all overcurrent devices protecting the conductors supplying that occupancy. [240.24(B)]

**E3705.9 Enclosures for overcurrent devices.**
Overcurrent devices shall be enclosed in cabinets, cutout boxes, or equipment assemblies. The operating handle of a circuit breaker shall be permitted to be accessible without opening a door or cover. [240.30(A) and (B)]

SECTION E3706
PANELBOARDS
E3706.1 Panelboard rating.
All panelboards shall have a rating not less than that of the minimum service or feeder capacity required for the calculated load. (408.30)

E3706.2 Panelboard-circuit identification.
All circuits and circuit modifications shall be legibly identified as to their clear, evident, and specific purpose or use. The identification shall include an approved degree of detail that allows each circuit to be distinguished from all others. Spare positions that contain unused overcurrent devices or switches shall be described accordingly. The identification shall be included in a circuit directory located on the face of the panelboard enclosure or inside the panel door. Circuits shall not be described in a manner that depends on transient conditions of occupancy. [408.4(A)]

E3706.3 Panelboard overcurrent protection.
In addition to the requirement of Section E3706.1, a panelboard shall be protected by an overcurrent protective device having a rating not greater than that of the panelboard. Such overcurrent protective device shall be located within or at any point on the supply side of the panelboard. (408.36)

E3706.4 Grounded conductor terminations.
Each grounded conductor shall terminate within the panelboard on an individual terminal that is not also used for another conductor, except that grounded conductors of circuits with parallel conductors shall be permitted to terminate on a single terminal where the terminal is identified for connection of more than one conductor. (408.41 and 408.41 Exception)

E3706.5 Back-fed devices.
Plug-in-type overcurrent protection devices or plug-in-type main lug assemblies that are back-fed and used to terminate field-installed ungrounded supply conductors shall be secured in place by an additional fastener that requires other than a pull to release the device from the mounting means on the panel. [408.36(D)]
CHAPTER 38
WIRING METHODS

Deleted. See the North Carolina Electrical Code.

SECTION E3801
GENERAL REQUIREMENTS

E3801.1 Scope.
This chapter covers the wiring methods for services, feeders and branch circuits for electrical power and distribution. (300.1)

E3801.2 Allowable wiring methods.
The allowable wiring methods for electrical installations shall be those listed in Table E3801.2. Single conductors shall be used only where part of one of the recognized wiring methods listed in Table E3801.2. As used in this code, abbreviations of the wiring method types shall be as indicated in Table E3801.2. [110.8, 300.3(A)]

TABLE E3801.2
ALLOWABLE WIRING METHODS

<table>
<thead>
<tr>
<th>ALLOWABLE WIRING METHOD</th>
<th>DESIGNATED ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armored cable</td>
<td>AC</td>
</tr>
<tr>
<td>Electrical metallic tubing</td>
<td>EMT</td>
</tr>
<tr>
<td>Electrical nonmetallic tubing</td>
<td>ENT</td>
</tr>
<tr>
<td>Flexible metal conduit</td>
<td>EMC</td>
</tr>
<tr>
<td>Intermediate metal conduit</td>
<td>IMC</td>
</tr>
<tr>
<td>Liquidtight flexible conduit</td>
<td>LFC</td>
</tr>
<tr>
<td>Metal-clad cable</td>
<td>MC</td>
</tr>
<tr>
<td>Nonmetallic sheathed cable</td>
<td>NM</td>
</tr>
<tr>
<td>Rigid polyvinyl chloride conduit (Type PVC)</td>
<td>RNC</td>
</tr>
<tr>
<td>Rigid metallic conduit</td>
<td>RMC</td>
</tr>
<tr>
<td>Service entrance cable</td>
<td>SE</td>
</tr>
<tr>
<td>Surface raceways</td>
<td>SR</td>
</tr>
<tr>
<td>Underground feeder cable</td>
<td>UF</td>
</tr>
<tr>
<td>Underground service cable</td>
<td>USE</td>
</tr>
</tbody>
</table>

E3801.3 Circuit conductors.
All conductors of a circuit, including equipment grounding conductors and bonding conductors, shall be contained in the same raceway, trench, cable or cord. [300.3(B)]

E3801.4 Wiring method applications.
Wiring methods shall be applied in accordance with Table E3801.4. (Chapter 3 and 300.2)

TABLE E3801.4 (Chapter 3 and 300.2)
ALLOWABLE APPLICATIONS FOR WIRING METHODS

2018 North Carolina Residential Code
| ALLOWABLE APPLICATIONS (application allowed where marked with an “A”) | AC | EMT | ENT | FMC | IMC/RNC | LFC | MC | NM | SR | SE | UF | USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Services | — | A | A | A | A | A | A | — | — | A | — | A | A |
| Feeders | A | A | A | A | A | A | A | — | — | A | b | A | b |
| Branch circuits | A | A | A | A | A | A | A | A | — | c | A | — | — |
| Inside a building | A | A | A | A | A | A | A | A | A | — | A | — | — |
| Wet locations exposed to sunlight | — | A | A | A | A | A | A | — | — | A | e | A | — |
| Damp locations | — | A | A | d | A | A | A | — | — | A | — | — | — |
| Embedded in noncinder concrete in dry location | — | A | A | — | A | A | — | — | — | — | — | — | — |
| In noncinder concrete in contact with grade | — | A | A | — | A | A | — | — | — | — | — | — | — |
| Embedded in plaster not exposed to dampness | A | A | A | A | A | A | — | — | A | A | — | — | — |
| Embedded in masonry | — | A | A | — | A | A | — | — | — | — | — | — | — |
| In masonry voids and cells exposed to dampness or below grade line | — | A | A | A | A | A | — | — | A | A | — | — | — |
| Fished in masonry voids | A | — | — | A | A | A | A | — | — | A | A | — | — |
| In masonry voids and cells not exposed to dampness | A | A | A | A | A | A | — | — | — | A | A | — | — |
| Run exposed | A | A | A | A | A | A | A | — | — | A | A | — | — |
| Run exposed and subject to physical damage | — | — | — | A | g | A | — | — | — | — | — | — | — |
| For direct burial | — | A | A | f | A | — | — | A | — | A | A | — | — |

For SI: 1 foot = 304.8 mm.
a. Liquid-tight flexible nonmetallic conduit without integral reinforcement within the conduit wall shall not exceed 6 feet in length.
b. Type USE cable shall not be used inside buildings.
c. The grounded conductor shall be insulated.
d. Conductors shall be a type approved for wet locations and the installation shall prevent water from entering other raceways.
e. Shall be listed as “Sunlight Resistant.”
f. Metal raceways shall be protected from corrosion and approved for the application. Aluminum RMC requires approved supplementary corrosion protection.
g. RNC shall be Schedule 80.
h. Shall be listed as “Sunlight Resistant” where exposed to the direct rays of the sun.
i. Conduit shall not exceed 6 feet in length.
j. Liquid-tight flexible nonmetallic conduit is permitted to be encased in concrete where listed for direct burial and only straight connectors listed for use with LFNC are used.
k. In wet locations under any of the following conditions:
   1. The metallic covering is impervious to moisture.
   2. A lead sheath or moisture-impervious jacket is provided under the metal covering.
   3. The insulated conductors under the metallic covering are listed for use in wet locations and a corrosion-resistant jacket is provided over the metallic sheath.
## SECTION E3802
### ABOVE-GROUND INSTALLATION REQUIREMENTS

**E3802.1 Installation and support requirements.**
Wiring methods shall be installed and supported in accordance with Table E3802.1. (Chapter 3 and 300.11)

**TABLE E3802.1 (Chapter 3)**

**GENERAL INSTALLATION AND SUPPORT REQUIREMENTS FOR WIRING METHODS**

| INSTALLATION REQUIREMENTS (Requirement applicable only to wiring methods marked “A”) | AC | MC | EMT | IMC | RMC | ENT | FMC | LFC | NM | UF | RNC | SE | SR | USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Where run parallel with the framing member or furring strip, the wiring shall be not less than 1 1/2 inches from the edge of a furring strip or a framing member such as a joist, rafter or stud or shall be physically protected. | A | — | A | A | A | — | A | — | — | — | — | — | — | — |
| Bored holes in framing members for wiring shall be located not less than 1 1/4 inches from the edge of the framing member or shall be protected with a minimum 0.0625-inch steel plate or sleeve, a listed steel plate or other physical protection. | k | A | k | k | k | — | k | — | — | — | — | — | — | — |
| Where installed in grooves, to be covered by wallboard, siding, paneling, carpeting, or similar finish, wiring methods shall be protected by 0.0625-inch-thick steel plate, sleeve, or equivalent, a listed steel plate or by not less than 1 1/4-inch free space for the full length of the groove in which the cable or raceway is installed. | A | — | A | A | A | — | A | A | A | — | — | — | — | — |
| Securely fastened bushings or grommets shall be provided to protect wiring run through openings in metal framing members. | — | — | A | — | A | — | A | — | — | — | — | — | — | — |
| The maximum number of 90-degree bends shall not exceed four between junction boxes. | — | A | A | A | A | — | A | — | — | — | — | — | — | — |
| Bushings shall be provided where entering a box, fitting or enclosure unless the box or fitting is designed to afford equivalent protection. | A | A | A | A | A | — | A | — | A | — | — | — | — | — |
| Ends of raceways shall be reamed to remove rough edges. | — | A | A | A | A | — | A | — | A | — | — | — | — | — |

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Maximum allowable on center support spacing for the wiring method in feet.

<table>
<thead>
<tr>
<th>Method of Wiring</th>
<th>b</th>
<th>10</th>
<th>b</th>
<th>4.5</th>
<th>b</th>
<th>4.5</th>
<th>d</th>
<th>2.5</th>
<th>—</th>
<th>2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>b</td>
<td>c</td>
<td>10</td>
<td>b</td>
<td>4</td>
<td>5</td>
<td>b</td>
<td>4</td>
<td>i</td>
<td>3</td>
</tr>
</tbody>
</table>

Maximum support distance in inches from box or other terminations.

| Method of Wiring | b | 36 | b | 36 | b | 12 | g | 12 | h | 36 | 12 | — | — |

For SI:
- 1 inch = 25.4 mm
- 1 foot = 304.8 mm
- 1 degree = 0.0175 rad.

a. Installed in accordance with listing requirements.
b. Supports not required in accessible ceiling spaces between light fixtures where lengths do not exceed 6 feet.
c. Six feet for MC cable.
d. Five feet for trade sizes greater than 1 inch.
e. Two and one-half feet where used for service or outdoor feeder and 4.5 feet where used for branch circuit or indoor feeder.
f. Twenty-four inches for Type AC cable and thirty-six inches for interlocking Type MC cable where flexibility is necessary.
g. Where flexibility after installation is necessary, lengths of flexible metal conduit and liquidtight flexible metal conduit measured from the last point where the raceway is securely fastened shall not exceed:
   - 36 inches for trade sizes 1 \( \frac{1}{2} \) through 1 \( \frac{3}{4} \), 48 inches for trade sizes 1 \( \frac{1}{2} \) through 2 and 5 feet for trade sizes 2 \( \frac{1}{2} \) and larger.
h. Within 8 inches of boxes without cable clamps.
i. Flat cables shall not be stapled on edge.
j. Bushings and grommets shall remain in place and shall be listed for the purpose of cable protection.
k. See Sections R502.8 and R802.7 for additional limitations on the location of bored holes in horizontal framing members.

**E3802.2 Cables in accessible attics.**

Cables in attics or roof spaces provided with access shall be installed as specified in Sections E3802.2.1 and E3802.2.2. (320.3 and 334.23)

**E3802.2.1 Across structural members.**

Where run across the top of floor joists, or run within 7 feet (2134 mm) of floor or floor joists across the face of rafters or studs, in attics and roof spaces that are provided with access, the cable shall be protected by substantial guard strips that are at least as high as the cable. Where such spaces are not provided with access by permanent stairs or ladders, protection shall only be required within 6 feet (1829 mm) of the nearest edge of the attic entrance. [330.23(A) and 334.23]

**E3802.2.2 Cable installed through or parallel to framing members.**

Where cables are installed through or parallel to the sides of rafters, studs or floor joists, guard strips and running boards shall not be required, and the installation shall comply with Table E3802.1. [330.23(B) and 334.23]

**E3802.3 Exposed cable.**

In exposed work, except as provided for in Sections E3802.2 and E3802.4, cable assemblies shall be installed as specified in Sections E3802.3.1 and E3802.3.2. (330.15 and 334.15)

**E3802.3.1 Surface installation.**

Cables shall closely follow the surface of the building finish or running boards. [334.15(A)]
**E3802.3.2 Protection from physical damage.**
Where subject to physical damage, cables shall be protected by rigid metal conduit, intermediate metal conduit, electrical metallic tubing, Schedule 80 PVC rigid nonmetallic conduit, or other approved means. Where passing through a floor, the cable shall be enclosed in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, Schedule 80 PVC rigid nonmetallic conduit or other approved means extending not less than 6 inches (152 mm) above the floor. [334.15(B)]

**E3802.3.3 Locations exposed to direct sunlight.**
Insulated conductors and cables used where exposed to direct rays of the sun shall be listed or listed and marked, as being “sunlight resistant,” or shall be covered with insulating material, such as tape or sleeving, that is listed or listed and marked as being “sunlight resistant.” [310.10(D)]

**E3802.4 In unfinished basements and crawl spaces.**
Where type NM or SE cable is run at angles with joists in unfinished basements and crawl spaces, cable assemblies containing two or more conductors of sizes 6 AWG and larger and assemblies containing three or more conductors of sizes 8 AWG and larger shall not require additional protection where attached directly to the bottom of the joists. Smaller cables shall be run either through bored holes in joists or on running boards. Type NM or SE cable installed on the wall of an unfinished basement shall be permitted to be installed in a listed conduit or tubing or shall be protected in accordance with Table E3802.1. Conduit or tubing shall be provided with a suitable insulating bushing or adapter at the point where the cable enters the raceway. The sheath of the Type NM or SE cable shall extend through the conduit or tubing and into the outlet or device box not less than \( \frac{1}{4} \) inch (6.4 mm). The cable shall be secured within 12 inches (305 mm) of the point where the cable enters the conduit or tubing. Metal conduit, tubing, and metal outlet boxes shall be connected to an equipment grounding conductor complying with Section E3908.13. [334.15(C)]

**E3802.5 Bends.**
Bends shall be made so as not to damage the wiring method or reduce the internal diameter of raceways.

For types NM and SE cable, bends shall be so made, and other handling shall be such that the cable will not be damaged and the radius of the curve of the inner edge of any bend shall be not less than five times the diameter of the cable. (334.24 and 338.24)

**E3802.6 Raceways exposed to different temperatures.**
Where portions of a raceway or sleeve are known to be subjected to different temperatures and where condensation is known to be a problem, as in cold storage areas of buildings or where passing from the interior to the exterior of a building, the raceway or sleeve shall be filled with an approved material to prevent the circulation of warm air to a colder section of the raceway or sleeve. [300.7(A)]

**E3802.7 Raceways in wet locations above grade.**
Where raceways are installed in wet locations above grade, the interior of such raceways shall be considered to be a wet location. Insulated conductors and cables installed in raceways in wet locations above grade shall be listed for use in wet locations. (300.9)
**SECTION E3803**
UNDERGROUND INSTALLATION REQUIREMENTS

**E3803.1 Minimum cover requirements.**
Direct buried cable or raceways shall be installed in accordance with the minimum cover requirements of Table E3803.1. [300.5(A)]

**TABLE E3803.1 (Table 300.5)**
MINIMUM COVER REQUIREMENTS, BURIAL IN INCHES

<table>
<thead>
<tr>
<th>LOCATION OF WIRING METHOD OR CIRCUIT</th>
<th>TYPE OF WIRING METHOD OR CIRCUIT</th>
<th>1 Direct burial cables or conductors</th>
<th>2 Rigid metal conduit or intermediate metal conduit</th>
<th>3 Nonmetallic raceways listed for direct burial without concrete encasement or other approved raceways</th>
<th>4 Residential branch circuits rated 120 volts or less with GFCI protection and maximum overcurrent protection of 20 amperes</th>
<th>5 Circuits for control of irrigation and landscape lighting limited to not more than 30 volts and installed with type UF or in other identified cable or raceway</th>
</tr>
</thead>
<tbody>
<tr>
<td>All locations not specified below</td>
<td>24</td>
<td>6</td>
<td>18</td>
<td>12</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>In trench below 2-inch-thick concrete or equivalent</td>
<td>18</td>
<td>6</td>
<td>12</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Under a building</td>
<td>0 (In raceway only or Type MC identified for direct burial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 (In raceway only or Type MC identified for direct burial)</td>
<td></td>
</tr>
<tr>
<td>Under minimum of 4-inch-thick concrete exterior slab with no vehicular traffic and the slab extending not less than 6 inches beyond the underground installation</td>
<td>18</td>
<td>4</td>
<td>4</td>
<td>6 (Direct burial)</td>
<td>6 (Direct burial)</td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
### E3803.1 Minimum cover requirements

<table>
<thead>
<tr>
<th>Under streets, highways, roads, alleys, driveways and parking lots</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>One- and two-family dwelling driveways and outdoor parking areas and used only for dwelling-related purposes</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>In solid rock where covered by minimum of 2 inches concrete extending down to rock</td>
<td>2 (In raceway only)</td>
<td>2</td>
<td>2</td>
<td>2 (In raceway only)</td>
<td>2 (In raceway only)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

- a. Raceways approved for burial only where encased concrete shall require concrete envelope not less than 2 inches thick.
- b. Lesser depths shall be permitted where cables and conductors rise for terminations or splices or where access is otherwise required.
- c. Where one of the wiring method types listed in columns 1 to 3 is combined with one of the circuit types in columns 4 and 5, the shallower depth of burial shall be permitted.
- d. Where solid rock prevents compliance with the cover depths specified in this table, the wiring shall be installed in metal or nonmetallic raceway permitted for direct burial. The raceways shall be covered by a minimum of 2 inches of concrete extending down to the rock.
- e. Cover is defined as the shortest distance in inches (millimeters) measured between a point on the top surface of any direct-buried conductor, cable, conduit or other raceway and the top surface of finished grade, concrete, or similar cover.

### E3803.2 Warning ribbon.

Underground service conductors that are not encased in concrete and that are buried 18 inches (457 mm) or more below grade shall have their location identified by a warning ribbon that is placed in the trench not less than 12 inches (305 mm) above the underground installation. [300.5(D)(3)]

### E3803.3 Protection from damage.

Direct buried conductors and cables emerging from the ground shall be protected by enclosures or raceways extending from the minimum cover distance below grade required by Section E3803.1 to a point at least 8 feet (2438 mm) above finished grade. In no case shall the protection be required to exceed 18 inches (457 mm) below finished grade. Conductors entering a building shall be protected to the point of entrance. Where the enclosure or raceway is subject to physical damage, the conductors shall be installed in rigid metal conduit, intermediate metal conduit, Schedule 80 rigid nonmetallic conduit or the equivalent. [300.5(D)(1)]

### E3803.4 Splices and taps.

Direct buried conductors or cables shall be permitted to be spliced or tapped without the use of splice boxes. The splices or taps shall be made by approved methods with materials listed for the application. [300.5(E)]
E3803.5 Backfill.
Backfill containing large rock, paving materials, cinders, large or sharply angular substances, or corrosive material shall not be placed in an excavation where such materials cause damage to raceways, cables or other substructures or prevent adequate compaction of fill or contribute to corrosion of raceways, cables or other substructures. Where necessary to prevent physical damage to the raceway or cable, protection shall be provided in the form of granular or selected material, suitable boards, suitable sleeves or other approved means. [300.5(F)]

E3803.6 Raceway seals.
Conduits or raceways shall be sealed or plugged at either or both ends where moisture will enter and contact live parts. [300.5(G)]

E3803.7 Bushing.
A bushing, or terminal fitting, with an integral bushed opening shall be installed on the end of a conduit or other raceway that terminates underground where the conductors or cables emerge as a direct burial wiring method. A seal incorporating the physical protection characteristics of a bushing shall be considered equivalent to a bushing. [300.5(H)]

E3803.8 Single conductors.
All conductors of the same circuit and, where present, the grounded conductor and all equipment grounding conductors shall be installed in the same raceway or shall be installed in close proximity in the same trench. [300.5(I)]

Exception: Conductors shall be permitted to be installed in parallel in raceways, multiconductor cables, and direct-buried single conductor cables. Each raceway or multiconductor cable shall contain all conductors of the same circuit, including equipment grounding conductors. Each direct-buried single conductor cable shall be located in close proximity in the trench to the other single conductor cables in the same parallel set of conductors in the circuit, including equipment grounding conductors. [300.5(I) Exception No.1]

E3803.9 Earth movement.
Where direct buried conductors, raceways or cables are subject to movement by settlement or frost, direct buried conductors, raceways or cables shall be arranged to prevent damage to the enclosed conductors or to equipment connected to the raceways. [300.5(J)]

E3803.10 Wet locations.
The interior of enclosures or raceways installed underground shall be considered to be a wet location. Insulated conductors and cables installed in such enclosures or raceways in underground installations shall be listed for use in wet locations. Connections or splices in an underground installation shall be approved for wet locations. [300.5(B)]

E3803.11 Under buildings.
Underground cable and conductors installed under a building shall be in a raceway. [300.5(C)]

Exception: Type MC Cable shall be permitted under a building without installation in a raceway where the cable is listed and identified for direct burial or concrete encasement and one or more of the following applies:

1. The metallic covering is impervious to moisture.
2. A moisture-impervious jacket is provided under the metal covering.

3. The insulated conductors under the metallic covering are listed for use in wet locations, and a corrosion-resistant jacket is provided over the metallic sheath. [300.5(C) Exception No.2]
CHAPTER 39
POWER AND LIGHTING DISTRIBUTION

Deleted. See the North Carolina Electrical Code.

SECTION E3901
RECEPTACLE OUTLETS

E3901.1 General.
Outlets for receptacles rated at 125 volts, 15- and 20-ampere shall be provided in accordance with Sections E3901.2 through E3901.11. Receptacle outlets required by this section shall be in addition to any receptacle that is:

1. Part of a luminaire or appliance;
2. Located within cabinets or cupboards;
3. Controlled by a wall switch in accordance with Section E3903.2, Exception 1; or
4. Located over 5.5 feet (1676 mm) above the floor.

Permanently installed electric baseboard heaters equipped with factory-installed receptacle outlets, or outlets provided as a separate assembly by the baseboard manufacturer shall be permitted as the required outlet or outlets for the wall space utilized by such permanently installed heaters. Such receptacle outlets shall not be connected to the heater circuits. (210.52)

E3901.2 General purpose receptacle distribution.
In every kitchen, family room, dining room, living room, parlor, library, den, sun room, bedroom, recreation room, or similar room or area of dwelling units, receptacle outlets shall be installed in accordance with the general provisions specified in Sections E3901.2.1 through E3901.2.3 (see Figure E3901.2).
E3901.2.1 Spacing.
Receptacles shall be installed so that no point measured horizontally along the floor line of any wall space is more than 6 feet (1829 mm), from a receptacle outlet. [210.52(A)(1)]

E3901.2.2 Wall space.
As used in this section, a wall space shall include the following: [210.52(A)(2)]

1. Any space that is 2 feet (610 mm) or more in width, including space measured around corners, and that is unbroken along the floor line by doorways and similar openings, fireplaces, and fixed cabinets.

2. The space occupied by fixed panels in exterior walls, excluding sliding panels.

3. The space created by fixed room dividers such as railings and freestanding bar-type counters.

E3901.2.3 Floor receptacles.
Receptacle outlets in floors shall not be counted as part of the required number of receptacle outlets except where located within 18 inches (457 mm) of the wall. [210.52(A)(3)]
**E3901.2.4 Countertop receptacles.**
Receptacles installed for countertop surfaces as specified in Section E3901.4 shall not be considered as the receptacles required by Section E3901.2. [210.52(A)(4)]

**E3901.3 Small appliance receptacles.**
In the kitchen, pantry, breakfast room, dining room, or similar area of a dwelling unit, the two or more 20-ampere small-appliance branch circuits required by Section E3703.2, shall serve all wall and floor receptacle outlets covered by Sections E3901.2 and E3901.4 and those receptacle outlets provided for refrigeration appliances. [210.52(B)(1)]

**Exceptions:**

1. In addition to the required receptacles specified by Sections E3901.1 and E3901.2, switched receptacles supplied from a general-purpose branch circuit as defined in Section E3903.2, Exception 1 shall be permitted. [210.52(B)(1) Exception No. 1]

2. The receptacle outlet for refrigeration appliances shall be permitted to be supplied from an individual branch circuit rated at 15 amperes or greater. [210.52(B)(1) Exception No. 2]

**E3901.3.1 Other outlets prohibited.**
The two or more small-appliance branch circuits specified in Section E3901.3 shall serve no other outlets. [210.52(B)(2)]

**Exceptions:**

1. A receptacle installed solely for the electrical supply to and support of an electric clock in any of the rooms specified in Section E3901.3. [210.52(B)(2) Exception No. 1]

2. Receptacles installed to provide power for supplemental equipment and lighting on gas-fired ranges, ovens, and counter-mounted cooking units. [210.52(B)(2) Exception No. 2]

**E3901.3.2 Limitations.**
Receptacles installed in a kitchen to serve countertop surfaces shall be supplied by not less than two small-appliance branch circuits, either or both of which shall also be permitted to supply receptacle outlets in the same kitchen and in other rooms specified in Section E3901.3. Additional small-appliance branch circuits shall be permitted to supply receptacle outlets in the kitchen and other rooms specified in Section E3901.3. A small-appliance branch circuit shall not serve more than one kitchen. [210.52(B)(3)]

**E3901.4 Countertop receptacles.**
In kitchens, pantries, breakfast rooms, dining rooms and similar areas of dwelling units, receptacle outlets for countertop spaces shall be installed in accordance with Sections E3901.4.1 through E3901.4.5 (see Figure E3901.4). [210.52(C)]
E3901.4.1 Wall countertop space.
A receptacle outlet shall be installed at each wall countertop space 12 inches (305 mm) or wider. Receptacle outlets shall be installed so that no point along the wall line is more than 24 inches (610 mm), measured horizontally from a receptacle outlet in that space. [210.52(C)(1)]

Exception: Receptacle outlets shall not be required on a wall directly behind a range, counter-mounted cooking unit or sink in the installation described in Figure E3901.4.1. [210.52(C)(1) Exception]
FIGURE E3901.4.1
DETERMINATION OF AREA BEHIND SINK OR RANGE

E3901.4.2 Island countertop spaces.
At least one receptacle outlet shall be installed at each island countertop space with a long dimension of 24 inches (610 mm) or greater and a short dimension of 12 inches (305 mm) or greater. [210.52(C)(2)]

E3901.4.3 Peninsular countertop space.
At least one receptacle outlet shall be installed at each peninsular countertop space with a long dimension of 24 inches (610 mm) or greater and a short dimension of 12 inches (305 mm) or greater. A peninsular countertop is measured from the connecting edge. [210.52(C)(3)]

E3901.4.4 Separate spaces.
Countertop spaces separated by range tops, refrigerators, or sinks shall be considered as separate countertop spaces in applying the requirements of Sections E3901.4.1, E3901.4.2 and E3901.4.3. Where a range, counter-mounted cooking unit, or sink is installed in an island or peninsular countertop and the depth of the countertop behind the range, counter-mounted cooking unit, or sink is less than 12 inches (305 mm), the range, counter-mounted cooking unit, or sink has divided the countertop space into two separate countertop spaces as defined in Section E3901.4.4. Each separate countertop space shall comply with the applicable requirements of this section. [210.52(C)(4)]
E3901.4.5 Receptacle outlet location.
Receptacle outlets shall be located not more than 20 inches (508 mm) above the countertop. Receptacle outlet assemblies installed in countertops shall be listed for the application. Receptacle outlets shall not be installed in a face-up position in the work surfaces or countertops. Receptacle outlets rendered not readily accessible by appliances fastened in place, appliance garages, sinks or rangetops as addressed in the exception to Section E3901.4.1, or appliances occupying dedicated space shall not be considered as these required outlets. [210.52(C)(5)]

Exception: Receptacle outlets shall be permitted to be mounted not more than 12 inches (305 mm) below the countertop in construction designed for the physically impaired and for island and peninsular countertops where the countertop is flat across its entire surface and there are no means to mount a receptacle within 20 inches (508 mm) above the countertop, such as in an overhead cabinet. Receptacles mounted below the countertop in accordance with this exception shall not be located where the countertop extends more than 6 inches (152 mm) beyond its support base. [210.52(C)(5) Exception]

E3901.5 Appliance receptacle outlets.
Appliance receptacle outlets installed for specific appliances, such as laundry equipment, shall be installed within 6 feet (1829 mm) of the intended location of the appliance. [210.50(C)]

E3901.6 Bathroom.
At least one wall receptacle outlet shall be installed in bathrooms and such outlet shall be located within 36 inches (914 mm) of the outside edge of each lavatory basin. The receptacle outlet shall be located on a wall or partition that is adjacent to the lavatory basin location, located on the countertop, or installed on the side or face of the basin cabinet. The receptacle outlet shall be located not more than 12 inches (305 mm) below the top of the basin. Receptacle outlets shall not be installed in a face-up position in the work surfaces or countertops in a bathroom basin location. Receptacle outlet assemblies installed in countertops shall be listed for the application. [210.52(D)]

E3901.7 Outdoor outlets.
Not less than one receptacle outlet that is readily accessible from grade level and located not more than 6 feet, 6 inches (1981 mm) above grade, shall be installed outdoors at the front and back of each dwelling unit having direct access to grade level. Balconies, decks, and porches that are accessible from inside of the dwelling shall have at least one receptacle outlet installed within the perimeter of the balcony, deck, or porch. The receptacle outlet shall be located not more than 6 feet, 6 inches (1981 mm) above the balcony, deck, or porch surface. [210.52(E)]

E3901.8 Laundry areas.
Not less than one receptacle outlet shall be installed in areas designated for the installation of laundry equipment.

E3901.9 Basements, garages and accessory buildings.
Not less than one receptacle outlet, in addition to any provided for specific equipment, shall be installed in each separate unfinished portion of a basement, in each attached garage, and in each detached garage or accessory building that is provided with electrical power. The branch circuit supplying the receptacle(s) in a garage shall not supply outlets outside of the garage and
not less than one receptacle outlet shall be installed for each motor vehicle space. [210.52(G)(1), (2), and (3)]

**E3901.10 Hallways.** Hallways of 10 feet (3048 mm) or more in length shall have at least one receptacle outlet. The hall length shall be considered the length measured along the centerline of the hall without passing through a doorway. [210.52(H)]

**E3901.11 Foyers.** Foyers that are not part of a hallway in accordance with Section E3901.10 and that have an area that is greater than 60 ft² (5.57 m²) shall have a receptacle(s) located in each wall space that is 3 feet (914 mm) or more in width. Doorways, door-side windows that extend to the floor, and similar openings shall not be considered as wall space. [210.52(H)]

**E3901.12 HVAC outlet.** A 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed at an accessible location for the servicing of heating, air-conditioning and refrigeration equipment. The receptacle shall be located on the same level and within 25 feet (7620 mm) of the heating, air-conditioning and refrigeration equipment. The receptacle outlet shall not be connected to the load side of the HVAC equipment disconnecting means. (210.63)

*Exception:* A receptacle outlet shall not be required for the servicing of evaporative coolers. (210.63 Exception)

**SECTION E3902 GROUND-FAULT AND ARC-FAULT CIRCUIT-INTERUPTER PROTECTION**

**E3902.1 Bathroom receptacles.** 125-volt, single-phase, 15- and 20-ampere receptacles installed in bathrooms shall have ground-fault circuit-interceptor protection for personnel. [210.8(A)(1)]

**E3902.2 Garage and accessory building receptacles.** 125-volt, single-phase, 15- or 20-ampere receptacles installed in garages and grade-level portions of unfinished accessory buildings used for storage or work areas shall have ground-fault circuit-interceptor protection for personnel. [210.8(A)(2)]

**E3902.3 Outdoor receptacles.** 125-volt, single-phase, 15- and 20-ampere receptacles installed outdoors shall have ground-fault circuit-interceptor protection for personnel. [210.8(A)(3)]

*Exception:* Receptacles as covered in Section E4101.7. [210.8(A)(3) Exception]

**E3902.4 Crawl space receptacles.** Where a crawl space is at or below grade level, 125-volt, single-phase, 15- and 20-ampere receptacles installed in such spaces shall have ground-fault circuit-interceptor protection for personnel. [210.8(A)(4)]

**E3902.5 Unfinished basement receptacles.** 125-volt, single-phase, 15- and 20-ampere receptacles installed in unfinished basements shall
have ground-fault circuit-interrupter protection for personnel. For purposes of this section, unfinished basements are defined as portions or areas of the basement not intended as habitable rooms and limited to storage areas, work areas, and similar areas. [210.8(A)(5)]

Exception: A receptacle supplying only a permanently installed fire alarm or burglar alarm system. Receptacles installed in accordance with this exception shall not be considered as meeting the requirement of Section E3901.9. [210.8(A)(5) Exception]

E3902.6 Kitchen receptacles. 125-volt, single-phase, 15- and 20-ampere receptacles that serve countertop surfaces shall have ground-fault circuit-interrupter protection for personnel. [210.8(A)(6)]

E3902.7 Sink receptacles. 125-volt, single-phase, 15- and 20-ampere receptacles that are located within 6 feet (1829 mm) of the outside edge of a sink shall have ground-fault circuit-interrupter protection for personnel. Receptacle outlets shall not be installed in a face-up position in the work surfaces or countertops. [210.8(A)(7)]

E3902.8 Bathtub or shower stall receptacles. 125-volt, single-phase, 15- and 20-ampere receptacles that are located within 6 feet (1829 mm) of the outside edge of a bathtub or shower stall shall have ground-fault circuit-interrupter protection for personnel. [210.8(A)(8)]

E3902.9 Laundry areas. 125-volt, single-phase, 15- and 20-ampere receptacles installed in laundry areas shall have ground-fault circuit-interrupter protection for personnel. [210.8(A)(9)]

E3902.10 Kitchen dishwasher branch circuit. Ground-fault circuit-interrupter protection shall be provided for outlets that supply dishwashers in dwelling unit locations. [210.8(D)]

E3902.11 Boathouse receptacles. 125-volt, single-phase, 15- or 20-ampere receptacles installed in boathouses shall have ground-fault circuit-interrupter protection for personnel. [210.8(A)(8)]

E3902.12 Boat hoists. Ground-fault circuit-interrupter protection for personnel shall be provided for 240-volt and less outlets that supply boat hoists. [210.8(G)]

E3902.13 Electrically heated floors. Ground-fault circuit-interrupter protection for personnel shall be provided for electrically heated floors in bathrooms, kitchens and in hydromassage bathtub, spa and hot tub locations. [424.44(G)]

E3902.14 Location of ground-fault circuit interrupters. Ground-fault circuit interrupters shall be installed in a readily accessible location. [210.8(A)]

E3902.15 Location of arc-fault circuit interrupters. Arc-fault circuit interrupters shall be installed in readily accessible locations.
E3902.16 Arc-fault circuit-interrupter protection.
Branch circuits that supply 120-volt, single-phase, 15- and 20-ampere outlets installed in kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreations rooms, closets, hallways, laundry areas and similar rooms or areas shall be protected by any of the following: [210.12(A)]

1. A listed combination-type arc-fault circuit interrupter, installed to provide protection of the entire branch circuit. [210.12(A)(1)]

2. A listed branch/feeder-type AFCI installed at the origin of the branch-circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit. [210.12(A)(2)]

3. A listed supplemental arc protection circuit breaker installed at the origin of the branch circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit where all of the following conditions are met:
   3.1. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.
   3.2. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 50 feet (15.2 m) for 14 AWG conductors and 70 feet (21.3 m) for 12 AWG conductors.
   3.3. The first outlet box on the branch circuit shall be marked to indicate that it is the first outlet on the circuit. [210.12(A)(3)]

4. A listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet on the branch circuit in combination with a listed branch-circuit overcurrent protective device where all of the following conditions are met:
   4.1. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.
   4.2. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 50 feet (15.2 m) for 14 AWG conductors and 70 feet (21.3 m) for 12 AWG conductors.
   4.3. The first outlet box on the branch circuit shall be marked to indicate that it is the first outlet on the circuit.
   4.4. The combination of the branch-circuit overcurrent device and outlet branch-circuit AFCI shall be identified as meeting the requirements for a system combination-type AFCI and shall be listed as such. [210.12(A)(4)]

5. Where metal outlet boxes and junction boxes and RMC, IMC, EMT, Type MC or steel- armored Type AC cables meeting the requirements of Section E3908.8, metal wireways or metal auxiliary gutters are installed for the portion of the branch circuit between the...
branch-circuit overcurrent device and the first outlet, a listed outlet branch-circuit type AFCI installed at the first outlet shall be considered as providing protection for the remaining portion of the branch circuit. [210.12(A)(5)]

6. Where a listed metal or nonmetallic conduit or tubing or Type MC cable is encased in not less than 2 inches (50.8 mm) of concrete for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, a listed outlet branch-circuit type AFCI installed at the first outlet shall be considered as providing protection for the remaining portion of the branch circuit. [210.12(A)(6)]

**Exception:** AFCI protection is not required for an individual branch circuit supplying only a fire alarm system where the branch circuit is wired with metal outlet and junction boxes and RMC, IMC, EMT or steel-sheathed armored cable Type AC or Type MC meeting the requirements of Section E3908.8.

**E3902.17 Arc-fault circuit interrupter protection for branch circuit extensions or modifications.**

Where branch-circuit wiring is modified, replaced, or extended in any of the areas specified in Section E3902.16, the branch circuit shall be protected by one of the following:

1. A combination-type AFCI located at the origin of the branch circuit

2. An outlet branch-circuit type AFCI located at the first receptacle outlet of the existing branch circuit. [210.12(B)]

**Exception:** AFCI protection shall not be required where the extension of the existing conductors is not more than 6 feet (1.8 m) in length and does not include any additional outlets or devices. [210.12(B) Exception]

**SECTION E3903 LIGHTING OUTLETS**

**E3903.1 General.**

Lighting outlets shall be provided in accordance with Sections E3903.2 through E3903.4. [210.70(A)]

**E3903.2 Habitable rooms.**

At least one wall switch-controlled lighting outlet shall be installed in every habitable room and bathroom. [210.70(A)(1)]

**Exceptions:**

1. In other than kitchens and bathrooms, one or more receptacles controlled by a wall switch shall be considered equivalent to the required lighting outlet. [210.70(A)(1) Exception No. 1]

2. Lighting outlets shall be permitted to be controlled by occupancy sensors that are in addition to wall switches, or that are located at a customary wall switch location and equipped with a manual override that will allow the sensor to function as a wall switch. [210.70(A)(1) Exception No. 2]
E3903.3 Additional locations.
At least one wall-switch-controlled lighting outlet shall be installed in hallways, stairways, attached garages, and detached garages with electric power. At least one wall-switch-controlled lighting outlet shall be installed to provide illumination on the exterior side of each outdoor egress door having grade level access, including outdoor egress doors for attached garages and detached garages with electric power. A vehicle door in a garage shall not be considered as an outdoor egress door. Where one or more lighting outlets are installed for interior stairways, there shall be a wall switch at each floor level and landing level that includes an entryway to control the lighting outlets where the stairway between floor levels has six or more risers. [210.70(A)(2)]

Exception: In hallways, stairways, and at outdoor egress doors, remote, central, or automatic control of lighting shall be permitted. [210.70(A)(2) Exception]

E3903.4 Storage or equipment spaces.
In attics, under floor spaces, utility rooms and basements, at least one lighting outlet shall be installed where these spaces are used for storage or contain equipment requiring servicing. Such lighting outlet shall be controlled by a wall switch or shall have an integral switch. At least one point of control shall be at the usual point of entry to these spaces. The lighting outlet shall be provided at or near the equipment requiring servicing. [210.70(A)(3)]

SECTION E3904
GENERAL INSTALLATION REQUIREMENTS

E3904.1 Electrical continuity of metal raceways and enclosures.
Metal raceways, cable armor and other metal enclosures for conductors shall be mechanically joined together into a continuous electric conductor and shall be connected to all boxes, fittings and cabinets so as to provide effective electrical continuity. Raceways and cable assemblies shall be mechanically secured to boxes, fittings cabinets and other enclosures. (300.10)

Exception: Short sections of raceway used to provide cable assemblies with support or protection against physical damage. (300.10 Exception No.1)

E3904.2 Mechanical continuity—raceways and cables.
Metal or nonmetallic raceways, cable armors and cable sheaths shall be continuous between cabinets, boxes, fittings or other enclosures or outlets.

Exception: Short sections of raceway used to provide cable assemblies with support or protection against physical damage. (300.12 Exception No.1)

E3904.3 Securing and supporting.
Raceways, cable assemblies, boxes, cabinets and fittings shall be securely fastened in place. (300.11)

E3904.3.1 Prohibited means of support.
Cable wiring methods shall not be used as a means of support for other cables, raceways and nonelectrical equipment. [300.11(C)]
E3904.4 Raceways as means of support.
Raceways shall be used as a means of support for other raceways, cables or nonelectric equipment only under the following conditions:

1. Where the raceway or means of support is identified as a means of support; or

2. Where the raceway contains power supply conductors for electrically controlled equipment and is used to support Class 2 circuit conductors or cables that are solely for the purpose of connection to the control circuits of the equipment served by such raceway; or

3. Where the raceway is used to support boxes or conduit bodies in accordance with Sections E3906.8.4 and E3906.8.5. [300.11(B)]

E3904.5 Raceway installations.
Raceways shall be installed complete between outlet, junction or splicing points prior to the installation of conductors. (300.18)

Exception: Short sections of raceways used to contain conductors or cable assemblies for protection from physical damage shall not be required to be installed complete between outlet, junction, or splicing points. (300.18 Exception)

E3904.6 Conduit and tubing fill.
The maximum number of conductors installed in conduit or tubing shall be in accordance with Tables E3904.6(1) through E3904.6(10). (300.17, Chapter 9, Table 1 and Annex C)

**TABLE E3904.6(1)(Annex C, Table C.1)**
MAXIMUM NUMBER OF CONDUCTORS IN ELECTRICAL METALLIC TUBING (EMT)\(^a\)

<table>
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<th>TYPE LETTERS</th>
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<th>TRADE SIZES (inches)</th>
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For SI: 1 inch = 25.4 mm.
a—Types RHW, and RHW-2 without outer covering.

### TABLE E3904.6(2)(Annex C, Table C.2)
MAXIMUM NUMBER OF CONDUCTORS IN ELECTRICAL NONMETALLIC TUBING (ENT)\(^a\)

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2018 North Carolina Residential Code
**TABLE E3904.6(3)(Annex C, Table C.3)**

**MAXIMUM NUMBER OF CONDUCTORS IN FLEXIBLE METALLIC CONDUIT (FMC)**

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For SI: 1 inch = 25.4 mm.
a—Types RHW, and RHW-2 without outer covering.
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For SI: 1 inch = 25.4 mm.
a. Types RHW, and RHW-2 without outer covering.

**TABLE E3904.6(4)(Annex C, Table C.4)**

MAXIMUM NUMBER OF CONDUCTORS IN INTERMEDIATE METALLIC CONDUIT (IMC)**a**
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For SI:1 inch = 25.4 mm.
a—Types RHW, and RHW-2 without outer covering.

**TABLE E3904.6(5)(Annex C, Table C.5)**
MAXIMUM NUMBER OF CONDUCTORS IN LIQUID-TIGHT FLEXIBLE NONMETALLIC CONDUIT (FNMC-B) 

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2018 North Carolina Residential Code
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2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm.
a. Types RHW, and RHW-2 without outer covering.

### TABLE E3904.6(6)(Annex C, Table C.6)
MAXIMUM NUMBER OF CONDUCTORS IN LIQUID-TIGHT FLEXIBLE NONMETALLIC CONDUIT (FNMC-A)\(^a\)

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| TW, THHW, THW, THW-2 | 14 | 5 | 9 | 15 | 24 | 43 | 58 | 96 |
|                       | 12 | 4 | 7 | 12 | 19 | 33 | 44 | 74 |
|                       | 10 | 4 | 7 | 12 | 19 | 33 | 44 | 74 |
|                       | 8  | 4 | 7 | 12 | 19 | 33 | 44 | 74 |

| RHH\(^a\), RHW\(^a\), RHW-2 | 14 | 3 | 6 | 10 | 16 | 28 | 38 | 64 |
|                            | 12 | 3 | 6 | 10 | 16 | 28 | 38 | 64 |
|                            | 10 | 3 | 6 | 10 | 16 | 28 | 38 | 64 |
|                            | 8  | 3 | 6 | 10 | 16 | 28 | 38 | 64 |

| RHH\(^a\), RHW\(^a\), RHW-2 | 6  | 1 | 1 | 3 | 4 | 8 | 11 | 18 |
|                            | 4  | 1 | 1 | 3 | 4 | 8 | 11 | 18 |
|                            | 3  | 1 | 1 | 3 | 4 | 8 | 11 | 18 |
|                            | 2  | 1 | 1 | 3 | 4 | 8 | 11 | 18 |
|                            | 1  | 1 | 1 | 3 | 4 | 8 | 11 | 18 |

2018 North Carolina Residential Code
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For SI: 1 inch = 25.4 mm.
\textsuperscript{a} Types RHW and RHW-2 without outer covering.

TABLE E3904.6(7)(Annex C, Table C.7)
MAXIMUM NUMBER OF CONDUCTORS IN LIQUID-TIGHT FLEXIBLE METAL CONDUIT (LFMC)\textsuperscript{a}
| RHH, RHW, RHW-2 | 14 | 4 | 7 | 21 | 27 | 44 |
| RHH a, RHW a, RHW-2 | 12 | 3 | 6 | 17 | 22 | 36 |
| THW, THHW, THW-2 | 10 | 5 | 14 | 18 | 29 |
| TW, THW, THW-2 | 8 | 6 | 7 | 9 | 1 | 2 |
| RHH a, RHW a, RHW-2 | 14 | 4 | 7 | 21 | 27 | 44 |
| RHH a, RHW a, RHW-2 | 12 | 3 | 6 | 17 | 22 | 36 |
| THHHN, THWN, THWN-2 | 10 | 5 | 14 | 18 | 29 |
| XHH, XHHW, XHHW-2 | 8 | 6 | 7 | 9 | 1 | 2 |

2018 North Carolina Residential Code
For SI: 1 inch = 25.4 mm.

a. Types RHW, and RHW-2 without outer covering.

### TABLE E3904.6(8) (Annex C, Table C.8)
**MAXIMUM NUMBER OF CONDUCTORS IN RIGID METAL CONDUIT (RMC)**

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TW, THHW, THW, THW-2

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RHH a, RHW a, RHW-2 a

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RHH a, RHW a, RHW-2 a

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For SI: 1 inch = 25.4 mm.
a. Types RHW, and RHW-2 without outer covering.

**TABLE E3904.6(9)(Annex C, Table C.9)**

**MAXIMUM NUMBER OF CONDUCTORS IN RIGID PVC CONDUIT, SCHEDULE 80 (PVC-80)**

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For SI: 1 inch = 25.4 mm.

### Types RHW, and RHW-2 without outer covering.

**TABLE E3904.6(10)(Annex C, Table C.10)**

**MAXIMUM NUMBER OF CONDUCTORS IN RIGID PVC CONDUIT SCHEDULE 40 (PVC-40)**

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THHN, THWN, THWN-2

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THHN, THWN, THWN-2

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XHH, XHHW, XHHW-2

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For SI: 1 inch = 25.4 mm.
a—Types RHW, and RHW-2 without outer covering.

E3904.7 Air-handling-stud cavity and joist spaces.
Where wiring methods having a nonmetallic covering pass through stud cavities and joist spaces used for air handling, such wiring shall pass through such spaces perpendicular to the long dimension of the spaces. [300.22(C) Exception]

SECTION E3905
BOXES, CONDUIT BODIES AND FITTINGS

E3905.1 Box, conduit body or fitting—where required.
A box or conduit body shall be installed at each conductor splice point, outlet, switch point, junction point and pull point except as otherwise permitted in Sections E3905.1.1 through E3905.1.6.

Fittings and connectors shall be used only with the specific wiring methods for which they are designed and listed. (300.15)

E3905.1.1 Equipment.
An integral junction box or wiring compartment that is part of listed equipment shall be permitted to serve as a box or conduit body. [300.15(B)]

E3905.1.2 Protection.
A box or conduit body shall not be required where cables enter or exit from conduit or tubing that is used to provide cable support or protection against physical damage. A fitting shall be
provided on the end(s) of the conduit or tubing to protect the cable from abrasion. [300.15(C)]

E3905.1.3 Integral enclosure.
A wiring device with integral enclosure identified for the use, having brackets that securely fasten the device to walls or ceilings of conventional on-site frame construction, for use with nonmetallic-sheathed cable, shall be permitted in lieu of a box or conduit body. [300.15(E)]

E3905.1.4 Fitting.
A fitting identified for the use shall be permitted in lieu of a box or conduit body where such fitting is accessible after installation and does not contain spliced or terminated conductors. [300.15(F)]

E3905.1.5 Buried conductors.
Splices and taps in buried conductors and cables shall not be required to be enclosed in a box or conduit body where installed in accordance with Section E3803.4.

E3905.1.6 Luminaires.
Where a luminaire is listed to be used as a raceway, a box or conduit body shall not be required for wiring installed therein. [300.15(J)]

E3905.2 Metal boxes.
Metal boxes shall be grounded. (314.4)

E3905.3 Nonmetallic boxes.
Nonmetallic boxes shall be used only with cabled wiring methods with entirely nonmetallic sheaths, flexible cords and nonmetallic raceways. (314.3)

Exceptions:

1. Where internal bonding means are provided between all entries, nonmetallic boxes shall be permitted to be used with metal raceways and metal-armored cables. (314.3 Exception No. 1)

2. Where integral bonding means with a provision for attaching an equipment grounding jumper inside the box are provided between all threaded entries in nonmetallic boxes listed for the purpose, nonmetallic boxes shall be permitted to be used with metal raceways and metal-armored cables. (314.3 Exception No. 2)

E3905.3.1 Nonmetallic-sheathed cable and nonmetallic boxes.
Where nonmetallic-sheathed cable is used, the cable assembly, including the sheath, shall extend into the box not less than $\frac{1}{4}$ inch (6.4 mm) through a nonmetallic-sheathed cable knockout opening. (314.7(C))

E3905.3.2 Securing to box.
Wiring methods shall be secured to the boxes. [314.17(G)]
Exception: Where nonmetallic-sheathed cable is used with boxes not larger than a nominal size of $2\frac{1}{4}$ inches by 4 inches (57 mm by 102 mm) mounted in walls or ceilings, and where the cable is fastened within 8 inches (203 mm) of the box measured along the sheath, and where the sheath extends through a cable knockout not less than $\frac{1}{4}$ inch (6.4 mm), securing the cable to the box shall not be required. [314.17(C) Exception]

E3905.3.3 Conductor rating.
Nonmetallic boxes shall be suitable for the lowest temperature-rated conductor entering the box. [314.17(C)]

E3905.4 Minimum depth of boxes for outlets, devices, and utilization equipment.
Outlet and device boxes shall have an approved depth to allow equipment installed within them to be mounted properly and without the likelihood of damage to conductors within the box. (314.24)

E3905.4.1 Outlet boxes without enclosed devices or utilization equipment.
Outlet boxes that do not enclose devices or utilization equipment shall have an internal depth of not less than $\frac{1}{2}$ inch (12.7 mm). [314.24(A)]

E3905.4.2 Utilization equipment.
Outlet and device boxes that enclose devices or utilization equipment shall have a minimum internal depth that accommodates the rearward projection of the equipment and the size of the conductors that supply the equipment. The internal depth shall include that of any extension boxes, plaster rings, or raised covers. The internal depth shall comply with all of the applicable provisions that follow. [314.24(B)]

Exception: Utilization equipment that is listed to be installed with specified boxes.

1. Large equipment. Boxes that enclose devices or utilization equipment that projects more than $\frac{7}{8}$ inches (48 mm) rearward from the mounting plane of the box shall have a depth that is not less than the depth of the equipment plus $\frac{1}{4}$ inch (6.4 mm). [314.24(B)(1)]

2. Conductors larger than 4 AWG. Boxes that enclose devices or utilization equipment supplied by conductors larger than 4 AWG shall be identified for their specific function. [314.24(B)(2)]

3. Conductors 8, 6, or 4 AWG. Boxes that enclose devices or utilization equipment supplied by 8, 6, or 4 AWG conductors shall have an internal depth that is not less than $2\frac{1}{16}$ inches (52.4 mm). [314.24(B)(3)]

4. Conductors 12 or 10 AWG. Boxes that enclose devices or utilization equipment supplied by 12 or 10 AWG conductors shall have an internal depth that is not
less than \( \frac{3}{16} \) inches (30.2 mm). Where the equipment projects rearward from the mounting plane of the box by more than 1 inch (25.4 mm), the box shall have a depth that is not less than that of the equipment plus \( \frac{1}{4} \) inch (6.4 mm).

[314.24(B)(4)]

5. Conductors 14 AWG and smaller. Boxes that enclose devices or utilization equipment supplied by 14 AWG or smaller conductors shall have a depth that is not less than \( \frac{15}{16} \) inch (23.8 mm). [314.24(B)(5)]

E3905.5 Boxes enclosing flush-mounted devices.
Boxes enclosing flush-mounted devices shall be of such design that the devices are completely enclosed at the back and all sides and shall provide support for the devices. Screws for supporting the box shall not be used for attachment of the device contained therein. (314.19)

E3905.6 Boxes at luminaire outlets.
Outlet boxes used at luminaire or lampholder outlets shall be designed for the support of luminaires and lampholders and shall be installed as required by Section E3904.3. [314.27(A)]

E3905.6.1 Vertical surface outlets.
Boxes used at luminaire or lampholder outlets in or on a vertical surface shall be identified and marked on the interior of the box to indicate the maximum weight of the luminaire or lamp holder that is permitted to be supported by the box if other than 50 pounds (22.7 kg). [314.27(A)(1)]

Exception: A vertically-mounted luminaire or lampholder weighing not more than 6 pounds (2.7 kg) shall be permitted to be supported on other boxes or plaster rings that are secured to other boxes, provided that the luminaire or its supporting yoke is secured to the box with not fewer than two No. 6 or larger screws. [314.27(A)(1) Exception]

E3905.6.2 Ceiling outlets.
For outlets used exclusively for lighting, the box shall be designed or installed so that a luminaire or lampholder can be attached. Such boxes shall be capable of supporting a luminaire weighing up to 50 pounds (22.7 kg). A luminaire that weighs more than 50 pounds (22.7 kg) shall be supported independently of the outlet box, unless the outlet box is listed and marked on the interior of the box to indicate the maximum weight that the box is permitted to support. [314.27(A)(2)]

E3905.7 Floor boxes.
Where outlet boxes for receptacles are installed in the floor, such boxes shall be listed specifically for that application. [314.27(B)]

E3905.8 Boxes at fan outlets.
Outlet boxes and outlet box systems used as the sole support of ceiling-suspended fans (paddle) shall be marked by their manufacturer as suitable for this purpose and shall not support ceiling-suspended fans (paddle) that weigh more than 70 pounds (31.8 kg). For outlet boxes and outlet box systems designed to support ceiling-suspended fans (paddle) that weigh more than 35 pounds (15.9 kg), the required marking shall include the maximum weight to be supported.
Where spare, separately switched, ungrounded conductors are provided to a ceiling-mounted outlet box and such box is in a location acceptable for a ceiling-suspended (paddle) fan, the outlet box or outlet box system shall be listed for sole support of a ceiling-suspended (paddle) fan. [314.27(C)]

**E3905.9 Utilization equipment.**

Boxes used for the support of utilization equipment other than ceiling-suspended (paddle) fans shall meet the requirements of Sections E3905.6.1 and E3905.6.2 for the support of a luminaire that is the same size and weight. [314.27(D)]

**Exception:** Utilization equipment weighing not more than 6 pounds (2.7 kg) shall be permitted to be supported on other boxes or plaster rings that are secured to other boxes, provided that the equipment or its supporting yoke is secured to the box with not fewer than two No. 6 or larger screws. [314.27(D) Exception]

**E3905.10 Conduit bodies and junction, pull and outlet boxes to be accessible.**

Conduit bodies and junction, pull and outlet boxes shall be installed so that the wiring therein can be accessed without removing any part of the building or structure or, in underground circuits, without excavating sidewalks, paving, earth or other substance used to establish the finished grade. (314.29)

**Exception:** Boxes covered by gravel, light aggregate or noncohesive granulated soil shall be listed for the application, and the box locations shall be effectively identified and access shall be provided for excavation. (314.29 Exception)

**E3905.11 Damp or wet locations.**

In damp or wet locations, boxes, conduit bodies and fittings shall be placed or equipped so as to prevent moisture from entering or accumulating within the box, conduit body or fitting. Boxes, conduit bodies and fittings installed in wet locations shall be listed for use in wet locations. Where drainage openings are installed in the field in boxes or conduit bodies listed for use in damp or wet locations, such openings shall be approved and not larger than $\frac{1}{4}$ inch (6.4 mm).

For listed drain fittings, larger openings are permitted where installed in the field in accordance with the manufacturer's instructions. (314.15)

**E3905.12 Number of conductors in outlet, device, and junction boxes, and conduit bodies.**

Boxes and conduit bodies shall be of an approved size to provide free space for all enclosed conductors. In no case shall the volume of the box, as calculated in Section E3905.12.1, be less than the box fill calculation as calculated in Section E3905.12.2. The minimum volume for conduit bodies shall be as calculated in Section E3905.12.3. The provisions of this section shall not apply to terminal housings supplied with motors or generators. (314.16)

**E3905.12.1 Box volume calculations.**

The volume of a wiring enclosure (box) shall be the total volume of the assembled sections, and, where used, the space provided by plaster rings, domed covers, extension rings, etc., that are marked with their volume in cubic inches or are made from boxes the dimensions of which are listed in Table E3905.12.1. [314.16(A)]
<table>
<thead>
<tr>
<th>BOX DIMENSIONS (inches-trade size and type)</th>
<th>MAXIMUM CAPACITY (cubic inches)</th>
<th>MAXIMUM NUMBER OF CONDUCTORS a</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 x 1 (\frac{1}{4}) round or (\frac{1}{2}) octagonal</td>
<td>12.5</td>
<td>8 7 6 5 4 3</td>
</tr>
<tr>
<td>4 x 1 (\frac{1}{4}) round or (\frac{1}{2}) octagonal</td>
<td>15.5</td>
<td>10 8 7 6 5 4</td>
</tr>
<tr>
<td>4 x 2 (\frac{1}{8}) round or (\frac{1}{2}) octagonal</td>
<td>21.0</td>
<td>14 12 10 9 8 7 6 5 4</td>
</tr>
<tr>
<td>4 x 1 (\frac{1}{4}) square</td>
<td>18.0</td>
<td>12 10 9 8 7 6 3</td>
</tr>
<tr>
<td>4 x 1 (\frac{1}{2}) square</td>
<td>21.0</td>
<td>14 12 10 9 8 7 4</td>
</tr>
<tr>
<td>4 x 2 (\frac{1}{8}) square</td>
<td>30.3</td>
<td>20 17 15 13 12 10 6</td>
</tr>
<tr>
<td>4 (\frac{1}{16}) x 2 (\frac{1}{8}) square</td>
<td>25.5</td>
<td>17 14 12 11 10 8 5</td>
</tr>
<tr>
<td>4 (\frac{1}{16}) x 2 (\frac{1}{4}) square</td>
<td>29.5</td>
<td>19 16 14 13 11 9 5</td>
</tr>
<tr>
<td>4 (\frac{1}{16}) x 2 (\frac{3}{4}) square</td>
<td>42.0</td>
<td>28 24 21 18 16 14 8</td>
</tr>
<tr>
<td>3 x 2 x 1 (\frac{1}{2}) device</td>
<td>7.5</td>
<td>5 4 3 3 2 1</td>
</tr>
<tr>
<td>3 x 2 x 2 device</td>
<td>10.0</td>
<td>6 5 5 4 3 2</td>
</tr>
<tr>
<td>3 x 2 x 2 (\frac{1}{4}) device</td>
<td>10.5</td>
<td>7 6 5 4 3 2</td>
</tr>
<tr>
<td>3 x 2 x 2 (\frac{1}{2}) device</td>
<td>12.5</td>
<td>8 7 6 5 4 2</td>
</tr>
<tr>
<td>3 x 2 x 2 (\frac{3}{4}) device</td>
<td>14.0</td>
<td>9 8 7 6 5 4 2</td>
</tr>
<tr>
<td>3 x 2 x 3 (\frac{1}{4}) device</td>
<td>18.0</td>
<td>12 10 9 8 7 6 3</td>
</tr>
<tr>
<td>4 x 2 (\frac{1}{8}) x 1 (\frac{1}{2}) device</td>
<td>10.3</td>
<td>6 5 4 4 3 2</td>
</tr>
<tr>
<td>4 x 2 (\frac{1}{8}) x 1 (\frac{7}{8}) device</td>
<td>13.0</td>
<td>8 7 6 5 4 2</td>
</tr>
<tr>
<td>4 x 2 (\frac{1}{8}) x 2 (\frac{1}{8}) device</td>
<td>14.5</td>
<td>9 8 7 6 5 4 2</td>
</tr>
</tbody>
</table>
E3905.12.1.1 Standard boxes.
The volumes of standard boxes that are not marked with a cubic-inch capacity shall be as given in Table E3905.12.1. [314.16(A)(1)]

E3905.12.1.2 Other boxes.
Boxes 100 cubic inches (1640 cm$^3$) or less, other than those described in Table E3905.12.1, and nonmetallic boxes shall be durably and legibly marked by the manufacturer with their cubic-inch capacity. Boxes described in Table E3905.12.1 that have a larger cubic inch capacity than is designated in the table shall be permitted to have their cubic-inch capacity marked as required by this section. [314.16(A)(2)]

E3905.12.2 Box fill calculations.
The volumes in Section E3905.12.2.1 through Section E3905.12.2.5, as applicable, shall be added together. No allowance shall be required for small fittings such as locknuts and bushings. [314.16(B)]

E3905.12.2.1 Conductor fill.
Each conductor that originates outside the box and terminates or is spliced within the box shall be counted once, and each conductor that passes through the box without splice or termination shall be counted once. Each loop or coil of unbroken conductor having a length equal to or greater than twice that required for free conductors by Section E3406.11.3, shall be counted twice. The conductor fill, in cubic inches, shall be computed using Table E3905.12.2.1. A conductor, no part of which leaves the box, shall not be counted. [314.16(B)(1)]

**Exception:** An equipment grounding conductor or not more than four fixture wires smaller than No. 14, or both, shall be permitted to be omitted from the calculations where such conductors enter a box from a domed fixture or similar canopy and terminate within that box. [314.16(B)(1) Exception]

**TABLE E3905.12.2.1 [Table 314.16(B)]
VOLUME ALLOWANCE REQUIRED PER CONDUCTOR**

<table>
<thead>
<tr>
<th>SIZE OF CONDUCTOR</th>
<th>FREE SPACE WITHIN BOX FOR EACH CONDUCTOR (cubic inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 AWG</td>
<td>1.50</td>
</tr>
<tr>
<td>16 AWG</td>
<td>1.75</td>
</tr>
<tr>
<td>14 AWG</td>
<td>2.00</td>
</tr>
<tr>
<td>12 AWG</td>
<td>2.25</td>
</tr>
<tr>
<td>10 AWG</td>
<td>2.50</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 cubic inch = 16.4 cm$^3$.
E3905.12.2.2 Clamp fill.
Where one or more internal cable clamps, whether factory or field supplied, are present in the box, a single volume allowance in accordance with Table E3905.12.2.1 shall be made based on the largest conductor present in the box. An allowance shall not be required for a cable connector having its clamping mechanism outside of the box. A clamp assembly that incorporates a cable termination for the cable conductors shall be listed and marked for use with specific nonmetallic boxes. Conductors that originate within the clamp assembly shall be included in conductor fill calculations provided in Section E3905.12.2.1 as though they entered from outside of the box. The clamp assembly shall not require a fill allowance, but, the volume of the portion of the assembly that remains within the box after installation shall be excluded from the box volume as marked in accordance with Section E3905.12.1.2. [314.16(B)(2)]

E3905.12.2.3 Support fittings fill.
Where one or more fixture studs or hiccups are present in the box, a single volume allowance in accordance with Table E3905.12.2.1 shall be made for each type of fitting based on the largest conductor present in the box. [314.16(B)(3)]

E3905.12.2.4 Device or equipment fill.
For each yoke or strap containing one or more devices or equipment, a double volume allowance in accordance with Table E3905.12.2.1 shall be made for each yoke or strap based on the largest conductor connected to a device(s) or equipment supported by that yoke or strap. For a device or utilization equipment that is wider than a single 2-inch (51 mm) device box as described in Table E3905.12.1, a double volume allowance shall be made for each ganged portion required for mounting of the device or equipment. [314.16(B)(4)]

E3905.12.2.5 Equipment grounding conductor fill.
Where one or more equipment grounding conductors or equipment bonding jumpers enters a box, a single volume allowance in accordance with Table E3905.12.2.1 shall be made based on the largest equipment grounding conductor or equipment bonding jumper present in the box. [314.16(B)(5)]

E3905.12.3 Conduit bodies.
Conduit bodies enclosing 6 AWG conductors or smaller, other than short-radius conduit bodies, shall have a cross-sectional area not less than twice the cross-sectional area of the largest conduit or tubing to which they can be attached. The maximum number of conductors permitted shall be the maximum number permitted by Section E3904.6 for the conduit to which it is attached. [314.16(C)(1)]

E3905.12.3.1 Splices, taps or devices.
Only those conduit bodies that are durably and legibly marked by the manufacturer with their cubic inch capacity shall be permitted to contain splices, taps or devices. The maximum number of conductors shall be calculated using the same procedure for similar conductors in other than standard boxes. [314.16(C)(2)]
**E3905.12.3.2 Short-radius conduit bodies.**
Conduit bodies such as capped elbows and service entrance elbows that enclose conductors 6 AWG or smaller and that are only intended to enable the installation of the raceway and the contained conductors, shall not contain splices, taps, or devices and shall be of sufficient size to provide free space for all conductors enclosed in the conduit body. [314.16(C)(3)]

**SECTION E3906**
**INSTALLATION OF BOXES, CONDUIT BODIES AND FITTINGS**

**E3906.1 Conductors entering boxes, conduit bodies or fittings.**
Conductors entering boxes, conduit bodies or fittings shall be protected from abrasion. (314.17)

**E3906.1.1 Insulated fittings.**
Where raceways contain 4 AWG or larger insulated circuit conductors and these conductors enter a cabinet, box enclosure, or raceway, the conductors shall be protected by an identified fitting providing a smoothly rounded insulating surface, unless the conductors are separated from the fitting or raceway by identified insulating material securely fastened in place. [300.4(G)]

**Exception:** Where threaded hubs or bosses that are an integral part of a cabinet, box enclosure, or raceway provide a smoothly rounded or flared entry for conductors. [300.4(G) Exception]

Conduit bushings constructed wholly of insulating material shall not be used to secure a fitting or raceway. The insulating fitting or insulating material shall have a temperature rating not less than the insulation temperature rating of the installed conductors. [330.4(G)]

**E3906.2 Openings.**
Openings through which conductors enter shall be closed in an approved manner. [314.17(A)]

**E3906.3 Metal boxes and conduit bodies.**
Where raceway or cable is installed with metal boxes, or conduit bodies, the raceway or cable shall be secured to such boxes and conduit bodies. [314.17(B)]

**E3906.4 Unused openings.**
Unused openings other than those intended for the operation of equipment, those intended for mounting purposes, or those permitted as part of the design for listed equipment, shall be closed to afford protection substantially equivalent to that of the wall of the equipment. Metal plugs or plates used with nonmetallic boxes or conduit bodies shall be recessed at least \( \frac{1}{4} \) inch (6.4 mm) from the outer surface of the box or conduit body. [110.12(A)]

**E3906.5 In wall or ceiling.**
In walls or ceilings of concrete, tile or other noncombustible material, boxes employing a flush-type cover or faceplate shall be installed so that the front edge of the box, plaster ring, extension ring, or listed extender will not be set back from the finished surface more than \( \frac{1}{4} \) inch (6.4 mm).
In walls and ceilings constructed of wood or other combustible material, boxes, plaster rings, extension rings and listed extenders shall be flush with the finished surface or project therefrom. (314.20)

**E3906.6 Noncombustible surfaces.**
Openings in noncombustible surfaces that accommodate boxes employing a flush type cover or faceplate shall be made so that there are no gaps or open spaces greater than \(\frac{1}{8}\) inch (3.2 mm) around the edge of the box. (314.21)

**E3906.7 Surface extensions.**
Surface extensions shall be made by mounting and mechanically securing an extension ring over the box. (314.22)

**Exception:** A surface extension shall be permitted to be made from the cover of a flush-mounted box where the cover is designed so it is unlikely to fall off, or be removed if its securing means becomes loose. The wiring method shall be flexible for an approved length that permits removal of the cover and provides access to the box interior and shall be arranged so that any bonding or grounding continuity is independent of the connection between the box and cover. (314.22 Exception)

**E3906.8 Supports.**
Boxes and enclosures shall be supported in accordance with one or more of the provisions in Sections E3906.8.1 through E3906.8.6. (314.23)

**E3906.8.1 Surface mounting.**
An enclosure mounted on a building or other surface shall be rigidly and securely fastened in place. If the surface does not provide rigid and secure support, additional support in accordance with other provisions of Section E3906.8 shall be provided. [314.23(A)]

**E3906.8.2 Structural mounting.**
An enclosure supported from a structural member or from grade shall be rigidly supported either directly, or by using a metal, polymeric or wood brace. [314.23(B)]

**E3906.8.2.1 Nails and screws.**
Nails and screws, where used as a fastening means, shall be attached by using brackets on the outside of the enclosure, or they shall pass through the interior within \(\frac{1}{4}\) inch (6.4 mm) of the back or ends of the enclosure. Screws shall not be permitted to pass through the box except where exposed threads in the box are protected by an approved means to avoid abrasion of conductor insulation. [314.23(B)(1)]

**E3906.8.2.2 Braces.**
Metal braces shall be protected against corrosion and formed from metal that is not less than 0.020 inch (0.508 mm) thick uncoated. Wood braces shall have a cross section not less than nominal 1 inch by 2 inches (25.4 mm by 51 mm). Wood braces in wet locations shall be treated for the conditions. Polymeric braces shall be identified as being suitable for the use. [314.23(B)(2)]
E3906.8.3 Mounting in finished surfaces. 
An enclosure mounted in a finished surface shall be rigidly secured there to by clamps, anchors, or fittings identified for the application. [314.23(C)]

E3906.8.4 Raceway supported enclosures without devices or fixtures. 
An enclosure that does not contain a device(s), other than splicing devices, or support a luminaire, lampholder or other equipment, and that is supported by entering raceways shall not exceed 100 cubic inches (1640 cm$^3$) in size. The enclosure shall have threaded entries or identified hubs. The enclosure shall be supported by two or more conduits threaded wrenchtight into the enclosure or hubs. Each conduit shall be secured within 3 feet (914 mm) of the enclosure, or within 18 inches (457 mm) of the enclosure if all entries are on the same side of the enclosure. [314.23(E)]

Exception: Rigid metal, intermediate metal, or rigid polyvinyl chloride nonmetallic conduit or electrical metallic tubing shall be permitted to support a conduit body of any size, provided that the conduit body is not larger in trade size than the largest trade size of the supporting conduit or electrical metallic tubing. [314.23(E) Exception]

E3906.8.5 Raceway supported enclosures, with devices or luminaire. 
An enclosure that contains a device(s), other than splicing devices, or supports a luminaire, lampholder or other equipment and is supported by entering raceways shall not exceed 100 cubic inches (1640 cm$^3$) in size. The enclosure shall have threaded entries or identified hubs. The enclosure shall be supported by two or more conduits threaded wrench tight into the enclosure or hubs. Each conduit shall be secured within 18 inches (457 mm) of the enclosure. [314.23(F)]

Exceptions:

1. Rigid metal or intermediate metal conduit shall be permitted to support a conduit body of any size, provided that the conduit bodies are not larger in trade size than the largest trade size of the supporting conduit. [314.23(F) Exception No. 1]

2. An unbroken length(s) of rigid or intermediate metal conduit shall be permitted to support a box used for luminaire or lampholder support, or to support a wiring enclosure that is an integral part of a luminaire and used in lieu of a box in accordance with Section E3905.1.1., where all of the following conditions are met:

   2.1. The conduit is securely fastened at a point so that the length of conduit beyond the last point of conduit support does not exceed 3 feet (914 mm).

   2.2. The unbroken conduit length before the last point of conduit support is 12 inches (305 mm) or greater, and that portion of the conduit is securely fastened at some point not less than 12 inches (305 mm) from its last point of support.

   2.3. Where accessible to unqualified persons, the luminaire or lampholder, measured to its lowest point, is not less than 8 feet (2438 mm) above grade or standing area and at least 3 feet (914 mm) measured
horizontally to the 8-foot (2438 mm) elevation from windows, doors, porches, fire escapes, or similar locations.

2.4. A luminaire supported by a single conduit does not exceed 12 inches (305 mm) in any direction from the point of conduit entry.

2.5. The weight supported by any single conduit does not exceed 20 pounds (9.1 kg).

2.6. At the luminaire or lampholder end, the conduit(s) is threaded wrenchtight into the box, conduit body, or integral wiring enclosure, or into hubs identified for the purpose. Where a box or conduit body is used for support, the luminaire shall be secured directly to the box or conduit body, or through a threaded conduit nipple not over 3 inches (76 mm) long. [314.23(F) Exception No.-2]

E3906.8.6 Enclosures in concrete or masonry.
An enclosure supported by embedment shall be identified as being suitably protected from corrosion and shall be securely embedded in concrete or masonry. [314.23(G)]

E3906.9 Covers and canopies.
Outlet boxes shall be effectively closed with a cover, faceplate or fixture canopy. Screws used for the purpose of attaching covers, or other equipment to the box shall be either machine screws matching the thread gauge or size that is integral to the box or shall be in accordance with the manufacturer’s instructions. (314.25)

E3906.10 Covers and plates.
Covers and plates shall be nonmetallic or metal. Metal covers and plates shall be grounded. [314.25(A)]

E3906.11 Exposed combustible finish.
Combustible wall or ceiling finish exposed between the edge of a fixture canopy or pan and the outlet box shall be covered with noncombustible material. [314.25(B)]

SECTION E3907
CABINETS AND PANELBOARDS

E3907.1 Switch and overcurrent device enclosures with splices, taps, and feed-through conductors.
Where the wiring space of enclosures for switches or overcurrent devices contains conductors that are feeding through, spliced, or tapping off to other enclosures, switches, or overcurrent devices, all of the following conditions shall apply:

1. The total area of all conductors installed at any cross-section of the wiring space shall not exceed 40 percent of the cross-sectional area of that space.

2. The total area of all conductors, splices, and taps installed at any cross section of the wiring space shall not exceed 75 percent of the cross-sectional area of that space.
3. A warning label shall be applied to the enclosure that identifies the closest disconnecting means for any feed-through conductors. (312.8)

**E3907.2 Damp and wet locations.**
In damp or wet locations, cabinets and panelboards of the surface type shall be placed or equipped so as to prevent moisture or water from entering and accumulating within the cabinet, and shall be mounted to provide an air-space not less than \( \frac{1}{4} \) inch (6.4 mm) between the enclosure and the wall or other supporting surface. Cabinets installed in wet locations shall be weatherproof. For enclosures in wet locations, raceways and cables entering above the level of uninsulated live parts shall be installed with fittings listed for wet locations. (312.2)

**Exception:** Nonmetallic enclosures installed on concrete, masonry, tile, or similar surfaces shall not be required to be installed with an air-space between the enclosure and the wall or supporting surface. (312.2 Exception)

**E3907.3 Position in wall.**
In walls of concrete, tile or other noncombustible material, cabinets and panelboards shall be installed so that the front edge of the cabinet will not set back of the finished surface more than \( \frac{1}{4} \) inch (6.4 mm). In walls constructed of wood or other combustible material, cabinets shall be flush with the finished surface or shall project therefrom. (312.3)

**E3907.4 Repairing noncombustible surfaces.**
Noncombustible surfaces that are broken or incomplete shall be repaired so that there will not be gaps or open spaces greater than \( \frac{1}{8} \) inch (3.2 mm) at the edge of the cabinet or cutout box employing a flush-type cover. (312.4)

**E3907.5 Unused openings.**
Unused openings, other than those intended for the operation of equipment, those intended for mounting purposes, and those permitted as part of the design for listed equipment, shall be closed to afford protection substantially equivalent to that of the wall of the equipment. Metal plugs and plates used with nonmetallic cabinets shall be recessed at least \( \frac{1}{4} \) inch (6.4 mm) from the outer surface. Unused openings for circuit breakers and switches shall be closed using identified closures, or other approved means that provide protection substantially equivalent to the wall of the enclosure. (110.12(A))

**E3907.6 Conductors entering cabinets.**
Conductors entering cabinets and panelboards shall be protected from abrasion and shall comply with Section E3906.1.1. (312.5)

**E3907.7 Openings to be closed.**
Openings through which conductors enter cabinets, panelboards and meter sockets shall be closed in an approved manner. [312.5(A)]

**E3907.8 Cables.**
Where cables are used, each cable shall be secured to the cabinet, panelboard, cutout box, or meter socket enclosure. [312.5(C)]
**Exception:** Cables with entirely nonmetallic sheaths shall be permitted to enter the top of a surface-mounted enclosure through one or more sections of rigid raceway not less than 18 inches (457 mm) nor more than 10 feet (3048 mm) in length, provided all the following conditions are met:

1. Each cable is fastened within 12 inches (305 mm), measured along the sheath, of the outer end of the raceway.

2. The raceway extends directly above the enclosure and does not penetrate a structural ceiling.

3. A fitting is provided on each end of the raceway to protect the cable(s) from abrasion and the fittings remain accessible after installation.

4. The raceway is sealed or plugged at the outer end using approved means so as to prevent access to the enclosure through the raceway.

5. The cable sheath is continuous through the raceway and extends into the enclosure beyond the fitting not less than \( \frac{1}{4} \) inch (6.4 mm).

6. The raceway is fastened at its outer end and at other points in accordance with Section E3802.1.

7. The allowable cable fill shall not exceed that permitted by Table E3907.8. A multiconductor cable having two or more conductors shall be treated as a single conductor for calculating the percentage of conduit fill area. For cables that have elliptical cross sections, the cross-sectional area calculation shall be based on the major diameter of the ellipse as a circle diameter. [312.5(C) Exception]

<table>
<thead>
<tr>
<th>NUMBER OF CONDUCTORS</th>
<th>MAXIMUM PERCENT OF CONDUIT AND TUBING AREA FILLED BY CONDUCTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td>Over 2</td>
<td>40</td>
</tr>
</tbody>
</table>

**E3907.9 Wire-bending space within an enclosure containing a panelboard.**

Wire-bending space within an enclosure containing a panelboard shall comply with the requirements of Sections E3907.9.1 through E3907.9.3.

**E3907.9.1 Top and bottom wire-bending space.**

The top and bottom wire-bending space for a panelboard enclosure shall be sized in accordance with Table E3907.9.1(1) based on the largest conductor entering or leaving the enclosure. [408.55 (A)]

**Exceptions:**

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1. For a panelboard rated at 225 amperes or less and designed to contain not more than 42 overcurrent devices, either the top or bottom wire-bending space shall be permitted to be sized in accordance with Table E3907.9.1(2). For the purposes of this exception, a 2-pole or a 3-pole circuit breaker shall be considered as two or three overcurrent devices, respectively. [408.55(A) Exception No. 1]

2. For any panelboard, either the top or bottom wire-bending space shall be permitted to be sized in accordance with Table E3907.9.1(2) where the wire-bending space on at least one side is sized in accordance with Table E3907.9.1(1) based on the largest conductor to be terminated in any side wire-bending space. [408.55(A) Exception No. 2]

3. Where the panelboard is designed and constructed for wiring using only a single 90-degree bend for each conductor, including the grounded circuit conductor, and the wiring diagram indicates and specifies the method of wiring that must be used, the top and bottom wire-bending space shall be permitted to be sized in accordance with Table E3907.9.1(2). [408.55(A) Exception No. 3]

4. Where there are no conductors terminated in that space, either the top or the bottom wire-bending space, shall be permitted to be sized in accordance with Table E3907.9.1(2). [408.55(A) Exception No. 4]

**TABLE E3907.9.1(1)**

<table>
<thead>
<tr>
<th>WIRES PER TERMINAL</th>
<th>WIRE SIZE (AWG or kcmil)</th>
<th>Compact-stranded AA- 8000 aluminum alloy conductors (see Note 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All-other</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conductors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14-10</td>
<td>12-8</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6</td>
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<td></td>
<td>6</td>
<td>4</td>
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<td>4</td>
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<tr>
<td></td>
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<td>1</td>
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<tr>
<td></td>
<td>2</td>
<td>1/0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2/0</td>
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<tr>
<td></td>
<td>1/0</td>
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</tr>
<tr>
<td></td>
<td>3/0</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>One (see note 2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inches</td>
<td>mm</td>
</tr>
<tr>
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<td>38.1</td>
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<tr>
<td></td>
<td>3</td>
<td>76.2</td>
</tr>
<tr>
<td></td>
<td>1/2</td>
<td>88.9</td>
</tr>
<tr>
<td></td>
<td>1/2</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>5/2</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>6/2</td>
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<tr>
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<td>6/2</td>
<td>165</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inches</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>1/2</td>
<td>38.1</td>
</tr>
<tr>
<td></td>
<td>3</td>
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<tr>
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<td>88.9</td>
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<td></td>
<td>6/2</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>6/2</td>
<td>165a</td>
</tr>
</tbody>
</table>

Note 1: 

Note 2: 

Note 3: 

2018 North Carolina Residential Code
1. Bending space at terminals shall be measured in a straight line from the end of the lug or wire connector in a direction perpendicular to the enclosure wall.

2. For removable and lay-in wire terminals intended for only one wire, bending space shall be permitted to be reduced by the following number of millimeters (inches):
   a. $\frac{1}{2}$ inches (12.7 mm)
   b. $\frac{1}{2} $ inches (25.4 mm)
   c. $\frac{1}{2}$ inches (38.1 mm)
   d. 2 inches (50.8 mm)

3. This column shall be permitted to determine the required wire-bending space for compact stranded aluminum conductors in sizes up to 1000 kcmil and manufactured using AA-8000 series electrical grade aluminum alloy conductor material.

**TABLE E3907.9.1(2)[Table 312.6(A)]**

**MINIMUM WIRE-BENDING SPACE AT TERMINALS AND MINIMUM WIDTH OF WIRING GUTTERS (see note 1)**

<table>
<thead>
<tr>
<th>WIRE SIZE (AWG or kcmil)</th>
<th>WIRES PER TERMINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wires</td>
</tr>
<tr>
<td></td>
<td>inches</td>
</tr>
<tr>
<td>4/0</td>
<td>300</td>
</tr>
<tr>
<td>250</td>
<td>350</td>
</tr>
<tr>
<td>300</td>
<td>400</td>
</tr>
<tr>
<td>350</td>
<td>500</td>
</tr>
<tr>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>500</td>
<td>700-750</td>
</tr>
<tr>
<td>600</td>
<td>800-900</td>
</tr>
<tr>
<td>700</td>
<td>1000</td>
</tr>
</tbody>
</table>

**TABLE E3907.9.1(2)[Table 312.6(A)]**

**MINIMUM WIRE-BENDING SPACE AT TERMINALS AND MINIMUM WIDTH OF WIRING GUTTERS (see note 1)**

<table>
<thead>
<tr>
<th>WIRE SIZE (AWG or kcmil)</th>
<th>WIRES PER TERMINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wires</td>
</tr>
<tr>
<td></td>
<td>inches</td>
</tr>
<tr>
<td>14-10</td>
<td>Not specified</td>
</tr>
<tr>
<td>8-6</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>4-3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1/0-2/0</td>
<td>$\frac{3}{2}$</td>
</tr>
<tr>
<td>3/0-4/0</td>
<td>4</td>
</tr>
<tr>
<td>250</td>
<td>$\frac{4}{2}$</td>
</tr>
</tbody>
</table>
**SECTION E3907**

**E3907.9.1 Side wire-bending space.**
Side wire-bending space shall be in accordance with Table E3907.9.1(2) based on the largest conductor to be terminated in that space. [408.55(B)]

**E3907.9.2 Back wire-bending space.**
The distance between the center of the rear entry and the nearest termination for the entering conductors shall be not less than the distance given in Table E3907.9.1(1). Where a raceway or cable entry is in the wall of the enclosure, opposite a removable cover, the distance from that wall to the cover shall be permitted to comply with the distance required in Table E3907.9.1(2). [408.55(C)]

**SECTION E3908**

**GROUNDING**

**E3908.1 Metal enclosures.**
Metal enclosures of conductors, devices and equipment shall be connected to the equipment grounding conductor. (250.86)

**Exceptions:**

1. Short sections of metal enclosures or raceways used to provide cable assemblies with support or protection against physical damage. (250.86 Exception No. 2)

2. A metal elbow that is installed in an underground installation of rigid nonmetallic conduit and is isolated from possible contact by a minimum cover of 18 inches (457 mm) to any part of the elbow or that is encased in not less than 2 inches (51 mm) of concrete. (250.86 Exception No. 3)

**E3908.2 Equipment fastened in place or connected by permanent wiring methods (fixed).**
Exposed, normally noncurrent-carrying metal parts of fixed equipment supplied by or enclosing conductors or components that are likely to become energized shall be connected to the equipment grounding conductor where any of the following conditions apply:

1. Where within 8 feet (2438 mm) vertically or 5 feet (1524 mm) horizontally of earth or grounded metal objects and subject to contact by persons;

2. Where located in a wet or damp location and not isolated; or

3. Where in electrical contact with metal. (250.110)
E3908.3 Specific equipment fastened in place (fixed) or connected by permanent wiring methods.
Exposed, normally noncurrent-carrying metal parts of the following equipment and enclosures shall be connected to an equipment grounding conductor:

1. Luminaires as provided in Chapter 40. [250.112(J)]

2. Motor-operated water pumps, including submersible types. Where a submersible pump is used in a metal well casing, the well casing shall be connected to the pump circuit equipment grounding conductor. [250.112(L)]

E3908.4 Effective ground-fault current path.
Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. Such circuit shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground-fault might occur to the electrical supply source. [250.4(A)(5)]

E3908.5 Earth as a ground-fault current path.
The earth shall not be considered as an effective ground-fault current path. [250.4(A)(5)]

E3908.6 Load-side grounded conductor neutral.
A grounded conductor shall not be connected to normally noncurrent-carrying metal parts of equipment, to equipment grounding conductor(s), or be reconnected to ground on the load side of the service disconnecting means. [250.24(A)(5)]

E3908.7 Load-side equipment.
A grounded circuit conductor shall not be used for grounding noncurrent-carrying metal parts of equipment on the load side of the service disconnecting means. [250.142(B)]

E3908.8 Types of equipment grounding conductors.
The equipment grounding conductor run with or enclosing the circuit conductors shall be one or more of the following:

1. A copper, aluminum or copper-clad conductor. This conductor shall be solid or stranded; insulated, covered or bare; and in the form of a wire or a busbar of any shape. [250.118(1)]

2. Rigid metal conduit. [250.118(2)]

3. Intermediate metal conduit. [250.118(3)]

4. Electrical metallic tubing. [250.118(4)]

5. Armor of Type AC cable in accordance with Section E3908.4. [250.118(8)]

6. Type MC cable that provides an effective ground-fault current path in accordance with one or more of the following:
6.1. It contains an insulated or uninsulated equipment grounding conductor in compliance with Item 1 of this section.

6.2. The combined metallic sheath and uninsulated equipment grounding/bonding conductor of interlocked metal tape-type MC cable that is listed and identified as an equipment grounding conductor.

6.3. The metallic sheath or the combined metallic sheath and equipment grounding conductors of the smooth or corrugated tube-type MC cable that is listed and identified as an equipment grounding conductor. [250.118(10)]

7. Other electrically continuous metal raceways and auxiliary gutters. [250.118(13)]

8. Surface metal raceways listed for grounding. [250.118(14)]

E3908.8.1 Flexible metal conduit.
Flexible metal conduit shall be permitted as an equipment grounding conductor where all of the following conditions are met:

1. The conduit is terminated in listed fittings.

2. The circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.

3. The combined length of flexible metal conduit and flexible metallic tubing and liquid-tight flexible metal conduit in the same ground return path does not exceed 6 feet (1829 mm).

If used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, an equipment grounding conductor shall be installed. [250.118(5)]

E3908.8.2 Liquid-tight flexible metal conduit.
Liquid-tight flexible metal conduit shall be permitted as an equipment grounding conductor where all of the following conditions are met:

1. The conduit is terminated in listed fittings.

2. For trade sizes $\frac{3}{8}$ through $\frac{1}{2}$ (metric designator 12 through 16), the circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.

3. For trade sizes $\frac{3}{4}$ through $1\frac{1}{4}$ (metric designator 21 through 35), the circuit conductors contained in the conduit are protected by overcurrent devices rated at not more than 60 amperes and there is no flexible metal conduit, flexible metallic tubing, or liquid-tight flexible metal conduit in trade sizes $\frac{3}{8}$ inch or $\frac{1}{2}$ inch (9.5 mm through 12.7 mm) in the ground fault current path.
4. The combined length of flexible metal conduit and flexible metallic tubing and liquid-tight flexible metal conduit in the same ground return path does not exceed 6 feet (1829 mm).

If used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, an equipment grounding conductor shall be installed. [250.118(6)]

E3908.8.3 Nonmetallic sheathed cable (Type NM).
In addition to the insulated conductors, the cable shall have an insulated, covered, or bare equipment grounding conductor. Equipment grounding conductors shall be sized in accordance with Table E3908.12. [334.108]

E3908.9 Equipment fastened in place or connected by permanent wiring methods.
Noncurrent-carrying metal parts of equipment, raceways and other enclosures, where required to be grounded, shall be grounded by one of the following methods: (250.134)

1. By any of the equipment grounding conductors permitted by Sections E3908.8 through E3908.8.3. [250.134(A)]

2. By an equipment grounding conductor contained within the same raceway, cable or cord, or otherwise run with the circuit conductors. Equipment grounding conductors shall be identified in accordance with Section E3407.2. [250.134(B)]

E3908.10 Methods of equipment grounding.
Fixtures and equipment shall be considered grounded where mechanically connected to an equipment grounding conductor as specified in Sections E3908.8 through E3908.8.3. Wire type equipment grounding conductors shall be sized in accordance with Section E3908.12. (250 Part VII)

E3908.11 Equipment grounding-conductor installation.
Where an equipment grounding conductor consists of a raceway, cable armor or cable sheath or where such conductor is a wire within a raceway or cable, it shall be installed in accordance with the provisions of this chapter and Chapters 34 and 38 using fittings for joints and terminations approved for installation with the type of raceway or cable used. All connections, joints and fittings shall be made tight using suitable tools. (250.120)

E3908.12 Equipment grounding-conductor size.
Copper, aluminum and copper-clad aluminum equipment grounding conductors of the wire type shall be not smaller than shown in Table E3908.12, but they shall not be required to be larger than the circuit conductors supplying the equipment. Where a raceway or a cable armor or sheath is used as the equipment grounding conductor, as provided in Section E3908.8, it shall comply with Section E3908.4. Where ungrounded conductors are increased in size from the minimum size that has sufficient ampacity for the intended installation, wire type equipment grounding conductors shall be increased proportionally according to the circular mil area of the ungrounded conductors. [250.122(A) and (B)]

TABLE E3908.12 (Table 250.122)
EQUIPMENT GROUNDING CONDUCTOR SIZING

<table>
<thead>
<tr>
<th>RATING OR SETTING OF AUTOMATIC OVERCURRENT DEVICE IN CIRCUIT AHEAD OF EQUIPMENT, CONDUIT, ETC., NOT EXCEEDING THE FOLLOWING RATINGS (amperes)</th>
<th>MINIMUM SIZE</th>
<th>Aluminum or copper-clad aluminum wire No. (AWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>10</td>
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<td>2</td>
</tr>
<tr>
<td>400</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

E3908.12.1 Multiple circuits.
Where a single equipment grounding conductor is run with multiple circuits in the same raceway or cable, it shall be sized for the largest overcurrent device protecting conductors in the raceway or cable. [250.122(C)]

E3908.13 Continuity and attachment of equipment grounding conductors to boxes.
Where circuit conductors are spliced within a box or terminated on equipment within or supported by a box, any equipment grounding conductors associated with the circuit conductors shall be connected within the box or to the box with devices suitable for the use. Connections depending solely on solder shall not be used. Splices shall be made in accordance with Section E3406.10 except that insulation shall not be required. The arrangement of grounding connections shall be such that the disconnection or removal of a receptacle, luminaire or other device fed from the box will not interfere with or interrupt the grounding continuity. [250.146(A) and (C)]

E3908.14 Connecting receptacle grounding terminal to box.
An equipment bonding jumper, sized in accordance with Table E3908.12 based on the rating of the overcurrent device protecting the circuit conductors, shall be used to connect the grounding terminal of a grounding-type receptacle to a grounded box except where grounded in accordance with one of the following: (C)

1. Surface mounted box. Where the box is mounted on the surface, direct metal-to-metal contact between the device yoke and the box shall be permitted to ground the receptacle to the box. At least one of the insulating washers shall be removed from receptacles that do not have a contact yoke or device designed and listed to be used in conjunction with the supporting screws to establish the grounding circuit between the device yoke and flush-type boxes. This provision shall not apply to cover-mounted receptacles except where the box and cover combination are listed as providing satisfactory ground continuity between the box and the receptacle. A listed exposed work cover shall be considered to be the grounding and bonding means where the device is attached to the cover with at least two fasteners that are permanent, such as a rivet or have a thread locking or screw locking means and where the cover mounting holes are located on a flat non-raised portion of the cover. [250.146(A)]
2. Contact devices or yokes. Contact devices or yokes designed and listed for the purpose shall be permitted in conjunction with the supporting screws to establish equipment bonding between the device yoke and flush-type boxes. [250.146(B)]

3. Floor boxes. The receptacle is installed in a floor box designed for and listed as providing satisfactory ground continuity between the box and the device. [250.146(C)]

E3908.15 Metal boxes.
A connection shall be made between the one or more equipment grounding conductors and a metal box by means of a grounding screw that shall be used for no other purpose, equipment listed for grounding or by means of a listed grounding device. Where screws are used to connect grounding conductors or connection devices to boxes, such screws shall be one or more of the following: [250.148(C)]

1. Machine screw-type fasteners that engage not less than two threads.

2. Machine screw-type fasteners that are secured with a nut.

3. Thread-forming machine screws that engage not less than two threads in the enclosure. [250.8(5) and (6)]

E3908.16 Nonmetallic boxes.
One or more equipment grounding conductors brought into a nonmetallic outlet box shall be arranged to allow connection to fittings or devices installed in that box. [250.148(D)]

E3908.17 Clean surfaces.
Nonconductive coatings such as paint, lacquer and enamel on equipment to be grounded shall be removed from threads and other contact surfaces to ensure electrical continuity or the equipment shall be connected by means of fittings designed so as to make such removal unnecessary. (250.12)

E3908.18 Bonding other enclosures.
Metal raceways, cable armor, cable sheath, enclosures, frames, fittings and other metal noncurrent-carrying parts that serve as equipment grounding conductors, with or without the use of supplementary equipment grounding conductors, shall be effectively bonded where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them. Any nonconductive paint, enamel and similar coating shall be removed at threads, contact points and contact surfaces, or connections shall be made by means of fittings designed so as to make such removal unnecessary. [250.96(A)]

E3908.19 Size of equipment bonding jumper on load side of an overcurrent device.
The equipment bonding jumper on the load side of an overcurrent devices shall be sized, as a minimum, in accordance with Table E3908.12, but shall not be required to be larger than the circuit conductors supplying the equipment. An equipment bonding conductor shall be not smaller than No. 14 AWG.

A single common continuous equipment bonding jumper shall be permitted to connect two or more raceways or cables where the bonding jumper is sized in accordance with Table E3908.12 for the largest overcurrent device supplying circuits therein. [250.102(D) and 250.122]
E3908.20 Installation equipment bonding jumper.
Bonding jumpers or conductors and equipment bonding jumpers shall be installed either inside or outside of a raceway or an enclosure in accordance with Sections E3908.20.1 and E3908.20.2. [250.102(E)]

E3908.20.1 Inside raceway or enclosure.
Where installed inside a raceway or enclosure, equipment bonding jumpers and bonding jumpers or conductors shall comply with the requirements of Sections E3407.2 and E3908.13. [250.102(E)(1)]

E3908.20.2 Outside raceway or enclosure.
Where installed outside of a raceway or enclosure, the length of the bonding jumper or conductor or equipment bonding jumper shall not exceed 6 feet (1829 mm) and shall be routed with the raceway or enclosure. [250.102(E)(2)]

Equipment bonding jumpers and supply-side bonding jumpers installed for bonding grounding electrodes and installed at outdoor pole locations for the purpose of bonding or grounding isolated sections of metal raceways or elbows installed in exposed risers of metal conduit or other metal raceway, shall not be limited in length and shall not be required to be routed with a raceway or enclosure. [250.102(E)(2) Exception]

E3908.20.3 Protection.
Bonding jumpers or conductors and equipment bonding jumpers shall be installed in accordance with Section E3610.2. [250.102(E)(3)]

SECTION E3909
FLEXIBLE CORDS

E3909.1 Where permitted.
Flexible cords shall be used only for the connection of appliances where the fastening means and mechanical connections of such appliances are designed to permit ready removal for maintenance, repair or frequent interchange and the appliance is listed for flexible cord connection. Flexible cords shall not be installed as a substitute for the fixed wiring of a structure; shall not be run through holes in walls, structural ceilings, suspended ceilings or floors; shall not be concealed behind walls, floors, ceilings or located above suspended or dropped ceilings. (400.7 and 400.8)

E3909.2 Loading and protection.
The ampere load of flexible cords serving fixed appliances shall be in accordance with Table E3909.2. This table shall be used in conjunction with applicable end use product standards to ensure selection of the proper size and type. Where flexible cord is approved for and used with a specific listed appliance, it shall be considered to be protected where applied within the appliance listing requirements. [240.4, 240.5(A), 240.5(B)(1), 400.5, and 400.13]

<p>| CORD SIZE (AWG) | CORD TYPES S, SE, SEO, SJ, SJE, SJE0, SJO, SJ00, SJT, SJTO, SJTO0, SO, SO0, SRD, SRDE, SRDT, ST, STD, SV, SVO, SVO0, SVTO, SVTO0 |</p>
<table>
<thead>
<tr>
<th>Diameter (in mm)</th>
<th>Three-current-carrying conductors</th>
<th>Two-current-carrying conductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

**E3909.3 Splices.**
Flexible cord shall be used only in continuous lengths without splices or taps. (400.9)

**E3909.4 Attachment plugs.**
Where used in accordance with Section E3909.1, each flexible cord shall be equipped with an attachment plug and shall be energized from a receptacle outlet. [400.7(B)]
CHAPTER 40
DEVICES AND LUMINAIRES

Deleted. See the North Carolina Electrical Code.

SECTION E4001
SWITCHES

E4001.1 Rating and application of snap switches.
General use snap switches shall be used within their ratings and shall control only the following loads:

1. Resistive and inductive loads not exceeding the ampere rating of the switch at the voltage involved.

2. Tungsten-filament lamp loads not exceeding the ampere rating of the switch at 120 volts.

3. Motor loads not exceeding 80 percent of the ampere rating of the switch at its rated voltage. [404.14(A)]

E4001.2 CO/ALR snap switches.
Snap switches rated 20 amperes or less directly connected to aluminum conductors shall be marked CO/ALR. [404.14(C)]

E4001.3 Indicating.
General use and motor-circuit switches and circuit breakers shall clearly indicate whether they are in the open OFF or closed ON position. Where single-throw switches or circuit-breaker handles are operated vertically rather than rotationally or horizontally, the up position of the handle shall be the closed (on) position.

E4001.4 Time switches and similar devices.
Time switches and similar devices shall be of the enclosed type or shall be mounted in cabinets or boxes or equipment enclosures. A barrier shall be used around energized parts to prevent operator exposure when making manual adjustments or switching. (404.5]

E4001.5 Grounding of enclosures.
Metal enclosures for switches or circuit breakers shall be connected to an equipment grounding conductor. Metal enclosures for switches or circuit breakers used as service equipment shall comply with the provisions of Section E3609.4. Where nonmetallic enclosures are used with metal raceways or metal-armored cables, provisions shall be made for connecting the equipment grounding conductor.

Nonmetallic boxes for switches shall be installed with a wiring method that provides or includes an equipment grounding conductor. (404.12)

E4001.6 Access.
Switches and circuit breakers used as switches shall be located to allow operation from a readily accessible location. Such devices shall be installed so that the center of the grip of the
operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6 feet 7 inches (2007 mm) above the floor or working platform. [404.8(A)]

**Exception:** This section shall not apply to switches and circuit breakers that are accessible by portable means and are installed adjacent to the motors, appliances and other equipment that they supply. [404.8(A) Exception]

**E4001.7 Damp or wet locations.**
A surface mounted switch or circuit breaker located in a damp or wet location or outside of a building shall be enclosed in a weatherproof enclosure or cabinet. A flush-mounted switch or circuit breaker in a damp or wet location shall be equipped with a weatherproof cover. Switches shall not be installed within wet locations in tub or shower spaces unless installed as part of a listed tub or shower assembly. [404.8(A),(B), and (C)]

**E4001.8 Grounded conductors.**
Switches or circuit breakers shall not disconnect the grounded conductor of a circuit except where the switch or circuit breaker simultaneously disconnects all conductors of the circuit. [404.2(B)]

**E4001.9 Switch connections.**
Three- and four-way switches shall be wired so that all switching occurs only in the ungrounded circuit conductor. Color coding of switch connection conductors shall comply with Section E3407.3. Where in metal raceways or metal-jacketed cables, wiring between switches and outlets shall be in accordance with Section E3406.7. [404.2(A)]

**Exception:** Switch loops do not require a grounded conductor. [404.2(A) Exception]

**E4001.10 Box mounted.**
Flush-type snap switches mounted in boxes that are recessed from the finished wall surfaces as covered in Section E3906.5 shall be installed so that the extension plaster ears are seated against the surface of the wall. Flush-type snap switches mounted in boxes that are flush with the finished wall surface or project therefrom shall be installed so that the mounting yoke or strap of the switch is seated against the box. Screws used for the purpose of attaching a snap switch to a box shall be of the type provided with a listed snap switch, or shall be machine screws having 32 threads per inch or part of listed assemblies or systems, in accordance with the manufacturer’s instructions. [404.10(B)]

**E4001.11 Snap switch faceplates.**
Faceplates provided for snap switches mounted in boxes and other enclosures shall be installed so as to completely cover the opening and, where the switch is flush mounted, seat against the finished surface. [404.9(A)]

**E4001.11.1 Faceplate grounding.**
Snap switches, including dimmer and similar control switches, shall be connected to an equipment grounding conductor and shall provide a means to connect metal faceplates to the equipment grounding conductor, whether or not a metal faceplate is installed. Snap switches shall be considered to be part of an effective ground-fault current path if either of the following conditions is met:
1. The switch is mounted with metal screws to a metal box or metal cover that is connected to an equipment grounding conductor or to a nonmetallic box with integral means for connecting to an equipment grounding conductor.

2. An equipment grounding conductor or equipment bonding jumper is connected to an equipment grounding termination of the snap switch. [404.9(B)]

Exceptions:

1. Where a means to connect to an equipment grounding conductor does not exist within the snap-switch enclosure or where the wiring method does not include or provide an equipment grounding conductor, a snap switch without a grounding connection to an equipment grounding conductor shall be permitted for replacement purposes only. A snap switch wired under the provisions of this exception and located within 8 feet (2438 mm) vertically or 5 feet (1524 mm) horizontally of ground or exposed grounded metal objects, shall be provided with a faceplate of nonconductive noncombustible material with nonmetallic attachment screws, except where the switch-mounting strap or yoke is nonmetallic or the circuit is protected by a ground-fault circuit interrupter. [404.9(B) Exception No.1]

2. Listed kits or listed assemblies shall not be required to be connected to an equipment grounding conductor if all of the following conditions apply:

   2.1. The device is provided with a nonmetallic faceplate that cannot be installed on any other type of device.

   2.2. The device does not have mounting means to accept other configurations of faceplates.

   2.3. The device is equipped with a nonmetallic yoke.

   2.4. All parts of the device that are accessible after installation of the faceplate are manufactured of nonmetallic materials. [404.9(B) Exception No. 2]

3. Connection to an equipment grounding conductor shall not be required for snap switches that have an integral nonmetallic enclosure complying with Section E3905.1.3. [404.9(B) Exception No.3]

---

**E4001.12 Dimmer switches.**

General-use dimmer switches shall be used only to control permanently installed incandescent luminaires (lighting fixtures) except where listed for the control of other loads and installed accordingly. [404.14(E)]

**E4001.13 Multipole snap switches.**

A multipole, general-use snap switch shall not be fed from more than a single circuit unless it is listed and marked as a two-circuit or three-circuit switch. [404.8(C)]

**E4001.14 Cord-and-plug-connected loads.**

Where snap switches are used to control cord-and-plug-connected equipment on a general-
purpose branch circuit, each snap switch controlling receptacle outlets or cord connectors that are supplied by permanently connected cord pendants shall be rated at not less than the rating of the maximum permitted ampere rating or setting of the overcurrent device protecting the receptacles or cord connectors, as provided in Sections E4002.1.1 and E4002.1.2. [404.14(F)]

E4001.15 Switches controlling lighting loads.
The grounded circuit conductor for the controlled lighting circuit shall be provided at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit other than the following:

1. Where conductors enter the box enclosing the switch through a raceway, provided that the raceway is large enough for all contained conductors, including a grounded conductor.

2. Where the box enclosing the switch is accessible for the installation of an additional or replacement cable without removing finish materials.

3. Where snap switches with integral enclosures comply with E3905.1.3.

4. Where the switch does not serve a habitable room or bathroom.

5. Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations.

6. Where lighting in the area is controlled by automatic means.

7. Where the switch controls a receptacle load. [404.2(C)]

SECTION E4002
RECEPTACLES

E4002.1 Rating and type.
Receptacles and cord connectors shall be rated at not less than 15 amperes, 125 volts, or 15 amperes, 250 volts, and shall not be a lampholder type. Receptacles shall be rated in accordance with this section. [406.3(B)]

E4002.1.1 Single receptacle.
A single receptacle installed on an individual branch circuit shall have an ampere rating not less than that of the branch circuit. [210.21(B)]

E4002.1.2 Two or more receptacles.
Where connected to a branch circuit supplying two or more receptacles or outlets, receptacles shall conform to the values listed in Table E4002.1.2. [210.21(B)(3)]

<table>
<thead>
<tr>
<th>CIRCUIT RATING (amperes)</th>
<th>RECEPTACLE RATING (amperes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
E4002.2 Grounding type.
Receptacles installed on 15- and 20-ampere-rated branch circuits shall be of the grounding type. [406.4(A)]

E4002.3 CO/ALR receptacles.
Receptacles rated at 20 amperes or less and directly connected to aluminum conductors shall be marked CO/ALR. [406.3(C)]

E4002.4 Faceplates.
Metal face plates shall be grounded. [406.6(B)]

E4002.5 Position of receptacle faces.
After installation, receptacle faces shall be flush with or project from face plates of insulating material and shall project a minimum of 0.015 inch (0.381 mm) from metal face plates. Faceplates shall be installed so as to completely cover the opening and seat against the mounting surface. Receptacle faceplates mounted inside of a box having a recess-mounted receptacle shall effectively close the opening and seat against the mounting surface. [406.5(D), 406.6]

Exception: Listed kits or assemblies encompassing receptacles and nonmetallic faceplates that cover the receptacle face, where the plate cannot be installed on any other receptacle, shall be permitted. [406.5(D) Exception]

E4002.6 Receptacle mounted in boxes.
Receptacles mounted in boxes that are set back from the finished wall surface as permitted by Section E3906.5 shall be installed so that the mounting yoke or strap of the receptacle is held rigidly at the finished surface of the wall. Screws used for the purpose of attaching receptacles to a box shall be of the type provided with a listed receptacle, or shall be machine screws having 32 threads per inch or part of listed assemblies or systems, in accordance with the manufacturer's instructions. Receptacles mounted in boxes that are flush with the wall surface or project therefrom shall be so installed that the mounting yoke or strap is seated against the box or raised cover. [406.5(A) and (B)]

E4002.7 Receptacles mounted on covers.
Receptacles mounted to and supported by a cover shall be held rigidly against the cover by more than one screw or shall be a device assembly or box cover listed and identified for securing by a single screw. [406.5(C)]

E4002.8 Damp locations.
A receptacle installed outdoors in a location protected from the weather or in other damp locations shall have an enclosure for the receptacle that is weatherproof when the receptacle cover(s) is closed and an attachment plug cap is not inserted. An installation suitable for wet locations shall also be considered suitable for damp locations. A receptacle shall be considered to be in a location protected from the weather where located under roofed open porches, canopies and similar structures and not subject to rain or water runoff. Fifteen- and 20-ampere,
125- and 250-volt nonlocking receptacles installed in damp locations shall be listed a weather-resistant type. [406.9(A)]

**E4002.9 Fifteen- and 20-ampere receptacles in wet locations.**
Where installed in a wet location, 15- and 20-ampere, 125- and 250-volt receptacles shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and identified as "extra-duty." Fifteen- and 20-ampere, 125- and 250-volt nonlocking receptacles installed in wet locations shall be a listed weather-resistant type. [406.9(B)(1)]

**E4002.10 Other receptacles in wet locations.**
Where a receptacle other than a 15- or 20-amp, 125- or 250-volt receptacle is installed in a wet location and where the product intended to be plugged into it is not attended while in use, the receptacle shall have an enclosure that is weatherproof both when the attachment plug cap is inserted and when it is removed. Where such receptacle is installed in a wet location and where the product intended to be plugged into it will be attended while in use, the receptacle shall have an enclosure that is weatherproof when the attachment plug cap is removed. [406.9(B)(2)]

**E4002.11 Bathtub and shower space.**
A receptacle shall not be installed within or directly over a bathtub or shower stall. [406.9(C)]

**E4002.12 Flush mounting with faceplate.**
In damp or wet locations, the enclosure for a receptacle installed in an outlet box flush-mounted in a finished surface shall be made weatherproof by means of a weatherproof faceplate assembly that provides a water-tight connection between the plate and the finished surface. [406.9(E)]

**E4002.13 Exposed terminals.**
Receptacles shall be enclosed so that live wiring terminals are not exposed to contact. [406.5(G)]

**E4002.14 Tamper-resistant receptacles.**
In areas specified in Section E3901.1, 125-volt, 15- and 20-ampere receptacles shall be listed tamper-resistant receptacles. [406.12(A)]

**Exception:** Receptacles in the following locations shall not be required to be tamper resistant:

1. Receptacles located more than 5.5 feet (1676 mm) above the floor.

2. Receptacles that are part of a luminaire or appliance.

3. A single receptacle for a single appliance or a duplex receptacle for two appliances where such receptacles are located in spaces dedicated for the appliances served and, under conditions of normal use, the appliances are not easily moved from one place to another. The appliances shall be cord-and-plug-connected to such receptacles in accordance with Section E3909.4. [406.12(A) Exception]

**E4002.15 Dimmer-controlled receptacles.**
A receptacle supplying lighting loads shall not be connected to a dimmer except where the plug
SECTION E4003
LUMINAIRES

E4003.1 Energized parts.
Luminaires, lampholders, and lamps shall not have energized parts normally exposed to contact. (410.5)

E4003.2 Luminaires near combustible material.
Luminaires shall be installed or equipped with shades or guards so that combustible material will not be subjected to temperatures in excess of 90°C (194°F). (410.11)

E4003.3 Exposed conductive parts.
The exposed metal parts of luminaires shall be connected to an equipment grounding conductor or shall be insulated from the equipment grounding conductor and other conducting surfaces. Lamp tie wires, mounting screws, clips and decorative bands on glass spaced at least \( 1\frac{1}{2} \) inches (38 mm) from lamp terminals shall not be required to be grounded. (410.42)

E4003.4 Screw-shell type.
Lampholders of the screw-shell type shall be installed for use as lampholders only. (410.90)

E4003.5 Recessed incandescent luminaires.
Recessed incandescent luminaires shall have thermal protection and shall be listed as thermally protected. [410.115(C)]

Exceptions:

1. Thermal protection shall not be required in recessed luminaires listed for the purpose and installed in poured concrete. [410.115(C) Exception No. 1]

2. Thermal protection shall not be required in recessed luminaires having design, construction, and thermal performance characteristics equivalent to that of thermally protected luminaires, and such luminaires are identified as inherently protected. [410.115(C) Exception No. 2]

E4003.6 Thermal protection.
The ballast of a fluorescent luminaire installed indoors shall have integral thermal protection. Replacement ballasts shall also have thermal protection integral with the ballast. A simple reactance ballast in a fluorescent luminaire with straight tubular lamps shall not be required to be thermally protected. [410.130(E)(1)]

E4003.7 High-intensity discharge luminaires.
Recessed high-intensity luminaires designed to be installed in wall or ceiling cavities shall have thermal protection and be identified as thermally protected. Thermal protection shall not be required in recessed high-intensity luminaires having design, construction and thermal performance characteristics equivalent to that of thermally protected luminaires, and such luminaires are identified as inherently protected. Thermal protection shall not be required in
recessed high-intensity discharge luminaires installed in and identified for use in poured concrete. A recessed remote ballast for a high-intensity discharge luminaire shall have thermal protection that is integral with the ballast and shall be identified as thermally protected. [110.130(F)(1),(2),(3), and (4)]

E4003.8 Metal halide lamp containment.
Luminaires that use a metal halide lamp other than a thick-glass parabolic reflector lamp (PAR) shall be provided with a containment barrier that encloses the lamp, or shall be provided with a physical means that allows the use of only a lamp that is Type O. [(110.130(F)(5)]

E4003.9 Wet or damp locations.
Luminaires installed in wet or damp locations shall be installed so that water cannot enter or accumulate in wiring compartments, lampholders or other electrical parts. All luminaires installed in wet locations shall be marked SUITABLE FOR WET LOCATIONS. All luminaires installed in damp locations shall be marked SUITABLE FOR WET LOCATIONS or SUITABLE FOR DAMP LOCATIONS. (410.10)

E4003.10 Lampholders in wet or damp locations.
Lampholders installed in wet locations shall be listed for use in wet locations. Lampholders installed in damp locations shall be listed for damp locations or shall be listed for wet locations. (410.96)

E4003.11 Bathtub and shower areas.
Cord-connected luminaires, chain-, cable-, or cord-suspended luminaires, lighting track, pendants, and ceiling-suspended (paddle) fans shall not have any parts located within a zone measured 3 feet (914 mm) horizontally and 8 feet (2438 mm) vertically from the top of a bathtub rim or shower stall threshold. This zone is all encompassing and includes the space directly over the tub or shower. Luminaires within the actual outside dimension of the bathtub or shower to a height of 8 feet (2438 mm) vertically from the top of the bathtub rim or shower threshold shall be marked for damp locations and where subject to shower spray, shall be marked for wet locations. [410.4(D)]

E4003.12 Luminaires in clothes closets.
For the purposes of this section, storage space shall be defined as a volume bounded by the sides and back closet walls and planes extending from the closet floor vertically to a height of 6 feet (1829 mm) or the highest clothes-hanging rod and parallel to the walls at a horizontal distance of 24 inches (610 mm) from the sides and back of the closet walls respectively, and continuing vertically to the closet ceiling parallel to the walls at a horizontal distance of 12 inches (305 mm) or the width of the shelf, whichever is greater. For a closet that permits access to both sides of a hanging rod, the storage space shall include the volume below the highest rod extending 12 inches (305 mm) on either side of the rod on a plane horizontal to the floor extending the entire length of the rod (see Figure E4003.12). (410.2)

The types of luminaires installed in clothes closets shall be limited to surface-mounted or recessed incandescent or LED luminaires with completely enclosed light sources, surface-mounted or recessed fluorescent luminaires, and surface-mounted fluorescent or LED luminaires identified as suitable for installation within the closet storage area. Incandescent luminaires with open or partially enclosed lamps and pendant luminaires or lamp holders shall be prohibited. The minimum clearance between luminaires installed in clothes closets and the nearest point of a closet storage area shall be as follows: [410.16(A) and (B)]
1. Surface-mounted incandescent or LED luminaires with a completely enclosed light source shall be installed on the wall above the door or on the ceiling, provided that there is a minimum clearance of 12 inches (305 mm) between the fixture and the nearest point of a storage space.

2. Surface-mounted fluorescent luminaires shall be installed on the wall above the door or on the ceiling, provided that there is a minimum clearance of 6 inches (152 mm).

3. Recessed incandescent luminaires or LED luminaires with a completely enclosed light source shall be installed in the wall or the ceiling provided that there is a minimum clearance of 6 inches (152 mm).

4. Recessed fluorescent luminaires shall be installed in the wall or on the ceiling provided that there is a minimum clearance of 6 inches (152 mm) between the fixture and the nearest point of a storage space.

5. Surface-mounted fluorescent or LED luminaires shall be permitted to be installed within the closet storage space where identified for this use. [410.16(C)]
E4003.13 Luminaire wiring—general.
Wiring on or within luminaires shall be neatly arranged and shall not be exposed to physical damage. Excess wiring shall be avoided. Conductors shall be arranged so that they are not subjected to temperatures above those for which the conductors are rated. (410.48)

E4003.13.1 Polarization of luminaires.
Luminaires shall be wired so that the screw shells of lampholders will be connected to the same luminaire or circuit conductor or terminal. The grounded conductor shall be connected to the screw shell.

E4003.13.2 Luminaires as raceways.
Luminaires shall not be used as raceways for circuit conductors except where such luminaires are listed and marked for use as a raceway or are identified for through-wiring. Luminaires designed for end-to-end connection to form a continuous assembly, and luminaires connected together by recognized wiring methods, shall not be required to be listed as a raceway where they contain the conductors of one 2-wire branch circuit or one multiwire branch circuit and such conductors supply the connected luminaires. One additional 2-wire branch circuit that separately supplies one or more of the connected luminaires shall also be permitted. [410.64(A),(B), and (C)]

SECTION E4004
LUMINAIRE INSTALLATION

E4004.1 Outlet box covers.
In a completed installation, each outlet box shall be provided with a cover except where covered by means of a luminaire canopy, lampholder or device with a faceplate. (410.22)

E4004.2 Combustible material at outlet boxes.
Combustible wall or ceiling finish exposed between the inside edge of a luminaire canopy or pan and the outlet box and having a surface area of 180 in.² (116 129 mm²) or more shall be covered with a noncombustible material.

E4004.3 Access.
Luminaires shall be installed so that the connections between the luminaire conductors and the circuit conductors can be accessed without requiring the disconnection of any part of the wiring. Luminaires that are connected by attachment plugs and receptacles meet the requirement of this section. (410.8)

E4004.4 Supports.
Luminaires and lampholders shall be securely supported. A luminaire that weighs more than 6 pounds (2.72 kg) or exceeds 16 inches (406 mm) in any dimension shall not be supported by the screw shell of a lampholder. [410.36(A)]

E4004.5 Means of support.
Outlet boxes or fittings installed as required by Sections E3905 and E3906 shall be permitted to support luminaires. [410.36(A)]
**E4004.6 Exposed components.**
Luminaires having exposed ballasts, transformers, LED drivers or power supplies shall be installed so that such ballasts, transformers, LED drivers or power supplies are not in contact with combustible material unless listed for such condition. [410.136(A)]

**E4004.7 Combustible low-density cellulose fiberboard.**
Where a surface-mounted luminaire containing a ballast, transformer, LED driver or power supply is installed on combustible low-density cellulose fiberboard, the luminaire shall be marked for this purpose or it shall be spaced not less than \(1 \frac{1}{2}\) inches (38 mm) from the surface of the fiberboard. Where such luminaires are partially or wholly recessed, the provisions of Sections E4004.8 and E4004.9 shall apply. [410.136(B)]

**E4004.8 Recessed luminaire clearance.**
A recessed luminaire that is not identified for contact with insulation shall have all recessed parts spaced at least \(1 \frac{1}{2}\) inch (12.7 mm) from combustible materials. The points of support and the finish trim parts at the opening in the ceiling, wall or other finished surface shall be permitted to be in contact with combustible materials. A recessed luminaire that is identified for contact with insulation, Type IC, shall be permitted to be in contact with combustible materials at recessed parts, points of support, and portions passing through the building structure and at finish trim parts at the opening in the ceiling or wall. [410.116(A)(1) and (A)(2)]

**E4004.9 Recessed luminaire installation.**
Thermal insulation shall not be installed above a recessed luminaire or within 3 inches (76 mm) of the recessed luminaire’s enclosure, wiring compartment, ballast, transformer, LED driver or power supply except where such luminaire is identified for contact with insulation, Type IC. [410.116(B)]

**SECTION E4005**
**TRACK LIGHTING**

**E4005.1 Installation.**
Lighting track shall be permanently installed and permanently connected to a branch circuit having a rating not more than that of the track. [410.151(A) and (B)]

**E4005.2 Fittings.**
Fittings identified for use on lighting track shall be designed specifically for the track on which they are to be installed. Fittings shall be securely fastened to the track, shall maintain polarization and connection to the equipment grounding conductor, and shall be designed to be suspended directly from the track. Only lighting track fittings shall be installed on lighting track. Lighting track fittings shall not be equipped with general-purpose receptacles. [410.151(A) and (B)]

**E4005.3 Connected load.**
The connected load on lighting track shall not exceed the rating of the track. [410.151(B)]

**E4005.4 Prohibited locations.**
Lighting track shall not be installed in the following locations:
1. Where likely to be subjected to physical damage.

2. In wet or damp locations.

3. Where subject to corrosive vapors.

4. In storage battery rooms.

5. In hazardous (classified) locations.


7. Where extended through walls or partitions.

8. Less than 5 feet (1524 mm) above the finished floor except where protected from physical damage or the track operates at less than 30 volts rms open-circuit voltage.

9. Where prohibited by Section E4003.11. [410.151(C)]

E4005.5 Fastening.
Lighting track shall be securely mounted so that each fastening will be suitable for supporting the maximum weight of luminaires that can be installed. Except where identified for supports at greater intervals, a single section 4 feet (1219 mm) or shorter in length shall have two supports and, where installed in a continuous row, each individual section of not more than 4 feet (1219 mm) in length shall have one additional support. (410.154)

E4005.6 Grounding.
Lighting track shall be grounded in accordance with Chapter 39, and the track sections shall be securely coupled to maintain continuity of the circuitry, polarization and grounding throughout. [410.155(B)]
CHAPTER 41
APPLIANCE INSTALLATION

Deleted. See the North Carolina Electrical Code.

SECTION E4101
GENERAL

E4101.1 Scope.
This section covers installation requirements for appliances and fixed heating equipment. (422.1 and 424.1)

E4101.2 Installation.
Appliances and equipment shall be installed in accordance with the manufacturer’s installation instructions. Electrically heated appliances and equipment shall be installed with the required clearances to combustible materials. [110.3(B) and 422.17]

E4101.3 Flexible cords.
Cord-and-plug-connected appliances shall use cords suitable for the environment and physical conditions likely to be encountered. Flexible cords shall be used only where the appliance is listed to be connected with a flexible cord. The cord shall be identified as suitable in the installation instructions of the appliance manufacturer. Receptacles for cord-and-plug-connected appliances shall be accessible and shall be located to avoid physical damage to the flexible cord. Except for a listed appliance marked to indicate that it is protected by a system of double-insulation, the flexible cord supplying an appliance shall terminate in a grounding-type attachment plug. A receptacle for a cord-and-plug-connected range hood shall be supplied by an individual branch circuit. Specific appliances have additional requirements as specified in Table E4101.3 (see Section E3909). [422.16(B)(1), (B)(2)]

TABLE E4101.3
FLEXIBLE CORD LENGTH

<table>
<thead>
<tr>
<th>APPLIANCE</th>
<th>MINIMUM CORD LENGTH (inches)</th>
<th>MAXIMUM CORD LENGTH (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrically operated in-</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>sink waste disposal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Built-in dishwasher</td>
<td>36</td>
<td>48</td>
</tr>
<tr>
<td>Trash compactor</td>
<td>36</td>
<td>48</td>
</tr>
<tr>
<td>Range hoods</td>
<td>18</td>
<td>36</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

E4101.4 Overcurrent protection.
Each appliance shall be protected against overcurrent in accordance with the rating of the appliance and its listing. [110.3(B), 422.11(A)]

E4101.4.1 Single nonmotor-operated appliance.
The overcurrent protection for a branch circuit that supplies a single nonmotor-operated appliance shall not exceed that marked on the appliance. Where the overcurrent protection
rating is not marked and the appliance is rated at over 13.3 amperes, the overcurrent protection shall not exceed 150 percent of the appliance rated current. Where 150 percent of the appliance rating does not correspond to a standard overcurrent device ampere rating, the next higher standard rating shall be permitted. Where the overcurrent protection rating is not marked and the appliance is rated at 13.3 amperes or less, the overcurrent protection shall not exceed 20 amperes. [422.11(E)]

**E4101.5 Disconnecting means.**
Each appliance shall be provided with a means to disconnect all ungrounded supply conductors. For fixed electric space-heating equipment, means shall be provided to disconnect the heater and any motor controller(s) and supplementary overcurrent protective devices. Switches and circuit breakers used as a disconnecting means shall be of the indicating type. Disconnecting means shall be as set forth in Table E4101.5. (422.30, 422.35, and 424.19)

**TABLE E4101.5**
**DISCONNECTING MEANS** [422.31(A), (B), and (C); 422.34; 422.35; 424.19; 424.20; and 440.14]

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>ALLOWED DISCONNECTING MEANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanently connected appliance rated at not over 300 volt-amperes or (\frac{1}{8}) horsepower.</td>
<td>Branch-circuit overcurrent device.</td>
</tr>
<tr>
<td>Permanently connected appliances rated in excess of 300 volt-amperes.</td>
<td>Branch-circuit breaker or switch located within sight of appliance or such devices in any location that are capable of being locked in the open position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed.</td>
</tr>
<tr>
<td>Motor-operated appliances rated over (\frac{1}{8}) horsepower.</td>
<td>A permanently connected motor-operated appliance with motors rated over (\frac{1}{8}) horsepower, the branch circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the appliance. Where the branch circuit switch is not located within sight from the appliance, the disconnecting means shall be one of the following types: a listed motor-circuit switch rated in horsepower, a listed molded case circuit breaker, a listed molded case switch, a listed manual motor controller additionally marked “Suitable as Motor Disconnect” where installed.</td>
</tr>
</tbody>
</table>
between the final motor branch-circuit short-circuit protective device and the motor. For stationary motors rated at 2 hp or less and 300 volts or less, the disconnecting means shall be permitted to be one of the following devices:

1. A general-use switch having an ampere rating not less than twice the full-load current rating of the motor.
2. On AC circuits, a general-use snap switch suitable only for use on AC, not general-use AC–DC snap switches, where the motor full-load current rating is not more than 80 percent of the ampere rating of the switch.
3. A listed manual motor controller having a horsepower rating not less than the rating of the motor and marked “Suitable as Motor Disconnect”.

The disconnecting means for motor circuits rated 600 volts, nominal, or less shall have an ampere rating not less than 115 percent of the full-load current rating of the motor except that a listed unfused motor-circuit switch having a horsepower rating not less than the motor horsepower shall be permitted to have an ampere rating less than 115 percent of the full-load current rating of the motor. The disconnecting means shall be installed within sight of the appliance.

**Exception:** A unit switch with a marked-off position that is a part of an appliance and disconnects all ungrounded conductors shall be permitted as the disconnecting means and the switch or circuit breaker serving as the other disconnecting means shall be permitted to be out of sight from the appliance.

### TABLE E4101.5—continued

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>ALLOWED DISCONNECTING MEANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanently installed heating equipment with motors rated at not over 1/4 horsepower with supplementary overcurrent protection.</td>
<td>Disconnect, on the supply side of fuses, in sight from the supplementary overcurrent device, and in sight of the heating equipment or, in any location, if capable of being locked in the open position.</td>
</tr>
</tbody>
</table>
### Heating equipment containing motors rated over \( \frac{1}{8} \) horsepower with supplementary overcurrent protection.

Disconnect permitted to serve as required disconnect for both the heating equipment and the controller where, on the supply side of fuses, and in sight from the supplementary overcurrent devices, if the disconnecting means is also in sight from the controller, or is capable of being locked off and simultaneously disconnects the heater, motor controller(s) and supplementary overcurrent protective devices from all ungrounded conductors. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed. The disconnecting means shall have an ampere rating not less than 125 percent of the total load of the motors and the heaters.

### Heating equipment containing no motor rated over \( \frac{1}{8} \) horsepower without supplementary overcurrent protection.

Branch-circuit switch or circuit breaker where within sight from the heating equipment or capable of being locked off and simultaneously disconnects the heater, motor controller(s) and supplementary overcurrent protective devices from all ungrounded conductors. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed. The disconnecting means shall have an ampere rating not less than 125 percent of the total load of the motors and the heaters.

### Heating equipment containing motors rated over \( \frac{1}{8} \) horsepower without supplementary overcurrent protection.

Disconnecting means in sight from motor controller or as provided for heating equipment with motor rated over \( \frac{1}{8} \) horsepower with supplementary overcurrent protection and simultaneously disconnects the heater, motor controller(s) and supplementary overcurrent protective devices from all ungrounded conductors. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall
<table>
<thead>
<tr>
<th><strong>Air-conditioning condensing units and heat pump units.</strong></th>
<th>A readily accessible disconnect within sight from unit as the only allowable means.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appliances and fixed heating equipment with unit switches having a marked OFF position.</strong></td>
<td>Unit switch where an additional individual switch or circuit breaker serves as a redundant disconnecting means.</td>
</tr>
<tr>
<td><strong>Thermostatically controlled fixed heating equipment.</strong></td>
<td>Thermostats with a marked OFF position that directly open all ungrounded conductors, which when manually placed in the OFF position are designed so that the circuit cannot be energized automatically and that are located within sight of the equipment controlled.</td>
</tr>
</tbody>
</table>

For SI: 1 horsepower = 0.746 kW.

a. The disconnecting means shall be permitted to be installed on or within the unit. It shall not be located on panels designed to allow access to the unit or located so as to obscure the air-conditioning equipment nameplate(s).

**E4101.6 Support of ceiling-suspended paddle fans.**
Ceiling-suspended fans (paddle) shall be supported independently of an outlet box or by a listed outlet box or outlet box system identified for the use and installed in accordance with Section E3905.9. (422.18)

**E4101.7 Snow-melting and deicing equipment protection.**
Outdoor receptacles that are not readily accessible and are supplied from a dedicated branch circuit for electric snow-melting or deicing equipment shall be permitted to be installed without ground-fault circuit-interrupter protection for personnel. However, ground-fault protection of equipment shall be provided for fixed outdoor electric deicing and snow-melting equipment. [210.8(A)(3) Exception, 426.28]
CHAPTER 42
SWIMMING POOLS

Deleted. See the North Carolina Electrical Code.

SECTION E4201
GENERAL

E4201.1 Scope.
The provisions of this chapter shall apply to the construction and installation of electric wiring and equipment associated with all swimming pools, wading pools, decorative pools, fountains, hot tubs and spas, and hydromassage bathtubs, whether permanently installed or storable, and shall apply to metallic auxiliary equipment, such as pumps, filters and similar equipment. Sections E4202 through E4206 provide general rules for permanent pools, spas and hot tubs. Section E4207 provides specific rules for storable pools and storable/portable spas and hot tubs. Section E4208 provides specific rules for spas and hot tubs. Section E4209 provides specific rules for hydromassage bathtubs. (680.1)

E4201.2 Definitions.
(680.2)

CORD-AND-PLUG-CONNECTED LIGHTING ASSEMBLY. A lighting assembly consisting of a cord-and-plug-connected transformer and a luminaire intended for installation in the wall of a spa, hot tub, or storable pool.

DRY-NICHE LUMINAIRE. A luminaire intended for installation in the floor or wall of a pool, spa or fountain in a niche that is sealed against the entry of water.

FORMING SHELL. A structure designed to support a wet-niche luminaire assembly and intended for mounting in a pool or fountain structure.

FOUNTAIN. Fountains, ornamental pools, display pools, and reflection pools. The definition does not include drinking fountains.

HYDROMASSAGE BATHTUB. A permanently installed bathtub equipped with a recirculating piping system, pump, and associated equipment. It is designed so it can accept, circulate and discharge water upon each use.

LOW VOLTAGE CONTACT LIMIT. A voltage not exceeding the following values:

1. 15 volts (RMS) for sinusoidal AC
2. 21.2 volts peak for nonsinusoidal AC
3. 30 volts for continuous DC
4. 12.4 volts peak for DC that is interrupted at a rate of 10 to 200 Hz
MAXIMUM WATER LEVEL. The highest level that water can reach before it spills out.

NO-NICHE LUMINAIRE. A luminaire intended for installation above or below the water without a niche.

PACKAGED SPA OR HOT TUB EQUIPMENT ASSEMBLY. A factory-fabricated unit consisting of water-circulating, heating and control equipment mounted on a common base, intended to operate a spa or hot tub. Equipment may include pumps, air blowers, heaters, luminaires, controls and sanitizer generators.

PERMANENTLY INSTALLED SWIMMING, WADING, IMMERSION AND THERAPEUTIC POOLS. Those that are constructed in the ground or partially in the ground, and all others capable of holding water with a depth greater than 42 inches (1067 mm), and all pools installed inside of a building, regardless of water depth, whether or not served by electrical circuits of any nature.

POOL. Manufactured or field-constructed equipment designed to contain water on a permanent or semipermanent basis and used for swimming, wading, immersion, or therapeutic purposes.

POOL COVER, ELECTRICALLY OPERATED. Motor-driven equipment designed to cover and uncover the water surface of a pool by means of a flexible sheet or rigid frame.

SELF-CONTAINED SPA OR HOT TUB. A factory-fabricated unit consisting of a spa or hot tub vessel with all water-circulating, heating and control equipment integral to the unit. Equipment may include pumps, air blowers, heaters, luminaires, controls and sanitizer generators.

SPA OR HOT TUB. A hydromassage pool, or tub for recreational or therapeutic use, not located in health care facilities, designed for immersion of users, and usually having a filter, heater, and motor-driven blower. They are installed indoors or outdoors, on the ground or supporting structure, or in the ground or supporting structure. Generally, a spa or hot tub is not designed or intended to have its contents drained or discharged after each use.

STORABLE SWIMMING, WADING OR IMMERSION POOLS; OR STORABLE/PORTABLE SPAS AND HOT TUBS. Those that are constructed on or above the ground and are capable of holding water with a maximum depth of 42 inches (1067 mm), or a pool with nonmetallic, molded polymeric walls or inflatable fabric walls regardless of dimension.

THROUGH-WALL LIGHTING ASSEMBLY. A lighting assembly intended for installation above grade, on or through the wall of a pool, consisting of two interconnected groups of components separated by the pool wall.

WET-NICHE LUMINAIRE. A luminaire intended for installation in a forming shell mounted in a pool or fountain structure where the luminaire will be completely surrounded by water.

SECTION E4202
WIRING METHODS FOR POOLS, SPAS, HOT TUBS AND HYDROMASSAGE BATHTUBS

E4202.1 General.
Wiring methods used in conjunction with permanently installed swimming pools, spas, hot tubs...
or hydromassage bathtubs shall be installed in accordance with Table E4202.1 and Chapter 38 except as otherwise stated in this section. Storable swimming pools shall comply with Section E4207. [680.7; 680.21(A); 680.23(B) and (F); 680.25(A); 680.42; 680.43; and 680.70]

### TABLE E4202.1

**ALLOWABLE APPLICATIONS FOR WIRING METHODS**

<table>
<thead>
<tr>
<th>WIRING LOCATION OR PURPOSE (Application allowed where marked with an “A”)</th>
<th>AC, FMC, NM, SR, SE</th>
<th>EMT</th>
<th>ENT</th>
<th>IMC, RMC, RNC</th>
<th>LFMC</th>
<th>LFNMC</th>
<th>UF</th>
<th>MC</th>
<th>FLEX CORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panelboard(s) that supply pool equipment from service equipment to panelboard</td>
<td>A, b, c, d, e, f, g, h, k</td>
<td>A</td>
<td>b</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>—</td>
</tr>
<tr>
<td>Wet-niche and no-niche luminaires: from branch circuit OCPD to deck or junction box</td>
<td>A</td>
<td>b</td>
<td>a</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>b</td>
<td>—</td>
</tr>
<tr>
<td>Wet-niche and no-niche luminaires: from deck or junction box to forming shell</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>—</td>
<td>A</td>
</tr>
<tr>
<td>Dry niche: from branch circuit OCPD to luminaires</td>
<td>A</td>
<td>b</td>
<td>a</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>b</td>
<td>—</td>
</tr>
<tr>
<td>Pool-associated motors: from branch circuit OCPD to motor</td>
<td>A</td>
<td>b</td>
<td>a</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>b</td>
<td>—</td>
</tr>
<tr>
<td>Packaged or self-contained outdoor spas and hot tubs with underwater luminaire: from branch circuit OCPD to spa or hot tub</td>
<td>A</td>
<td>b</td>
<td>a</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>b</td>
<td>—</td>
</tr>
<tr>
<td>Packaged or self-contained outdoor spas and hot tub without underwater luminaire: from branch circuit OCPD to spa or hot tub</td>
<td>A</td>
<td>b</td>
<td>a</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>b</td>
<td>—</td>
</tr>
<tr>
<td>Indoor spas and hot tubs, hydromassage bathtubs, and other pool, spa or hot tub associated equipment: from branch circuit OCPD to equipment</td>
<td>A</td>
<td>b</td>
<td>a</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>b</td>
<td>—</td>
</tr>
<tr>
<td>Connection at pool lighting transformers or power supplies</td>
<td>A</td>
<td>b, c, d, e, f, g, h, k</td>
<td>A</td>
<td>a</td>
<td>A</td>
<td>—</td>
<td>A</td>
<td>—</td>
<td>b</td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
For SI: 1 foot = 304.8 mm.
a. For all wiring methods, see Section E4205 for equipment grounding conductor requirements.
b. Limited to use within buildings.
c. Limited to use on or within buildings.
d. Metal conduit shall be constructed of brass or other approved corrosion-resistant metal.
e. Limited to where necessary to employ flexible connections at or adjacent to a pool motor.
f. Sections installed external to spa or hot tub enclosure limited to individual lengths not to exceed 6 feet. Length not limited inside spa or hot tub enclosure.
g. Flex conduit shall be installed in accordance with Section E4202.2.
h. Nonmetallic conduit shall be rigid polyvinyl chloride conduit Type PVC or reinforced thermosetting resin conduit Type RTRC.
i. Aluminum conduits shall not be permitted in the pool area where subject to corrosion.
j. Where installed as direct burial cable or in wet locations, Type MC cable shall be listed and identified for the location.
k. See Section E4202.3 for listed, double-insulated pool pump motors.
l. Limited to use in individual lengths not to exceed 6 feet. The total length of all individual runs of LFMC shall not exceed 10 feet.

E4202.2 Flexible cords.
Flexible cords used in conjunction with a pool, spa, hot tub or hydromassage bathtub shall be installed in accordance with the following:

1. For other than underwater luminaires, fixed or stationary equipment shall be permitted to be connected with a flexible cord to facilitate removal or disconnection for maintenance or repair. For other than storable pools, the flexible cord shall not exceed 3 feet (914 mm) in length. Cords that supply swimming pool equipment shall have a copper equipment grounding conductor not smaller than 12 AWG and shall terminate in a grounding-type attachment plug. [680.7(A), (B), and (C); 680.21(A)(5)]

2. Other than listed low-voltage lighting systems not requiring grounding, wet-niche luminaires that are supplied by a flexible cord or cable shall have all exposed noncurrent-carrying metal parts grounded by an insulated copper equipment grounding conductor that is an integral part of the cord or cable. Such grounding conductor shall be connected to a grounding terminal in the supply junction box, transformer enclosure, or other enclosure and shall be not smaller than the supply conductors and not smaller than 16 AWG. [680.23(B)(3)]

3. A listed packaged spa or hot tub installed outdoors that is GFCI protected shall be permitted to be cord-and-plug-connected provided that such cord does not exceed 15 feet (4572 mm) in length. [680.42(A)(2)]

4. A listed packaged spa or hot tub rated at 20 amperes or less and installed indoors shall be permitted to be cord-and-plug-connected to facilitate maintenance and repair. [680.43 Exception No. 1]

5. For other than underwater and storable pool lighting luminaire, the requirements of Item 1 shall apply to any cord-equipped luminaire that is located within 16 feet (4877 mm) radially from any point on the water surface. [680.22(B)(5)]

E4202.3 Double-insulated pool pumps.
A listed cord and plug-connected pool pump incorporating an approved system of double insulation that provides a means for grounding only the internal and nonaccessible, noncurrent-carrying metal parts of the pump shall be connected to any wiring method recognized in Chapter 38 that is suitable for the location. Where the bonding grid is connected to the equipment...
grounding conductor of the motor circuit in accordance with Section E4204.2, Item 6.1, the branch circuit wiring shall comply with Sections E4202.1 and E4205.5.[680.21(B)]

SECTION E4203
EQUIPMENT LOCATION AND CLEARANCES

E4203.1 Receptacle outlets.
Receptacle outlets shall be installed and located in accordance with Sections E4203.1.1 through E4203.1.5. Distances shall be measured as the shortest path that an appliance supply cord connected to the receptacle would follow without penetrating a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier.[680.22(A)(5)]

E4203.1.1 Location.
Receptacles that provide power for water-pump motors or other loads directly related to the circulation and sanitation system shall be permitted to be located between 6 feet and 10 feet (1829 mm and 3048 mm) from the inside walls of pools and outdoor spas and hot tubs, where the receptacle is single and of the grounding type and protected by ground-fault circuit interrupters.

Other receptacles on the property shall be located not less than 6 feet (1829 mm) from the inside walls of pools and outdoor spas and hot tubs.[680.22(A)(2) and (A)(3)]

E4203.1.2 Where required.
At least one 125-volt, 15- or 20-ampere receptacle supplied by a general-purpose branch circuit shall be located a minimum of 6 feet (1829 mm) from and not more than 20 feet (6096 mm) from the inside wall of pools and outdoor spas and hot tubs. This receptacle shall be located not more than 6 feet, 6 inches (1981 mm) above the floor, platform or grade level serving the pool, spa or hot tub.[680.22(A)(1)]

E4203.1.3 GFCI protection.
All 15- and 20-ampere, single phase, 125 volt receptacles located within 20 feet (6096 mm) of the inside walls of pools and outdoor spas and hot tubs shall be protected by a ground-fault circuit-interrupter. Outlets supplying pool pump motors supplied from branch circuits rated at 120 volts through 240 volts, single phase, whether by receptacle or direct connection, shall be provided with ground-fault circuit-interrupter protection for personnel.[680.21(C) and 680.22(A)(4)]

E4203.1.4 Indoor locations.
Receptacles shall be located not less than 6 feet (1829 mm) from the inside walls of indoor spas and hot tubs. A minimum of one 125-volt receptacle shall be located between 6 feet (1829 mm) and 10 feet (3048 mm) from the inside walls of indoor spas or hot tubs.[680.43(A) and 680.43(A)(1)]

E4203.1.5 Indoor GFCI protection.
All 125-volt receptacles rated 30 amperes or less and located within 10 feet (3048 mm) of the inside walls of spas and hot tubs installed indoors, shall be protected by ground-fault circuit-interrupters.[680.43(A)(2)]

E4203.2 Switching devices.
Switching devices shall be located not less than 5 feet (1524 mm) horizontally from the inside
walls of pools, spas and hot tubs except where separated from the pool, spa or hot tub by a solid fence, wall, or other permanent barrier or the switches are listed for use within 5 feet (1524 mm). Switching devices located in a room or area containing a hydromassage bathtub shall be located in accordance with the general requirements of this code. [680.22(C); 680.43(C); and 680.72]

**E4203.3 Disconnecting means.**
One or more means to simultaneously disconnect all ungrounded conductors for all utilization equipment, other than lighting, shall be provided. Each of such means shall be readily accessible and within sight from the equipment it serves and shall be located at least 5 feet (1524 mm) horizontally from the inside walls of a pool, spa, or hot tub unless separated from the open water by a permanently installed barrier that provides a 5-foot (1524 mm) or greater reach path. This horizontal distance shall be measured from the water’s edge along the shortest path required to reach the disconnect. [680.12]

**E4203.4 Luminaires and ceiling fans.**
Lighting outlets, luminaires, and ceiling suspended paddle fans shall be installed and located in accordance with Sections E4203.4.1 through E4203.4.6. [680.22(B)]

**E4203.4.1 Outdoor location.**
In outdoor pool, outdoor spas and outdoor hot tubs areas, luminaires, lighting outlets, and ceiling suspended paddle fans shall not be installed over the pool or over the area extending 5 feet (1524 mm) horizontally from the inside walls of a pool except where no part of the luminaire or ceiling suspended paddle fan is less than 12 feet (3658 mm) above the maximum water level. [680.22(B)(1)]

**E4203.4.2 Indoor locations.**
In indoor pool areas, the limitations of Section E4203.4.1 shall apply except where the luminaires, lighting outlets and ceiling suspended paddle fans comply with all of the following conditions:

1. The luminaires are of a totally enclosed type;
2. Ceiling suspended paddle fans are identified for use beneath ceiling structures such as porches and patios.
3. A ground-fault circuit interrupter is installed in the branch circuit supplying the luminaires or ceiling suspended paddle fans; and
4. The distance from the bottom of the luminaire or ceiling suspended paddle fan to the maximum water level is not less than 7 feet, 6 inches (2286 mm). [680.22(B)(2)]

**E4203.4.3 Low-voltage luminaires.**
Listed low-voltage luminaires not requiring grounding, not exceeding the low-voltage contact limit, and supplied by listed transformers or power supplies that comply with Section E4206.1 shall be permitted to be located less than 1.5 m (5 ft) from the inside walls of the pool. [680.22(B)(6)]

**E4203.4.4 Existing lighting outlets and luminaires.**
Existing lighting outlets and luminaires that are located within 5 feet (1524 mm) horizontally...
from the inside walls of pools and outdoor spas and hot tubs shall be permitted to be located
not less than 5 feet (1524 mm) vertically above the maximum water level, provided that such
luminaires and outlets are rigidly attached to the existing structure and are protected by a
ground-fault circuit interrupter. [680.22(B)(3)]

**E4203.4.5 Indoor spas and hot tubs.**

1. Luminaires, lighting outlets, and ceiling-suspended paddle fans located over the
spa or hot tub or within 5 feet (1524 mm) from the inside walls of the spa or hot tub shall
be not less than 7 feet, 6 inches (2286 mm) above the maximum water level and shall be
protected by a ground-fault circuit interrupter. [680.43(B)(1)(b)]

Luminaires, lighting outlets, and ceiling-suspended paddle fans that are located 12 feet
(3658 mm) or more above the maximum water level shall not require ground-fault circuit
interrupter protection. [680.43(B)(1)(a)]

2. Luminaires protected by a ground-fault circuit interrupter and complying with Item
2.1 or 2.2 shall be permitted to be installed less than 7 feet, 6 inches (2286 mm) over a
spa or hot tub.

2.1. Recessed luminaires shall have a glass or plastic lens and nonmetallic or
electrically isolated metal trim, and shall be suitable for use in damp locations.

2.2. Surface-mounted luminaires shall have a glass or plastic globe and a nonmetallic
body or a metallic body isolated from contact. Such luminaires shall be suitable for use in
damp locations. [680.43(B)(1)(c)]

**E4203.4.6 GFCI protection in adjacent areas.**

Luminaires and outlets that are installed in the area extending between 5 feet (1524 mm)
and 10 feet (3048 mm) from the inside walls of pools and outdoor spas and hot tubs shall be
protected by ground-fault circuit interrupters except where such fixtures and outlets are
installed not less than 5 feet (1524 mm) above the maximum water level and are rigidly
attached to the structure. [680.22(B)(4)]

**E4203.5 Other outlets.**

Other outlets such as for remote control, signaling, fire alarm and communications shall be not
less than 10 feet (3048 mm) from the inside walls of the pool. Measurements shall be
determined in accordance with Section E4203.1. [680.22(D)]

<table>
<thead>
<tr>
<th>Voltage to ground</th>
<th>0.15 kV</th>
<th>Greater than 15 to 50 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TABLE E4203.5 [Table 680.8(A)]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OVERHEAD CONDUCTOR CLEARANCES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INSULATED SUPPLY OR SERVICE DROP CABLES, 0-750 VOLTS TO GROUND, SUPPORTED ON AND CABLED TOGETHER WITH AN EFFECTIVELY GROUNDED BARE MESSENGER OR EFFECTIVELY GROUNDED NEUTRAL CONDUCTOR (feet)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ALL OTHER SUPPLY OR SERVICE DROP CONDUCTORS (feet)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Voltage to ground</strong></td>
<td>0.15 kV</td>
<td>Greater than 15 to 50 kV</td>
</tr>
</tbody>
</table>
A. Clearance in any direction to the water level, edge of water surface, base of diving platform, or permanently anchored raft

<table>
<thead>
<tr>
<th></th>
<th>22.5</th>
<th>25</th>
<th>27</th>
</tr>
</thead>
</table>

B. Clearance in any direction to the diving platform

<table>
<thead>
<tr>
<th></th>
<th>14.5</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
</table>

For SI: 1 foot = 304.8 mm.

E4203.6 Overhead conductor clearances.
Except where installed with the clearances specified in Table E4203.5, the following parts of pools and outdoor spas and hot tubs shall not be placed under existing service drop conductors, overhead service conductor, or any other open overhead wiring; nor shall such wiring be installed above the following:

1. Pools and the areas extending not less than 10 feet (3048 mm) horizontally from the inside of the walls of the pool;

2. Diving structures and the areas extending not less than 10 feet (3048 mm) horizontally from the outer edge of such structures.

3. Observation stands, towers, and platforms and the areas extending not less than 10 feet (3048 mm) horizontally from the outer edge of such structures.

Overhead conductors of network-powered broadband communications systems shall comply with the provisions in Table E4203.5 for conductors operating at 0 to 750 volts to ground.

Utility-owned, operated and maintained communications conductors, community antenna system coaxial cables and the supporting messengers shall be permitted at a height of not less than 10 feet (3048 mm) above swimming and wading pools, diving structures, and observation stands, towers, and platforms. [680.8(A), (B), and (C)]

E4203.7 Underground wiring.
Underground wiring shall not be installed under or within the area extending 5 feet (1524 mm) horizontally from the inside walls of pools and outdoor hot tubs and spas except where the wiring is installed to supply pool, spa or hot tub equipment or where space limitations prevent wiring from being routed 5 feet (1524 mm) or more horizontally from the inside walls. Where installed within 5 feet (1524 mm) of the inside walls, the wiring method shall be a complete raceway system of rigid metal conduit, intermediate metal conduit or a nonmetallic raceway system. Metal conduit shall be corrosion resistant and suitable for the location. The minimum cover depths shall be in accordance with Table E4203.7. (680.10)

<table>
<thead>
<tr>
<th>WIRING METHOD</th>
<th>UNDERGROUND WIRING (inches)</th>
</tr>
</thead>
</table>

TABLE E4203.7 (680.10)
MINIMUM BURIAL DEPTHS
Rigid metal conduit 6
Intermediate metal conduit 6
Nonmetallic raceways listed for direct burial and under concrete exterior slab not less than 4 inches in thickness and extending not less than 6 inches (162 mm) beyond the underground installation 6
Nonmetallic raceways listed for direct burial without concrete encasement 18
Other approved raceways a 18

For 1 inch = 25.4 mm.
a— Raceways approved for burial only where concrete-encased shall require a concrete envelope not less than 2 inches in thickness.

SECTION E4204
BONDING

E4204.1 Performance.
The equipotential bonding required by this section shall be installed to reduce voltage gradients in the prescribed areas of permanently installed swimming pools and spas and hot tubs other than the storable/portable type.

E4204.2 Bonded parts.
The parts of pools, spas, and hot tubs specified in Items 1 through 7 shall be bonded together using insulated, covered or bare solid copper conductors not smaller than 8 AWG or using rigid metal conduit of brass or other identified corrosion-resistant metal. An 8 AWG or larger solid copper bonding conductor provided to reduce voltage gradients in the pool, spa, or hot tub area shall not be required to be extended or attached to remote panelboards, service equipment, or electrodes. Connections shall be made by exothermic welding, by listed pressure connectors or clamps that are labeled as being suitable for the purpose and that are made of stainless steel, brass, copper or copper alloy, machine screw-type fasteners that engage not less than two threads or are secured with a nut, thread-forming machine screws that engage not less than two-threads, or terminal bars. Connection devices or fittings that depend solely on solder shall not be used. Sheet metal screws shall not be used to connect bonding conductors or connection devices: [680.26(B)]

1. Conductive pool shells. Bonding to conductive pool shells shall be provided as specified in Item 1.1 or 1.2. Poured concrete, pneumatically applied or sprayed concrete, and concrete block with painted or plastered coatings shall be considered to be conductive materials because of their water permeability and porosity. Vinyl liners and fiberglass composite shells shall be considered to be nonconductive materials.

1.1. Structural reinforcing steel. Unencapsulated structural reinforcing steel shall be bonded together by steel tie wires or the equivalent. Where structural reinforcing steel is encapsulated in a nonconductive compound, a copper-conductor grid shall be installed in accordance with Item 1.2.

1.2. Copper conductor grid. A copper conductor grid shall be provided and shall comply with Items 1.2.1 through 1.2.4.
1.2.1. It shall be constructed of minimum 8 AWG bare solid copper conductors bonded to each other at all points of crossing.

1.2.2. It shall conform to the contour of the pool.

1.2.3. It shall be arranged in a 12-inch (305 mm) by 12-inch (305 mm) network of conductors in a uniformly spaced perpendicular grid pattern with a tolerance of 4 inches (102 mm).

1.2.4. It shall be secured within or under the pool not more than 6 inches (152 mm) from the outer contour of the pool shell. [680.26(B)(1)]

2. Perimeter surfaces. The perimeter surface shall extend for 3 feet (914 mm) horizontally beyond the inside walls of the pool and shall include unpaved surfaces, poured concrete surfaces and other types of paving. Perimeter surfaces that extend less than 3 feet (914 mm) beyond the inside wall of the pool and that are separated from the pool by a permanent wall or building 5 feet (1524 mm) or more in height shall require equipotential bonding on the pool side of the permanent wall or building. Bonding to perimeter surfaces shall be provided as specified in Item 2.1 or 2.2 and shall be attached to the pool, spa, or hot tub reinforcing steel or copper conductor grid at a minimum of four points uniformly spaced around the perimeter of the pool, spa, or hot tub. For nonconductive pool shells, bonding at four points shall not be required.

Exceptions:

1. Equipotential bonding of perimeter surfaces shall not be required for spas and hot tubs where all of the following conditions apply:

   1.1. The spa or hot tub is listed as a self-contained spa for aboveground use.

   1.2. The spa or hot tub is not identified as suitable only for indoor use.

   1.3. The installation is in accordance with the manufacturer’s instructions and is located on or above grade.

   1.4. Top rim of the spa or hot tub is not less than 28 in. (711 mm) above all perimeter surfaces that are within 30 in. (762 mm), measured horizontally from the spa or hot tub. The height of nonconductive external steps for entry to or exit from the self-contained spa is not used to reduce or increase this rim height measurement.

2. The equipotential bonding requirements for perimeter surfaces shall not apply to a listed self-contained spa or hot tub located indoors and installed above a finished floor.

2.1. Structural reinforcing steel. Structural reinforcing steel shall be bonded in accordance with Item 1.1.
2.2. Alternate means. Where structural reinforcing steel is not available or is
encapsulated in a nonconductive compound, a copper conductor(s) shall be used
in accordance with Items 2.2.1 through 2.2.5:

2.2.1. At least one minimum 8 AWG bare solid copper conductor shall be provided.

2.2.2. The conductors shall follow the contour of the perimeter surface.

2.2.3. Splices shall be listed.

2.2.4. The required conductor shall be 18 to 24 inches (457 to 610 mm) from the
inside walls of the pool.

2.2.5. The required conductor shall be secured within or under the perimeter
surface 4 to 6 inches (102 mm to 152 mm) below the subgrade.

[680.26(B)(2)]

3—Metallic components. All metallic parts of the pool structure, including reinforcing metal
not addressed in Item 1.1, shall be bonded. Where reinforcing steel is encapsulated with
a nonconductive compound, the reinforcing steel shall not be required to be bonded.
[680.26(B)(3)]

4—Underwater lighting. All metal forming shells and mounting brackets of no-niche
luminaires shall be bonded. [680.26(B)(4)]

*Exception*: Listed low-voltage lighting systems with nonmetallic forming shells shall
not require bonding. [680.26(B)(4) Exception]

5—Metal fittings. All metal fittings within or attached to the pool structure shall be bonded.
Isolated parts that are not over 4 inches (102 mm) in any dimension and do not
penetrate into the pool structure more than 1 inch (25.4 mm) shall not require bonding.
[680.26(B)(5)]

6—Electrical equipment. Metal parts of electrical equipment associated with the pool water
circulating system, including pump motors and metal parts of equipment associated with
pool covers, including electric motors, shall be bonded. [680.26(B)(6)]

*Exception*: Metal parts of listed equipment incorporating an approved system of
double insulation shall not be bonded. [680.26(B)(6) Exception]

6.1—Double-insulated water pump motors. Where a double-insulated water pump
motor is installed under the provisions of this item, a solid 8 AWG copper
conductor of sufficient length to make a bonding connection to a replacement
motor shall be extended from the bonding grid to an accessible point in the
vicinity of the pool pump motor. Where there is no connection between the
swimming pool bonding grid and the equipment grounding system for the
premises, this bonding conductor shall be connected to the equipment
grounding conductor of the motor circuit. [680.26(B)(6)(a)]
6.2. Pool water heaters. For pool water heaters rated at more than 50 amperes and having specific instructions regarding bonding and grounding, only those parts designated to be bonded shall be bonded and only those parts designated to be grounded shall be grounded. [680.26(B)(6)(b)]

7. All fixed metal parts including, but not limited to, metal-sheathed cables and raceways, metal piping, metal awnings, metal fences and metal door and window frames. [680.26(B)(7)]

Exceptions:

1. Those separated from the pool by a permanent barrier that prevents contact by a person shall not be required to be bonded. [680.26(B)(7) Exception No. 1]

2. Those greater than 5 feet (1524 mm) horizontally from the inside walls of the pool shall not be required to be bonded. [680.26(B)(7) Exception No. 2]

3. Those greater than 12 feet (3658 mm) measured vertically above the maximum water level of the pool, or as measured vertically above any observation stands, towers, or platforms, or any diving structures, shall not be required to be bonded. [680.26(B)(7) Exception No. 3]

E4204.3 Pool water.
Where none of the bonded parts is in direct connection with the pool water, the pool water shall be in direct contact with an approved corrosion-resistant conductive surface that exposes not less than 9 in.² (5800 mm²) of surface area to the pool water at all times. The conductive surface shall be located where it is not exposed to physical damage or dislodgement during usual pool activities, and it shall be bonded in accordance with Section E4204.2.

E4204.4 Bonding of outdoor hot tubs and spas.
Outdoor hot tubs and spas shall comply with the bonding requirements of Sections E4204.1 through E4204.3. Bonding by metal-to-metal mounting on a common frame or base shall be permitted. The metal bands or hoops used to secure wooden staves shall not be required to be bonded as required in Section E4204.2. [680.42 and 680.42(B)]

E4204.5 Bonding of indoor hot tubs and spas.
The following parts of indoor hot tubs and spas shall be bonded together:

1. All metal fittings within or attached to the hot tub or spa structure. [680.43(D)(1)]

2. Metal parts of electrical equipment associated with the hot tub or spa water circulating system, including pump motors unless part of a listed self-contained spa or hot tub. [680.43(D)(2)]

3. Metal raceway and metal piping that are within 5 feet (1524 mm) of the inside walls of the hot tub or spa and that are not separated from the spa or hot tub by a permanent barrier. [680.43(D)(3)]
4. All metal surfaces that are within 5 feet (1524 mm) of the inside walls of the hot tub or spa and that are not separated from the hot tub or spa area by a permanent barrier. [680.43(D)(4)]

   Exception: Small conductive surfaces not likely to become energized, such as air and water jets and drain fittings, where not connected to metallic piping, towel bars, mirror frames, and similar nonelectrical equipment, shall not be required to be bonded. [680.43(D)(4) Exception]

5. Electrical devices and controls that are not associated with the hot tubs or spas and that are located less than 5 feet (1524 mm) from such units. [680.43(D)(5)]

E4204.5.1 Methods.
All metal parts associated with the hot tub or spa shall be bonded by any of the following methods:

1. The interconnection of threaded metal piping and fittings. [680.43(E)(1)]

2. Metal-to-metal mounting on a common frame or base. [680.43(E)(2)]

3. The provision of an insulated, covered or bare solid copper bonding jumper not smaller than 8 AWG. It shall not be the intent to require that the 8 AWG or larger solid copper bonding conductor be extended or attached to any remote panelboard, service equipment, or any electrode, but only that it shall be employed to eliminate voltage gradients in the hot tub or spa area as prescribed. [680.43(E)(3)]

E4204.5.2 Connections.
Connections to bonded parts shall be made in accordance with Section E3406.13.1.

SECTION E4205
GROUNDING

E4205.1 Equipment to be grounded.
The following equipment shall be grounded:

1. Through-wall lighting assemblies and underwater luminaires other than those low-voltage lighting products listed for the application without a grounding conductor.

2. All electrical equipment located within 5 feet (1524 mm) of the inside wall of the pool, spa or hot tub.

3. All electrical equipment associated with the recirculating system of the pool, spa or hot tub.


5. Transformer and power supply enclosures.

7. Panelboards that are not part of the service equipment and that supply any electrical equipment associated with the pool, spa or hot tub. (680.7)

### E4205.2 Luminaires and related equipment.

Other than listed low-voltage luminaires not requiring grounding, all through-wall lighting assemblies, wet-niche, dry-niche, or no-niche luminaires shall be connected to an insulated copper equipment grounding conductor sized in accordance with Table E3908.12 but not smaller than 12 AWG. The equipment grounding conductor between the wiring chamber of the secondary winding of a transformer and a junction box shall be sized in accordance with the overcurrent device in such circuit. The junction box, transformer enclosure, or other enclosure in the supply circuit to a wet-niche or no-niche luminaire and the field-wiring chamber of a dry-niche luminaire shall be grounded to the equipment grounding terminal of the panelboard. The equipment grounding terminal shall be directly connected to the panelboard enclosure. The equipment grounding conductor shall be installed without joint or splice. [680.23(F)(2) and 680.23(F)(2) Exception]

**Exceptions:**

1. Where more than one underwater luminaire is supplied by the same branch circuit, the equipment grounding conductor, installed between the junction boxes, transformer enclosures, or other enclosures in the supply circuit to wet-niche luminaires, or between the field-wiring compartments of dry-niche luminaires, shall be permitted to be terminated on grounding terminals. [680.23(F)(2)(a)]

2. Where an underwater luminaire is supplied from a transformer, ground-fault circuit-interrupter, clock-operated switch, or a manual snap switch that is located between the panelboard and a junction box connected to the conduit that extends directly to the underwater luminaire, the equipment grounding conductor shall be permitted to terminate on grounding terminals on the transformer, ground-fault circuit-interrupter, clock-operated switch enclosure, or an outlet box used to enclose a snap switch. [680.23(F)(2)(b)]

### E4205.3 Nonmetallic conduit.

Where a nonmetallic conduit is installed between a forming shell and a junction box, transformer enclosure, or other enclosure, a 8 AWG insulated copper bonding jumper shall be installed in this conduit except where a listed low voltage lighting system not requiring grounding is used. The bonding jumper shall be terminated in the forming shell, junction box or transformer enclosure, or ground-fault circuit-interrupter enclosure. The termination of the 8 AWG bonding jumper in the forming shell shall be covered with, or encapsulated in, a listed potting compound to protect such connection from the possible deteriorating effect of pool water. [680.23(B)(2)(b)]

### E4205.4 Flexible cords.

Other than listed low-voltage lighting systems not requiring grounding, wet-niche luminaires that are supplied by a flexible cord or cable shall have all exposed noncurrent-carrying metal parts grounded by an insulated copper equipment grounding conductor that is an integral part of the cord or cable. This grounding conductor shall be connected to a grounding terminal in the supply junction box, transformer enclosure, or other enclosure. The grounding conductor shall not be smaller than the supply conductors and not smaller than 16 AWG. [680.23(B)(3)]
E4205.5 Motors.
Pool-associated motors shall be connected to an insulated copper equipment grounding conductor sized in accordance with Table E3908.12, but not smaller than 12 AWG. Where the branch circuit supplying the motor is installed in the interior of a one-family dwelling or in the interior of accessory buildings associated with a one-family dwelling, using a cable wiring method permitted by Table E4202.1, an uninsulated equipment grounding conductor shall be permitted provided that it is enclosed within the outer sheath of the cable assembly. [680.21(A)(1) and (A)(4)]

E4205.6 Feeders.
An equipment grounding conductor shall be installed with the feeder conductors between the grounding terminal of the pool equipment panelboard and the grounding terminal of the applicable service equipment. The equipment grounding conductor shall be insulated, shall be sized in accordance with Table E3908.12, and shall be not smaller than 12 AWG.

E4205.6.1 Separate buildings.
A feeder to a separate building or structure shall be permitted to supply swimming pool equipment branch circuits, or feeders supplying swimming pool equipment branch circuits, provided that the grounding arrangements in the separate building meet the requirements of Section E3607.3. The feeder equipment grounding conductor shall be an insulated conductor. (680.25(B)(2)]

E4205.7 Cord-connected equipment.
Where fixed or stationary equipment is connected with a flexible cord to facilitate removal or disconnection for maintenance, repair, or storage, as provided in Section E4202.2, the equipment grounding conductors shall be connected to a fixed metal part of the assembly. The removable part shall be mounted on or bonded to the fixed metal part. [680.7(C)]

E4205.8 Other equipment.
Other electrical equipment shall be grounded in accordance with Section E3908. (Article 250, Parts V, VI, and VII; and 680.6)

SECTION E4206
EQUIPMENT INSTALLATION

E4206.1 Transformers and power supplies.
Transformers and power supplies used for the supply of underwater luminaires, together with the transformer or power supply enclosure, shall be listed for swimming pool and spa use. The transformer or power supply shall incorporate either a transformer of the isolated-winding type with an ungrounded secondary that has a grounded metal barrier between the primary and secondary windings, or a transformer that incorporates an approved system of double insulation between the primary and secondary windings. [680.23(A)(2)]

E4206.2 Ground-fault circuit-interrupters.
Ground-fault circuit-interrupters shall be self-contained units, circuit-breaker types, receptacle types or other approved types. (680.5)

E4206.3 Wiring on load side of ground-fault circuit-interrupters and transformers.
For other than grounding conductors, conductors installed on the load side of a ground-fault circuit-interrupter or transformer used to comply with the provisions of Section E4206.4, shall
not occupy raceways, boxes, or enclosures containing other conductors except where the other conductors are protected by ground-fault circuit interrupters or are grounding conductors. Supply conductors to a feed-through type ground-fault circuit interrupter shall be permitted in the same enclosure. Ground-fault circuit interrupters shall be permitted in a panelboard that contains circuits protected by other than ground-fault circuit interrupters. [680.23(F)(3)]

E4206.4 Underwater luminaires.

The design of an underwater luminaire supplied from a branch circuit either directly or by way of a transformer or power supply meeting the requirements of Section E4206.1, shall be such that, where the fixture is properly installed without a ground-fault circuit interrupter, there is no shock hazard with any likely combination of fault conditions during normal use (not relamping). In addition, a ground-fault circuit-interrupter shall be installed in the branch circuit supplying luminaires operating at more than the low-voltage contact limit, such that there is no shock hazard during relamping. The installation of the ground-fault circuit interrupter shall be such that there is no shock hazard with any likely fault-condition combination that involves a person in a conductive path from any ungrounded part of the branch circuit or the luminaire to ground. Compliance with this requirement shall be obtained by the use of a listed underwater luminaire and by installation of a listed ground-fault circuit-interrupter in the branch circuit or a listed transformer or power supply for luminaires operating at more than the low-voltage contact limit. Luminaires that depend on submersion for safe operation shall be inherently protected against the hazards of overheating when not submerged. [680.23(A)(1), (A)(3), (A)(7) and (A)(8)]

E4206.4.1 Maximum voltage.

Luminaires shall not be installed for operation on supply circuits over 150 volts between conductors. [680.23(A)(4)]

E4206.4.2 Luminaire location.

Luminaires mounted in walls shall be installed with the top of the fixture lens not less than 18 inches (457 mm) below the normal water level of the pool, except where the luminaire is listed and identified for use at a depth of not less than 4 inches (102 mm) below the normal water level of the pool. A luminaire facing upward shall have the lens adequately guarded to prevent contact by any person or shall be listed for use without a guard. [680.23(A)(5) and (A)(6)]

E4206.5 Wet-niche luminaires.

Forming shells shall be installed for the mounting of all wet-niche underwater luminaires and shall be equipped with provisions for conduit entries. Conduit shall extend from the forming shell to a suitable junction box or other enclosure located as provided in Section E4206.9. Metal parts of the luminaire and forming shell in contact with the pool water shall be of brass or other approved corrosion-resistant metal. [680.23(B)(1)]

The end of flexible-cord jackets and flexible-cord conductor terminations within a luminaire shall be covered with, or encapsulated in, a suitable potting compound to prevent the entry of water into the luminaire through the cord or its conductors. If present, the grounding connection within a luminaire shall be similarly treated to protect such connection from the deteriorating effect of pool water in the event of water entry into the luminaire. [680.23(B)(4)]

Luminaires shall be bonded to and secured to the forming shell by a positive locking device that ensures a low-resistance contact and requires a tool to remove the luminaire from the forming shell. [680.23(B)(5)]
**E4206.5.1 Servicing.**
All wet-niche luminaires shall be removable from the water for inspection, relamping, or other maintenance. The forming shell location and length of cord in the forming shell shall permit personnel to place the removed luminaire on the deck or other dry location for such maintenance. The luminaire maintenance location shall be accessible without entering or going into the pool water. [680.23(B)(6)]

**E4206.6 Dry-niche luminaires.**
Dry-niche luminaires shall have provisions for drainage of water. Other than listed low-voltage luminaires not requiring grounding, a dry-niche luminaire shall have means for accommodating one equipment grounding conductor for each conduit entry. Junction boxes shall not be required but, if used, shall not be required to be elevated or located as specified in Section E4206.9 if the luminaire is specifically identified for the purpose. [680.23(C)(1) and (C)(2)]

**E4206.7 No-niche luminaires.**
No-niche luminaires shall be listed for the purpose and shall be installed in accordance with the requirements of Section E4206.5. Where connection to a forming shell is specified, the connection shall be to the mounting bracket. [680.23(D)]

**E4206.8 Through-wall lighting assembly.**
A through-wall lighting assembly shall be equipped with a threaded entry or hub, or a nonmetallic hub, for the purpose of accommodating the termination of the supply conduit. A through-wall lighting assembly shall meet the construction requirements of Section E4206.4 and be installed in accordance with the requirements of Section E4206.5 Where connection to a forming shell is specified, the connection shall be to the conduit termination point. [680.23(E)]

**E4206.9 Junction boxes and enclosures for transformers or ground-fault circuit interrupters.**
Junction boxes for underwater luminaires and enclosures for transformers and ground-fault circuit-interrupters that supply underwater luminaires shall comply with the following: [680.24(A)]

**E4206.9.1 Junction boxes.**
A junction box connected to a conduit that extends directly to a forming shell or mounting bracket of a no-niche luminaire shall be:

1. Listed as a swimming pool junction box; [680.24(A)(1)]
2. Equipped with threaded entries or hubs or a nonmetallic hub; [680.24(A)(1)(1)]
3. Constructed of copper, brass, suitable plastic, or other approved corrosion-resistant material; [680.24(A)(1)(2)]
4. Provided with electrical continuity between every connected metal conduit and the grounding terminals by means of copper, brass, or other approved corrosion-resistant metal that is integral with the box; and [680.24(A)(1)(3)]
5. Located not less than 4 inches (102 mm), measured from the inside of the bottom of the box, above the ground level, or pool deck, or not less than 8 inches (203 mm) above the maximum pool water level, whichever provides the greatest elevation, and shall be located not less than 4 feet (1219 mm) from the inside wall of the pool,
unless separated from the pool by a solid fence, wall or other permanent barrier. Where used on a lighting system operating at the low-voltage contact limit or less, a flush deck box shall be permitted provided that an approved potting compound is used to fill the box to prevent the entrance of moisture; and the flush deck box is located not less than 4 feet (1219 mm) from the inside wall of the pool. [680.24(A)(2)]

E4206.9.2 Other enclosures.
An enclosure for a transformer, ground-fault circuit-interrupter or a similar device connected to a conduit that extends directly to a forming shell or mounting bracket of a no-niche luminaire shall be:

1. Listed and labeled for the purpose, comprised of copper, brass, suitable plastic, or other approved corrosion-resistant material; [680.24(B)(1)]

2. Equipped with threaded entries or hubs or a nonmetallic hub; [680.24(B)(2)]

3. Provided with an approved seal, such as duct seal at the conduit connection, that prevents circulation of air between the conduit and the enclosures; [680.24(B)(3)]

4. Provided with electrical continuity between every connected metal conduit and the grounding terminals by means of copper, brass or other approved corrosion-resistant metal that is integral with the enclosures; and [680.24(B)(4)]

5. Located not less than 4 inches (102 mm), measured from the inside bottom of the enclosure, above the ground level or pool deck, or not less than 8 inches (203 mm) above the maximum pool water level, whichever provides the greater elevation, and shall be located not less than 4 feet (1219 mm) from the inside wall of the pool, except where separated from the pool by a solid fence, wall or other permanent barrier. [680.24(B)(2)]

E4206.9.3 Protection of junction boxes and enclosures.
Junction boxes and enclosures mounted above the grade of the finished walkway around the pool shall not be located in the walkway unless afforded additional protection, such as by location under diving boards or adjacent to fixed structures. [680.24(C)]

E4206.9.4 Grounding terminals.
Junction boxes, transformer and power supply enclosures, and ground-fault circuit-interrupter enclosures connected to a conduit that extends directly to a forming shell or mounting bracket of a no-niche luminaire shall be provided with grounding terminals in a quantity not less than the number of conduit entries plus one. [680.24(D)]

E4206.9.5 Strain relief.
The termination of a flexible cord of an underwater luminaire within a junction box, transformer or power supply enclosure, ground-fault circuit-interrupter, or other enclosure shall be provided with a strain relief. [680.24(E)]

E4206.10 Underwater audio equipment.
Underwater audio equipment shall be identified for the purpose. [680.27(A)]
E4206.10.1 Speakers.
Each speaker shall be mounted in an approved metal forming shell, the front of which is enclosed by a captive metal screen, or equivalent, that is bonded to and secured to the forming shell by a positive locking device that ensures a low-resistance contact and requires a tool to open for installation or servicing of the speaker. The forming shell shall be installed in a recess in the wall or floor of the pool. [680.27(A)(1)]

E4206.10.2 Wiring methods.
Rigid metal conduit of brass or other identified corrosion-resistant metal, rigid polyvinyl chloride conduit, rigid thermosetting resin conduit or liquid-tight flexible nonmetallic conduit (LFNC-B) shall extend from the forming shell to a suitable junction box or other enclosure as provided in Section E4206.9. Where rigid nonmetallic conduit or liquid-tight flexible nonmetallic conduit is used, an 8 AWG solid or stranded insulated copper bonding jumper shall be installed in this conduit with provisions for terminating in the forming shell and the junction box. The termination of the 8 AWG bonding jumper in the forming shell shall be covered with, or encapsulated in, a suitable potting compound to protect such connection from the possible deteriorating effect of pool water. [680.27(A)(2)]

E4206.10.3 Forming shell and metal screen.
The forming shell and metal screen shall be of brass or other approved corrosion-resistant metal. Forming shells shall include provisions for terminating an 8 AWG copper conductor. [680.27(A)(3)]

E4206.11 Electrically operated pool covers.
The electric motors, controllers, and wiring for pool covers shall be located not less than 5 feet (1524 mm) from the inside wall of the pool except where separated from the pool by a wall, cover, or other permanent barrier. Electric motors installed below grade level shall be of the totally enclosed type. The electric motor and controller shall be connected to a branch circuit protected by a ground fault circuit interrupter. The device that controls the operation of the motor for an electrically operated pool cover shall be located so that the operator has full view of the pool. [680.27(B)(1) and (B)(2)]

E4206.12 Electric pool water heaters.
Electric pool water heaters shall have the heating elements subdivided into loads not exceeding 48 amperes and protected at not more than 60 amperes. The ampacity of the branch-circuit conductors and the rating or setting of overcurrent protective devices shall be not less than 125 percent of the total nameplate load rating. (680.9)

E4206.13 Pool area heating.
The provisions of Sections E4206.13.1 through E4206.13.3 shall apply to all pool deck areas, including a covered pool, where electrically operated comfort heating units are installed within 20 feet (6096 mm) of the inside wall of the pool. [680.27(C)]

E4206.13.1 Unit heaters.
Unit heaters shall be rigidly mounted to the structure and shall be of the totally enclosed or guarded types. Unit heaters shall not be mounted over the pool or within the area extending 5 feet (1524 mm) horizontally from the inside walls of a pool. [680.27(C)(1)]

E4206.13.2 Permanently wired radiant heaters.
Electric radiant heaters shall be suitably guarded and securely fastened to their mounting devices. Heaters shall not be installed over a pool or within the area extending 5 feet (1524
mm) horizontally from the inside walls of the pool and shall be mounted not less than 12 feet (3658 mm) vertically above the pool deck. [680.27(C)(2)]

E4206.13.3 Radiant heating cables prohibited.
Radiant heating cables embedded in or below the deck shall be prohibited. [680.27(C)(3)]

SECTION E4207
STORABLE SWIMMING POOLS, STORABLE SPAS, AND STORABLE HOT TUBS

E4207.1 Pumps.
A cord-and-plug-connected pool filter pump for use with storable pools shall incorporate an approved system of double insulation or its equivalent and shall be provided with means for grounding only the internal and nonaccessible noncurrent-carrying metal parts of the appliance.

The means for grounding shall be an equipment grounding conductor run with the power-supply conductors in a flexible cord that is properly terminated in a grounding-type attachment plug having a fixed grounding contact. Cord-and-plug-connected pool filter pumps shall be provided with a ground-fault circuit interrupter that is an integral part of the attachment plug or located in the power supply cord within 12 inches (305 mm) of the attachment plug. (680.31)

E4207.2 Ground-fault circuit-interrupters required.
Electrical equipment, including power-supply cords, used with storable pools shall be protected by ground-fault circuit-interrupters. 125-volt, 15- and 20-ampere receptacles located within 20 feet (6096 mm) of the inside walls of a storable pool, storable spa, or storable hot tub shall be protected by a ground-fault circuit interrupter. In determining these dimensions, the distance to be measured shall be the shortest path that the supply cord of an appliance connected to the receptacle would follow without passing through a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier. (680.32)

E4207.3 Luminaires.
Luminaires for storable pools, storable spas, and storable hot tubs shall not have exposed metal parts and shall be listed for the purpose as an assembly. In addition, luminaires for storable pools shall comply with the requirements of Section E4207.3.1 or E4207.3.2. (680.33)

E4207.3.1 Within the low-voltage contact limit.
A luminaire installed in or on the wall of a storable pool shall be part of a cord-and-plug-connected lighting assembly. The assembly shall:

1. Have a luminaire lamp that is suitable for the use at the supplied voltage;
2. Have an impact-resistant polymeric lens, luminaire body, and transformer enclosure;
3. Have a transformer meeting the requirements of section E4206.1 with a primary rating not over 150 volts; and
4. Have no exposed metal parts. [680.33(A)]

E4207.3.2 Over the low-voltage contact limit but not over 150 volts.
A lighting assembly without a transformer or power supply, and with the luminaire lamp(s)
operating at over the low-voltage contact limit, but not over 150 volts, shall be permitted to be cord and plug-connected where the assembly is listed as an assembly for the purpose and complies with all of the following:

1. It has an impact-resistant polymeric lens and luminaire body.

2. A ground-fault circuit interrupter with open neutral conductor protection is provided as an integral part of the assembly.

3. The luminaire lamp is permanently connected to the ground-fault circuit interrupter with open-neutral protection.

4. It complies with the requirements of Section E4206.4.

5. It has no exposed metal parts. [680.33(B)]

E4207.4 Receptacle locations.
Receptacles shall be located not less than 6 feet (1829 mm) from the inside walls of a storable pool, storable spa or storable hot tub. In determining these dimensions, the distance to be measured shall be the shortest path that the supply cord of an appliance connected to the receptacle would follow without passing through a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier. (680.34)

E4207.5 Clearances.
Overhead conductor installations shall comply with Section E4203.6 and underground conductor installations shall comply with Section E4203.7.

E4207.6 Disconnecting means.
Disconnecting means for storable pools and storable/portable spas and hot tubs shall comply with Section E4203.3.

E4207.7 Ground-fault circuit interrupters.
Ground-fault circuit interrupters shall comply with Section E4206.2.

E4207.8 Grounding of equipment.
Equipment shall be grounded as required by Section E4205.1.

E4207.9 Pool water heaters.
Electric pool water heaters shall comply with Section E4206.12.

SECTION E4208
SPAS AND HOT TUBS

E4208.1 Ground-fault circuit-interrupters.
The outlet(s) that supplies a self-contained spa or hot tub, or a packaged spa or hot tub equipment assembly, or a field-assembled spa or hot tub with a heater load of 50 amperes or less, shall be protected by a ground-fault circuit-interrupter. (680.44)

A listed self-contained unit or listed packaged equipment assembly marked to indicate that integral ground-fault circuit-interrupter protection is provided for all electrical parts within the unit.
or assembly, including pumps, air blowers, heaters, lights, controls, sanitizer generators and wiring, shall not require that the outlet supply be protected by a ground-fault circuit interrupter. [680.44(A)]

E4208.2 Electric water heaters.
Electric spa and hot tub water heaters shall be listed and shall have the heating elements subdivided into loads not exceeding 48 amperes and protected at not more than 60 amperes. The ampacity of the branch-circuit conductors, and the rating or setting of overcurrent protective devices, shall be not less than 125 percent of the total nameplate load rating. (680.9)

E4208.3 Underwater audio equipment.
Underwater audio equipment used with spas and hot tubs shall comply with the provisions of Section E4206.10. [680.43(G)]

E4208.4 Emergency switch for spas and hot tubs.
A clearly labeled emergency shutoff or control switch for the purpose of stopping the motor(s) that provides power to the recirculation system and jet system shall be installed at a point that is readily accessible to the users, adjacent to and within sight of the spa or hot tub and not less than 5 feet (1524 mm) away from the spa or hot tub. This requirement shall not apply to single-family dwellings. (680.41)

SECTION E4209
HYDROMASSAGE BATHTUBS

E4209.1 Ground-fault circuit-interrupters.
Hydromassage bathtubs and their associated electrical components shall be supplied by an individual branch circuit(s) and protected by a readily accessible ground-fault circuit interrupter. All 125-volt, single-phase receptacles not exceeding 30 amperes and located within 6 feet (1829 mm) measured horizontally of the inside walls of a hydromassage tub shall be protected by a ground-fault circuit interrupter(s). (680.71)

E4209.2 Other electric equipment.
Luminaires, switches, receptacles, and other electrical equipment located in the same room, and not directly associated with a hydromassage bathtub, shall be installed in accordance with the requirements of this code relative to the installation of electrical equipment in bathrooms. (680.72)

E4209.3 Accessibility.
Hydromassage bathtub electrical equipment shall be accessible without damaging the building structure or building finish. Where the hydromassage bathtub is cord- and plug-connected with the supply receptacle accessible only through a service access opening, the receptacle shall be installed so that its face is within direct view and not more than 12 inches (305 mm) from the plane of the opening. (680.73)

E4209.4 Bonding.
Both metal piping systems and grounded metal parts in contact with the circulating water shall be bonded together using an insulated, covered or bare solid copper bonding jumper not smaller than 8 AWG. The bonding jumper shall be connected to the terminal on the circulating pump motor that is intended for this purpose. The bonding jumper shall not be required to be connected to a double insulated circulating pump motor. The 8 AWG or larger solid copper
bonding jumper shall be required for equipotential bonding in the area of the hydromassage bathtub and shall not be required to be extended or attached to any remote panelboard, service equipment, or any electrode. Where a double-insulated circulating pump motor is used, the 8 AWG or larger solid copper bonding jumper shall be long enough to terminate on a replacement nondouble-insulated pump motor and shall be terminated to the equipment grounding conductor of the branch circuit for the motor. (680.74)
CHAPTER 43
CLASS 2 REMOTE-CONTROL, SIGNALING AND POWER-LIMITED CIRCUITS

Deleted. See the North Carolina Electrical Code.

SECTION E4301
GENERAL

E4301.1 Scope.
This chapter contains requirements for power supplies and wiring methods associated with Class 2 remote-control, signaling, and power limited circuits that are not an integral part of a device or appliance. Other classes of remote-control, signaling and power-limited conductors shall comply with Article 725 of NFPA 70. (725.1)

E4301.2 Definitions.

CLASS 2 CIRCUIT. That portion of the wiring system between the load side of a Class 2 power source and the connected equipment. Due to its power limitations, a Class 2 circuit considers safety from a fire initiation standpoint and provides acceptable protection from electric shock. (725.2)

REMOTE-CONTROL CIRCUIT. Any electrical circuit that controls any other circuit through a relay or an equivalent device. (Article 100)

SIGNALING CIRCUIT. Any electrical circuit that energizes signaling equipment. (Article 100)

SECTION E4302
POWER SOURCES

E4302.1 Power sources for Class 2 circuits.
The power source for a Class 2 circuit shall be one of the following:

1. A listed Class 2 transformer.

2. A listed Class 2 power supply.

3. Other listed equipment marked to identify the Class 2 power source.

4. Listed information technology (computer) equipment limited power circuits.

5. A dry-cell battery provided that the voltage is 30 volts or less and the capacity is equal to or less than that available from series connected No. 6 carbon zinc cells. [725.121(A)]
E4302.2 Interconnection of power sources.
A Class 2 power source shall not have its output connections paralleled or otherwise interconnected with another Class 2 power source except where listed for such interconnection. [725.121(B)]

SECTION E4303
WIRING METHODS

E4303.1 Wiring methods on supply side of Class 2 power source.
Conductors and equipment on the supply side of the power source shall be installed in accordance with the appropriate requirements of Chapters 34 through 41. Transformers or other devices supplied from electric light or power circuits shall be protected by an over-current device rated at not over 20 amperes. The input leads of a transformer or other power source supplying Class 2 circuits shall be permitted to be smaller than 14 AWG, if not over 12 inches (305 mm) long and if the conductor insulation is rated at not less than 600 volts. In no case shall such leads be smaller than 18 AWG. (725.127 and 725.127 Exception)

E4303.2 Wiring methods and materials on load side of the Class 2 power source.
Class 2 cables installed as wiring within buildings shall be listed as being resistant to the spread of fire and listed as meeting the criteria specified in Sections E4303.2.1 through E4303.2.3. Cables shall be marked in accordance with Section E4303.2.4. Cable substitutions as described in Table E4303.2 and wiring methods covered in Chapter 38 shall also be permitted. (725.130 (B); 725.135 (A), (C), (G) and (M); 725.154; Table 725.154; Figure 725.154 (A); and 725.179)

TABLE E4303.2
CABLE USES AND PERMITTED SUBSTITUTIONS
[Figure 725.154(A)]

<table>
<thead>
<tr>
<th>CABLE TYPE</th>
<th>USE</th>
<th>PERMITTED SUBSTITUTIONS a</th>
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<tbody>
<tr>
<td>CL2P</td>
<td>Class 2 Plenum Cable</td>
<td>CMP, CL3P</td>
</tr>
<tr>
<td>CL2R</td>
<td>Class 2 Plenum Cable</td>
<td>CMP, CL3P, CL2P, CMR, CL3R</td>
</tr>
</tbody>
</table>

a—For identification of cables other than Class 2 cables, see NFPA 70.

E4303.2.1 Type CL2P cables.
Cables installed in ducts, plenums and other spaces used to convey environmental air shall be Type CL2P cables listed as being suitable for the use and listed as having adequate fire-resistant and low-smoke-producing characteristics. [725.179(A)]

E4303.2.2 Type CL2 cables.
Cables for general-purpose use, shall be listed as being resistant to the spread of fire and listed for the use. [725.179 (C)]
E4303.2.3 Type CL2X cables.
Type CL2X limited-use cable shall be listed as being suitable for use in dwellings and for the use and in raceways and shall also be listed as being flame retardant. Cables with a diameter of less than \( \frac{1}{4} \) inch (6.4 mm) shall be permitted to be installed without a raceway. [725.179(D)]

E4303.2.4 Type CL2R cables.
Cables installed in a vertical run in a shaft or installed from floor to floor shall be listed as suitable for use in a vertical run in a shaft or from floor to floor and shall also be listed as having fire-resistant characteristics capable of preventing fire from being conveyed from floor to floor. [725.179(B)]

Exception: CL2X and CL3X cables with a diameter of less than \( \frac{1}{4} \) inch (6.4 mm) and CL2 and CL3 cables shall be permitted in risers in one- and two-family dwelling units. [725.154(G)]

E4303.2.5 Marking.
Cables shall be marked in accordance with Table E4303.2.5. Voltage ratings shall not be marked on cables.

Table E4303.2.5 [Table 725.179(K)]

<table>
<thead>
<tr>
<th>CABLE MARKING</th>
<th>TYPE</th>
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<tbody>
<tr>
<td>CL2P</td>
<td>Class 2 plenum cable</td>
</tr>
<tr>
<td>CL2R</td>
<td>Class 2 riser cable</td>
</tr>
<tr>
<td>CL2</td>
<td>Class 2 cable</td>
</tr>
<tr>
<td>CL2X</td>
<td>Class 2 cable, limited use</td>
</tr>
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</table>

SECTION E4304
INSTALLATION REQUIREMENTS

E4304.1 Separation from other conductors.
In cables, compartments, enclosures, outlet boxes, device boxes, and raceways, conductors of Class 2 circuits shall not be placed in any cable, compartment, enclosure, outlet box, device box, raceway, or similar fitting with conductors of electric light, power, Class 1 and nonpower-limited fire alarm circuits. (725.136)

Exceptions:

1. Where the conductors of the electric light, power, Class 1 and nonpower-limited fire alarm circuits are separated by a barrier from the Class 2 circuits. In enclosures, Class 2 circuits shall be permitted to be installed in a raceway within the enclosure to separate them from Class 1, electric light, power and nonpower-limited fire alarm circuits. [725.136(B)]

2. Class 2 conductors in compartments, enclosures, device boxes, outlet boxes and similar fittings where electric light, power, Class 1 or nonpower-limited fire alarm
circuit conductors are introduced solely to connect to the equipment connected to the Class 2 circuits. The electric light, power, Class 1 and nonpower-limited fire alarm circuit conductors shall be routed to maintain a minimum of \( \frac{1}{4} \) inch (6.4 mm) separation from the conductors and cables of the Class 2 circuits; or the electric light power, Class 1 and nonpower-limited fire alarm circuit conductors operate at 150 volts or less to ground and the Class 2 circuits are installed using Types CL3, CL3R, or CL3P or permitted substitute cables, and provided that these Class 3 cable conductors extending beyond their jacket are separated by a minimum of \( \frac{1}{4} \) inch (6.4 mm) or by a nonconductive sleeve or nonconductive barrier from all other conductors. [725.136(D)]

E4304.2 Other applications.
Conductors of Class 2 circuits shall be separated by not less than 2 inches (51 mm) from conductors of any electric light, power, Class 1 or nonpower-limited fire alarm circuits except where one of the following conditions is met:

1. All of the electric light, power, Class 1 and nonpower-limited fire alarm circuit conductors are in raceways or in metal-sheathed, metal-clad, nonmetallic-sheathed or Type UF cables.

2. All of the Class 2 circuit conductors are in raceways or in metal-sheathed, metal-clad, nonmetallic-sheathed or Type UF cables. [725.136(I)]

E4304.3 Class 2 circuits with communications circuits.
Where Class 2 circuit conductors are in the same cable as communications circuits, the Class 2 circuits shall be classified as communications circuits and shall meet the requirements of Article 800 of NFPA 70. The cables shall be listed as communications cables or multipurpose cables.

Cables constructed of individually listed Class 2 and communications cables under a common jacket shall be permitted to be classified as communications cables. The fire-resistance rating of the composite cable shall be determined by the performance of the composite cable. [725.139(D)]

E4304.4 Class 2 cables with other circuit cables.
Jacketed cables of Class 2 circuits shall be permitted in the same enclosure or raceway with jacketed cables of any of the following:

1. Power-limited fire alarm systems in compliance with Article 760 of NFPA 70.

2. Nonconductive and conductive optical fiber cables in compliance with Article 770 of NFPA 70.

3. Communications circuits in compliance with Article 800 of NFPA 70.

4. Community antenna television and radio distribution systems in compliance with Article 820 of NFPA 70.
5. Low-power, network-powered broadband communications in compliance with Article 830 of NFPA 70. [725.139(E)]

E4304.5 Installation of conductors and cables.
Cables and conductors installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that they will not be damaged by normal building use. Such cables shall be supported by straps, staples, hangers, cable ties or similar fittings designed so as to not damage the cable. Nonmetallic cable ties and other nonmetallic accessories used to secure and support cables located in stud cavity and joist space plenums shall be listed as having low smoke and heat release properties. The installation shall comply with Table E3802.1 regarding cables run parallel with framing members and furring strips. The installation of wires and cables shall not prevent access to equipment nor prevent removal of panels, including suspended ceiling panels. Raceways shall not be used as a means of support for Class 2 circuit conductors, except where the supporting raceway contains conductors supplying power to the functionally associated equipment controlled by the Class 2 conductors. [300.22 (C) (1) and 725.24]
**Part VI—Referenced Standards**

### CHAPTER 44

**REFERENCED STANDARDS**

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section R102.4.

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<td>506—11</td>
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R606.12.2.3.1,

R703.12

ACCA
Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206

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AISI
American Iron and Steel Institute
25 Massachusetts Avenue, NW Suite 800
Washington, DC 20001

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**AMCA**

Air Movement and Control Association  
300 West University  
Arlington Heights, IL 60004

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**AMD**

Association of Millwork Distributors Standards  
10047 Robert Trent Parkway  
New Port Richey, FL 34655-4649

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**ANCE**

Association of the Electric Sector  
Av. Lázaro Cardenas No. 869  
Col. Nueva Industrial Vallejo  
C.P. 07700 México D.F.

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**ANSI**

American National Standards Institute  
25 West 43rd Street, Fourth Floor  
New York, NY 10036

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APA—The Engineered Wood Association
7011 South 19th
Tacoma, WA 98466

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**APSP**
The Association of Pool and Spa Professionals
2111 Eisenhower Avenue
Alexandria, VA 22314

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**ASCE/SEI**
American Society of Civil Engineers
Structural Engineering Institute
1801 Alexander Bell Drive
Reston, VA 20191

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ASHRAE
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle, NE
Atlanta, GA 30329

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ASME
American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990

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ASSE
American Society of Sanitary Engineering
901 Canterbury, Suite A
Westlake, OH 44145

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**ASTM**

ASTM International  
100 Barr Harbor Drive  
West Conshohocken, PA 19428

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AWC American Wood Council
222 Catocin Circle, Suite 201
Leesburg, VA 20175

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**AWS**

American Welding Society
8669 NW 36 Street, #130
Doral, FL 33166

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**AWWA**

American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235

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**CEN**

European Committee for Standardization (EN)
Central Secretariat
Rue de Stassart 36
B-10 50 Brussels

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**CGSB**

Canadian General Standards Board
Place du Portage 111, 6B1
11 Laurier Street
Gatineau, Quebec, Canada K1A 1G6

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**CISPI**

Cast Iron Soil Pipe Institute
5959 Shallowford Road, Suite 419
Chattanooga, TN 37421

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## CPA

**Composite Panel Association**  
19465 Deerfield Avenue, Suite 306  
Leesburg, VA 20176

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## CPSC

**Consumer Product Safety Commission**  
4330 East West Highway  
Bethesda, MD 20814-4408

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## CSA

**CSA Group**  
8501 East Pleasant Valley Road  
Cleveland, OH 44131-5516

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**DOC**

United States Department of Commerce  
1401 Constitution Avenue, NW  
Washington, DC 20230

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**DOTn**

Department of Transportation  
1200 New Jersey Avenue SE  
East Building, 2nd floor  
Washington, DC 20590

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**FEMA**

Federal Emergency Management Agency  
500 C Street, SW  
Washington, DC 20472

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**ISO**

International Organization for Standardization
1, ch. de la Voie - Creuse
Case postale 56
CH-1211 Geneva 20, Switzerland

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MSS
Manufacturers Standardization Society of the Valve and Fittings Industry
127 Park Street, Northeast
Vienna, VA 22180

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NAIMA
North American Insulation Manufacturers Association
44 Canal Center Plaza, Suite 310
Alexandria, VA 22314

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NFPA
National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02269

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### PCA
Portland Cement Association  
5420 Old Orchard Road  
Skokie, IL 60077

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### SBCA
Structural Building Components Association  
6300 Enterprise Lane  
Madison, WI 53719

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### SMACNA
Sheet Metal & Air Conditioning Contractors National Assoc. Inc.  
4021 Lafayette Center Road  
Chantilly, VA 22021

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### SRCC
Solar Rating & Certification Corporation  
400 High Point Drive, Suite 400  
Cocoa, FL 32926

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### TMS
The Masonry Society  
105 South Sunset Street, Suite Q  
Longmont, CO 80501

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### TPI
Truss Plate Institute  
218 N. Lee Street, Suite 312  
Alexandria, VA 22314

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### UL
UL LLC  
333 Pfingsten Road  
Northbrook, IL 60062

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58—14 Liquefied Petroleum Gas Code M2201.1

80—2007 Steel Tanks for Oil-burner Fuel—with revisions August 2009 M2201.1

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127—2011 Factory-built Fireplaces R1001.11, R1004.1, R1004.4, R1004.5, R1005.4, G2445.7

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181A—2013 Closure Systems for Use with Rigid Air Ducts and Air Connectors—
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181B—2013 Closure Systems for Use with Flexible Air Ducts and Air Connectors—
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441—10 Gas Vents G2426.1

508—99 Industrial Control Equipment—with revisions through March 2013 M1411.3.1

536—97 Flexible Metallic Hose—with revisions through June 2003 M2202.3

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<tr>
<td>7 Underwriters Road</td>
<td></td>
</tr>
<tr>
<td>Toronto, Ontario, Canada M1R 3B4</td>
<td></td>
</tr>
<tr>
<td>Standard reference number</td>
<td>Title</td>
</tr>
<tr>
<td>CAN/ULC S 102.2—2010 Standard Methods for Test for Surface Burning</td>
<td>R302.10.1, R302.10.2</td>
</tr>
<tr>
<td>Characteristics of Building Materials and Assemblies</td>
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<td>WDMA</td>
<td></td>
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<tr>
<td>2025 M Street, NW Suite 800</td>
<td></td>
</tr>
<tr>
<td>Washington, DC 20036-3309</td>
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</tr>
<tr>
<td>Standard reference number</td>
<td>Title</td>
</tr>
<tr>
<td>AAMA/WDMA/CSA 101/L.S2/A440—11 North American Fenestration Standard/</td>
<td>R308.6.9, R609.3, N1102.4.4.3</td>
</tr>
<tr>
<td>Specifications for Windows, Doors and Skylights Industry Standard</td>
<td></td>
</tr>
<tr>
<td>Analytical Method for Design Pressure (DP) Ratings of</td>
<td></td>
</tr>
<tr>
<td>Fenestration Products</td>
<td></td>
</tr>
<tr>
<td>Standard reference number</td>
<td>Title</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>400—2009</td>
<td>Procedure for Determining Fenestration Product Air Leakage—Second Edition</td>
</tr>
</tbody>
</table>
CHAPTER 45
HIGH WIND ZONES

This chapter is a North Carolina addition and not part of the 2015 International Residential Code. There will be no underlined text.

SECTION R4501
GENERAL

R4501.1 General.
The provisions of this chapter shall be applicable to buildings constructed in high wind zones as noted by the text. These provisions shall be in addition to or in lieu of previous chapters.

R4501.2 Alternate construction.
In lieu of specific code requirements for structures in the 130, 140, and 150 miles per hour (58 m/s, 63 m/s and 67 m/s) wind zones, compliance with International Code Council ICC 600 Standard for Residential Construction in High-Wind Regions or AF&PA Wood Frame Construction Manual for One- and Two-Family Dwellings is acceptable.

SECTION R4502
DESIGN PRESSURE FOR DOORS AND WINDOWS

TABLE R4502(a)
DESIGN PRESSURES FOR DOORS AND WINDOWS\textsuperscript{a, b, c, d}
POSITIVE AND NEGATIVE IN PSF

<table>
<thead>
<tr>
<th>VELOCITY (mph)</th>
<th>\textsuperscript{a}</th>
<th>MEAN ROOF HEIGHT (ft)</th>
<th>\textsuperscript{b}</th>
<th>MEAN ROOF HEIGHT (ft)</th>
<th>\textsuperscript{c}</th>
<th>MEAN ROOF HEIGHT (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>15</td>
<td>25</td>
<td>29</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>25</td>
<td>29</td>
<td>35</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>31</td>
<td>35</td>
<td>43</td>
<td>47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 degree = 0.01745 rad.
\textsuperscript{a} Alternate pressures may be determined by using the North Carolina Building Code, ASCE-7, or the International Building Code.
\textsuperscript{b} If window or door is more than 4 feet from a corner, the pressure from this table shall be permitted to be multiplied by 0.87. This adjustment does not apply to garage doors.
\textsuperscript{c} For windows or doors in structures with a roof slope of 10 degrees (2:12) or less from the horizontal, the pressure from this table may be multiplied by 0.90.
\textsuperscript{d} Design pressure ratings based on the standards listed in Section R609 are adequate documentation of capacity to resist pressures from the table.
\textsuperscript{e} Where the mean roof height exceeds this table, values shall be determined by a design professional.

TABLE R4502(b)
DESIGN PRESSURES (IN PSF) GARAGE DOORS\textsuperscript{a, b, c, d, e}

<table>
<thead>
<tr>
<th>VELOCITY (mph)</th>
<th>\textsuperscript{a}</th>
<th>MEAN ROOF HEIGHT (ft)</th>
<th>\textsuperscript{b}</th>
<th>MEAN ROOF HEIGHT (ft)</th>
<th>\textsuperscript{c}</th>
<th>MEAN ROOF HEIGHT (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>15</td>
<td>25</td>
<td>23</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>20</td>
<td>25</td>
<td>29</td>
<td>32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2018 North Carolina Residential Code
a. The pressures in this table are for garage doors at least 9 feet by 7 feet and at least 2 feet from the corner.
b. Alternate design pressures may be determined by using the North Carolina Building Code, ASCE-7, or the International Building Code.
c. For doors in a structure with a roof slope of 10 degrees (2:12) or less from the horizontal the pressures from this table may be multiplied by 0.90.
d. Design pressure ratings based on tests done according to ASTM E330 are adequate documentation.
e. Garage doors on the ground level of a structure in a flood zone do not have to meet the above design pressures provided all of the following conditions are met:
   1. Structure is anchored to the girders and top of the piling to resist the forces given in Chapter 45.
   2. The garage door occurs below the top of the piling.
   3. Provide openings at the garage level that comply with either of the following options:
      i. Design all exterior walls at the garage level to break away at 20 psf or less or;
      ii. Provide openings (in walls at the garage level without the garage door) equal to at least 20 percent of the total wall area from the ground to the roof.
f. Where the mean roof height exceeds this table, values shall be determined by a design professional.

SECTION R4503
FOOTINGS

R4503.1 General.
All exterior walls shall be supported on continuous concrete footings in the 140 and 150 mph (63 m/s and 67 m/s) wind zones. Exterior wall footings in the 130 mph (58 m/s) wind zone shall be constructed in accordance with Section R403.1.

Exception: Pile foundations shall be constructed in accordance with Chapter 46.

R4503.1.1 Footing size.
Footings shall be a minimum of 8 inches by 24 inches (203 mm by 610 mm) for houses 2 ½ stories and less. The footings for a three-story building shall be 10 inches by 24 inches (254 mm by 610 mm).

Exception: Alternate footing sizes are permitted when a footing mass equivalent is provided to resist uplift forces. See Figure R4503.1.1.

R4503.1.2 Footing reinforcement.
Footings shall be reinforced with three #4 bars or two #5 bars at 3 inches (76 mm) above the bottom of the footing. The bars shall be equally spaced with 3 inches (76 mm) clear minimum from the side of the footing. The bars shall be continuous or lapped 25 inches at all splices.

R4503.1.3 Interior piers and pier footings.
The dimensions for the interior piers and pier footings shall comply with Table R403.1(2).

R4503.1.4 Interior thickened slabs.
Monolithic slabs with integral footings resisting uplift shall be reinforced in accordance with Section R4503.1.2.

R4503.1.5 Interior foundation walls.
Interior foundation walls resisting uplift shall be reinforced in accordance with Section R4503.1.2.

![Diagram of foundation walls](image)

24 inches x 8 inches = 192 square inches

16 inches x 12 inches = 192 square inches

For SI: 1 foot = 304.8 mm.

**FIGURE R4503.1.1**

**ALTERNATE FOOTING SIZE**

R4503.2 Pier and curtain wall footings.

Pier and curtain walls in the 140 and 150 mph (63 m/s and 67 m/s) wind zones shall be constructed in accordance with Sections R4503.2.1 and R4503.2.2 and Figures R4503.2(a) through R4503.2(d).

R4503.2.1 Enlarged footings at piers.

The curtain wall footing must meet the minimum projection requirements in Figure R403.1(1) and footing dimensions for the pier footings shall comply with Table R4503.2.1.

**TABLE R4503.2.1**

FOOTINGS TO RESIST UPLIFT FROM PIERs IN 140 AND 150 MPH WIND ZONES SUPPORTING GIRDERS IN EXTERIOR WALLS

<table>
<thead>
<tr>
<th>VELOCITY (mph)</th>
<th>4'-0&quot;</th>
<th>6'-0&quot;</th>
<th>8'-0&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>140</td>
<td>2'-0&quot; x 2'-0&quot; x 10&quot;</td>
<td>2'-4&quot; x 2'-4&quot; x 10&quot;</td>
<td>2'-8&quot; x 2'-8&quot; x 10&quot;</td>
</tr>
<tr>
<td>150</td>
<td>3'-0&quot; x 3'-0&quot; x 10&quot;</td>
<td>3'-4&quot; x 3'-4&quot; x 12&quot;</td>
<td>3'-8&quot; x 3'-8&quot; x 12&quot;</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s.

Note: See Table R403.1(2) for 130 mph wind zone.

R4503.2.2 Continuous width footings.

Uniform continuous width footings for pier and curtain wall foundations shall be a minimum of 8 inches (203 mm) thick and 24 inches (60 mm) wide. Footings shall be reinforced with three #4 bars (or two #5 bars) at 3 inches (76 mm) above the bottom of the footing. The bars shall be continuous or lapped 25 inches (635 mm) at all splices.
R4503.3 Footing dowels.
All footings shall have reinforcing dowel bars to match the vertical reinforcing bars in the foundation wall above. Dowels or threaded rods shall have a standard hook length of 12 times the bar diameter embedded in the footing and shall lap the wall or pier reinforcing at least 25 inches (635 mm).

R4503.4 Footing anchor bolts.
All anchor bolts shall have a standard hook length of 12 times the bolt diameter embedded in the footing or foundation wall. They shall not be permitted to be lapped.

Exceptions:
1. Anchor bolts in bond beams as permitted by Section R4504.2.1.1
2. Anchor bolts in slabs on grade as permitted by Section R4504.2.2

SECTION R4504
WALL AND FOUNDATION ANCHORAGE

R4504.1 Anchorage in the 130 mph wind zone.
Exterior walls of structures in the 130 mph (58 m/s) wind zone shall be anchored to the foundation wall or slab on grade with 1/2-inch (13 mm) anchor bolts, 4 feet (1219 mm) on center extended 15 inches (381 mm) into masonry and 7 inches (178 mm) into concrete and are exempt from the other requirements of this section.

R4504.2 Anchorage in the 140 and 150 mph wind zones.
Exterior walls of structures in the 140 and 150 mph (63 m/s and 67 m/s) wind zones shall be anchored to the footing to resist the forces specified in Section R4508.2, by the prescriptive requirements of this section and Figures R4504.2(a) through R4504.2(f), or as allowed by Section R4508.4.

R4504.2.1 Exterior foundation walls.
Vertical reinforcement bars shall be installed not more than 2 feet (51 mm) from each corner and at intervals not to exceed Table R4504.2.1 with all reinforced cells grouted solid. The reinforcement bars shall terminate in a bond beam in accordance with Section R4504.2.1.1 or continuous anchorage bolts shall terminate at the sill plate or exterior wall framing in accordance with Section R4504.2.1.2.

<table>
<thead>
<tr>
<th>BAR/BOLT SIZE (inches)</th>
<th>5/8</th>
<th>1/2</th>
<th>3/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAXIMUM SPACING (inches)</td>
<td>96</td>
<td>72</td>
<td>42</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
a. Applies to 140 and 150 mph wind zones.
b. Continuous anchorage from footing to girder or wall framing.
c. Applies to footing dowel bars, vertical reinforcement and anchor bolts.
d. Spacing may exceed the tabulated values by up to 8 inches provided the total number of required bars is installed.
R4504.2.1.1 Bond beams.
The top of a concrete or masonry foundation wall shall have a bond beam in accordance with Figure R4504.2(a). The bond beam shall be reinforced with one #5 bar. The bar shall be continuous or lapped 25 inches (635 mm) at all splices.

R4504.2.1.1.1 Bond beam plate anchorage.
A minimum of two 2 × 6 sill plates shall be anchored with 1/2-inch (13 mm) anchor bolts with 2 × 2 × 1/8 inch (51 × 51 × 3 mm) washers at intervals not to exceed Table R4504.2.1.1. An approved anchor from the sill plate to the wall framing shall be installed to resist the forces specified in Table R4508.2 or sheathing shall be fastened in accordance with Figure R4508.4(b). See Figure R4504.2(a).

<table>
<thead>
<tr>
<th>WIND SPEED (mph)</th>
<th>140</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAXIMUM SPACING (inches)</td>
<td>21</td>
<td>18</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.
a. Required spacing of 1/2-inch anchor bolts where a bond beam is required and for slab on grade with a single sole plate. See Figure R403.1(1) for 130 mph or less.

R4504.2.1.2 Continuous anchorage bolts.
A minimum of two 2 × 6 sill plates shall be anchored with continuous anchor bolts in accordance with Table R4504.2.1 with 2 × 2 × 1/8 inch (51 × 51 × 3 mm) washers. Where the vertical anchorage bolts terminate at the sill plate, an approved anchor from the sill plate to the wall framing shall be installed to resist the forces specified in Table R4508.2 or sheathing shall be fastened in accordance with Figure R4508.4(b). See Figure R4504.2(b)

Exception: Where the uplift anchorage bolts from Table R4504.2.1 are continuous from the footing to the exterior wall framing, a single 2 x 6 sill plate is permitted. See Figure R4504.2(c)

R4504.2.2 Exterior concrete slab-on-grade footings.
Anchorage shall be installed at intervals not to exceed Table R4504.2.1 and shall terminate in a minimum 2 × 4 double sole plate. See Figure 4504.2(d).

Exceptions:
1. Where the bolts terminate in a single sole plate, anchorage shall be installed at intervals not to exceed Table R4504.2.1.1. See Figure R4504.2(e).

2. Foundation anchorage spaced and installed in accordance with the manufacturer's installation instructions that provides equivalent anchorage to resist the forces in Table R4508.2 shall be installed to provide continuous load path from the single sole plate to the wall.

R4504.2.3 Ground supported slab with masonry stem wall.
A minimum of two 2x sill plates shall be anchored with 1/2-inch (13 mm) continuous anchor bolts with 2 × 2 × 1/8 inch (51 × 51 × 3 mm) washers at intervals not to exceed Table R4504.2.1.1. An approved anchor from the sill plate to the wall framing shall be installed to
resist the forces specified in Table R4508.2 or sheathing shall be fastened in accordance with Figure R4508.4(b). See Figure R4504.2(f).

SECTION R4505
WALL CONSTRUCTION

R4505.1 Construction.
Exterior walls of wood frame construction shall be in accordance with Figures R602.3(1) and R602.3(2). Components of exterior walls shall be fastened in accordance with Table R602.3(1). Walls of wood frame construction shall be designed and constructed in accordance with ANSI AWC “National Design Specification for Wood Construction,” listed in Chapter 44.

Exterior walls subject to wind speeds of 130 mph (58 m/s) or greater as established in Table R301.2(1) shall be designed in accordance with accepted engineering practice. See Tables R4505(a) and R4505(b).

In bearing walls, studs which are not more than 10 feet (3048 mm) in length shall be spaced not more than is specified in Tables R4505(a) and R4505(b) for the corresponding stud size.

**TABLE R4505(a)**
**STUDS IN 130, 140, AND 150 MPH ZONES**

**Requirements for Wood Stud In: Exterior Walls Supporting One Floor, Roof and Ceiling or Less/Exterior Nonloadbearing Walls in Two Story Structure or Less/Interior Walls Supporting One Floor, Roof and Ceiling or Less**

<table>
<thead>
<tr>
<th>STUD LENGTH</th>
<th>STUD SPACING</th>
<th>130 MPH</th>
<th>130 MPH</th>
<th>140 MPH</th>
<th>150 MPH</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>2x4</td>
<td>2x6</td>
<td>2x4</td>
<td>2x6</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>#2</td>
<td>Stud</td>
<td>Stud</td>
<td>Stud</td>
</tr>
<tr>
<td>8</td>
<td>24</td>
<td>#2</td>
<td>Stud</td>
<td>#2</td>
<td>Stud</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>#2</td>
<td>Stud</td>
<td>#2</td>
<td>Stud</td>
</tr>
<tr>
<td>10</td>
<td>24</td>
<td>Design</td>
<td>#2</td>
<td>Design</td>
<td>#2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Species: Spruce Pine Fir (South) without Structural Sheathing</td>
<td>Species: Spruce Pine Fir (South) with 3/8&quot; Wood Structural Sheathing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

**Explanation of Table Entries:**
- **Design** – Studs with this entry shall be in accordance with accepted engineering practice.
- #2 – #2 Grade construction
- #3 – #3 Grade
- **Stud** – Stud grade
- **Standard** – Standard grade
- **Utility** – Utility grade

3/8” wood structural sheathing shall be attached with 8d nails at 6” at perimeter and 12” at intermediate supports. When a grade is specified in the table any grade above it in this list may be used.

**TABLE R4505(b)**
**EXTERIOR WALLS FOR FIRST FLOOR OF THREE STORY**

2018 North Carolina Residential Code
Exterior Bearing Walls* First Floor of Three Story

<table>
<thead>
<tr>
<th>WIND ZONE (mph)</th>
<th>2x4 @ 12&quot; oc Structural Sheathing</th>
<th>3x4 or 2x6 @ 16&quot; oc Structural Sheathing</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>#2</td>
<td>Any grade</td>
</tr>
<tr>
<td>140</td>
<td>#2</td>
<td>Any grade</td>
</tr>
<tr>
<td>150</td>
<td>#2</td>
<td>Any grade</td>
</tr>
</tbody>
</table>

Exterior Nonbearing Walls* First Floor of Three Story

<table>
<thead>
<tr>
<th>WIND ZONE (mph)</th>
<th>2x4 @ 12&quot; oc Blocking</th>
<th>2x4 @ 16&quot; oc Blocking</th>
<th>3x4 or 2x6 @ 16&quot; oc Structural Sheathing</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>#2, Stud</td>
<td>#2</td>
<td>Any grade</td>
</tr>
<tr>
<td>140</td>
<td>#2, Stud</td>
<td>NP</td>
<td>Any grade</td>
</tr>
<tr>
<td>150</td>
<td>#2</td>
<td>NP</td>
<td>Any grade</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Any grade = any grade except standard, utility and economy.
b. Corner bracing is required where blocking is specified.
c. 2 – 2x4s at 16 inches or 1 – 2x4 at 8 inches may be used where 3x4 at 16 inches is specified.
d. Refer to Sections R4506 and R4508.4 for sheathing requirements.
e. Bearing stud height is limited to 10 feet.
f. 2x full depth blocking at mid-height.

SECTION R4506
STRUCTURAL BRACING

R4506.1 Structural bracing in 130 mph wind zone.
Structural bracing in the 130 mph (58 m/s) wind zone shall comply with Section R602.10.3.

R4506.2 Structural bracing in 140 and 150 mph wind zones.
All stories shall be continuously sheathed with wood structural panels. All panels shall be fastened in accordance with Table R4506.2. Where sheathing is used to resist uplift, see Section R4508.4 for blocking requirements. Otherwise, blocking shall be installed if less than 50 percent of the wall length is sheathed. If a wall is sheathed less than 25 percent of its length, then that wall shall be designed in accordance with approved engineering practice.

TABLE R4506.2
PANEL FASTENER SPACING*

<table>
<thead>
<tr>
<th>Center of Panel</th>
<th>Blocking Required</th>
<th>No Blocking Required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>Vertical Edge of Panel</td>
<td>6&quot;</td>
<td>6&quot;</td>
</tr>
<tr>
<td>Horizontal Edge of Panel</td>
<td>3&quot;</td>
<td>3&quot;</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. Table based on 8d nails.

R4506.3 Gable endwalls.
Gable endwalls in the 130, 140 and 150 mph (58 m/s, 63 m/s and 67 m/s) wind zones shall either be supported by lateral bracing at the ceiling or have continuous studs from the floor to the roof. 2 x 4 studs at 16 inches (406 mm) on center are limited to 10 feet (3048 mm) in length between supports. Nonbearing 2 x 6 SPF#2 studs at 16 inches (406 mm) on center with 3/8-inch (9 mm) wood structural panel sheathing are limited to unsupported lengths of 18 feet (5486 mm) in 130 mph (58 m/s), 16 feet (4877 mm) in 140 mph (53 m/s) and 14 feet (4267 mm) in 150
mph (67 m/s) wind zones. Where open web trusses are installed, wood structural panel sheathing shall extend 12 inches (305 mm) beyond horizontal construction joints. Where the horizontal joint occurs over minimum 1 inch (25 mm) thick OSB or plywood or 2x rimboard, a minimum 1-1/2 inch (38 mm) overlap is required.

R4506.4 Lateral support at ceiling.
Where studs are not continuous, the ceiling must be used to support the endwall. 2 × 4 lateral bracing shall be installed on the top of ceiling joists or truss bottom chords at 8 feet (2438 mm) on center and extend 8 feet (2438 mm) inward from the gable endwall. See Figure R4506.7(a).

R4506.5 Full height studs.
Full height studs may be sized using the bracing at the ceiling to limit the stud length. See Figure R4506.5.

R4506.6 Cathedral endwalls.
Studs shall be continuous from the uppermost floor to either the ceiling or the roof.

R4506.7 Overhang at endwalls.
The overhang is limited to 12 inches (305 mm) where a laddered soffit is installed. The overhang may be increased to 24 inches (610 mm) where outlookers are framed over a dropped endwall into the first rafter or truss. See Figures R4506.7(a) and R4506.7(b). If the overhang exceeds 24 inches (610 mm), then the overhang shall be designed in accordance with approved engineering practice.

R4506.8 Roof sheathing attachment.
The roof sheathing panel edges shall be blocked and nailed at the end two rafter or truss spaces. See Figure R4506.8.

Exception: The panel edges need not be blocked where 2 × 4 diagonal braces are framed from the top of the endwall to the lateral bracing at the ceiling.

SECTION R4507
MASONRY WALL CONSTRUCTION

R4507.1 Reinforcement.
Masonry walls subject to wind speeds of 140 mph (63 m/s) or greater, as established in Table R301.2(1), shall be constructed in accordance with Table R4507.1 or the requirements of Figures R4507.1(a) and R4507.1(b) and this section. Additionally, the minimum area of reinforcement shall not be less than 0.002 times the gross cross-sectional area wall, not more than two-thirds of which may be used in either direction. No required vertical reinforcement shall be less than 3/8 inch (9.5 mm) in diameter. Principal wall reinforcement shall have a maximum spacing of 4 feet (1219 mm) on center.

For 130 mph (58 m/s) wind zones, see Figure R606.11(1) and Table R606.6.4.

TABLE R4507.1
H/T LATERAL SUPPORT RATIOS FOR UNREINFORCED EXTERIOR MASONRY WALLS

<table>
<thead>
<tr>
<th>ULTIMATE WIND SPEED, MPH</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
### Wall Construction

<table>
<thead>
<tr>
<th></th>
<th>140</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid masonry units</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Hollow concrete masonry units or masonry bonded hollow walls</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Cavity walls identical wythes</td>
<td>The H/t ratio shall be 0.70 of the H/t ratio for single wythe walls. The t-value shall be the sum of the nominal thickness of the individual wythes.</td>
<td></td>
</tr>
<tr>
<td>Cavity walls with wythes of different types or size masonry</td>
<td>The wall shall be designed based on ACI-530 or the H/t ratio may be 0.70 of the H/t ratio of a single wythe hollow wall. The t-value shall be the sum of the nominal thickness of the individual wythes.</td>
<td></td>
</tr>
</tbody>
</table>

- **H** = clear height or length between lateral supports.
- **t** = nominal wall thickness.
- All masonry units shall be laid in Type M, S or N mortar. Where Type N mortar is used and the wall spans in the vertical direction, the ratios shall be reduced by 10 percent.
- Design based on partially enclosed building.
- These values are based on using masonry cement mortar. If non-air-entrained Portland cement/lime mortar is used the values in the table may be increased by 1.25. Larger H/t ratios may be used if the design is done in accordance with ACI-530.
- Larger H/t ratios may be used if the design is done in accordance with ACI-530.

### SECTION 4508
ROOF TIE DOWN

**R4508.1 Roof tie down.**

Roof assemblies in the 130, 140 and 150 mph (58 m/s, 63 m/s and 67 m/s) wind zones as established in Table R301.2(1) shall have rafter or truss ties provided in accordance with either Table R4508.2 or the prescriptive requirements of Section R4508. Anchorage in the 130 mph (58 m/s) wind zone shall be continuous from the roof to the foundation wall or pier. Anchorage in the 140 and 150 mph (63 m/s and 67 m/s) wind zones shall be continuous from the roof to the footing. See Section R4504.

**R4508.2 Considerations.**

For trusses, the nailing requirements from Table R4508.2 shall include the nailing requirements for both rafters and ceiling joists. As an alternative to the anchorage requirements of Tables R602.3(1) and R4508.2, the anchorage for roof members may be based on a designed connection taking into account all horizontal and vertical forces. Forces for alternative anchorage design may result from wind uplift; wind lateral on roof; wind lateral on walls to be transferred to the top plate of the wall; roof/ceiling loads; and other loads depending on the specific building design. If roof members align with the studs, the connection may be made from the roof member directly to the studs. If the connection is from the roof member to the top plate, a double top plate is required and both connections must meet the requirements of Table R4508.2. Where ceiling joists are not parallel with and connect to the roof members, the anchorage requirements for each roof member shall be increased by 110 pound (50 kg). Hip end walls and hip rafters shall be anchored in accordance with this section.

### TABLE R4508.2
ROOF TIE DOWN REQUIREMENTS ALONG EXTERIOR WALLS (plf)\(^{a,b,c,d}\)

<table>
<thead>
<tr>
<th>WIND SPEED (mph)</th>
<th>STRUCTURE WIDTH</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
a. Alternate to the requirements of this table or roof not covered by this table shall be designed in accordance with the North Carolina Building Code or ICC Standard for Residential Construction in High-Wind Regions (ICC 600).

b. See Section 4505 for material requirements in Coastal High Hazard Areas and Ocean Hazard Areas.

c. Roof slope 2:12 to 12:12.

d. The uplift load requirements may be interpolated for intermediate structure widths.

R4508.3 Anchorage from roof to wall.
One and one-half inch (38 mm) by 18 gage fabricated metal ties at 24 inches (610 mm) on center with five 8d nails at each end may be used to resist the uplift loads from the roof to the double top plate. Install one tie at each end of each rafter in 130mph (58 m/s) and two ties at each end of each rafter in 140 mph (63 m/s) and 150 mph (67 m/s) wind zones. Truss anchorage shall be per designed specifications. See Figure R4508.3.

R4508.4 Anchorage using wood structural panels.
Wood structural panel sheathing may be used to resist both lateral load and uplift simultaneously. Panels shall be installed as follows:

1. Panels may be installed parallel or perpendicular to studs.

2. Panels shall be 3/8-inch (10 mm) minimum thickness.

3. Nail spacing shall be 8d at 6 inches (152 mm) on center along vertical edges of panel and 12 inches (305 mm) at intermediate vertical framing.

4. At double edge panel locations, the horizontal nail spacing shall be 8d staggered at 3 inches (76 mm) on center. See Figure R4508.4(b).

5. Where open web trusses are installed, panel shall extend 12 inches (305 mm) beyond horizontal construction joints and shall overlap girders their full depth. Where the horizontal joint occurs over minimum 1 inch (25 mm) thick OSB or plywood or 2x rimboard, a minimum 1-1/2 inch (38 mm) overlap is required. See Figure R4508.4(a).

6. Panel attachment to framing shall be as illustrated in Figure R4508.4(b).

7. Blocking shall be required at all joints if sheathing is used to resist uplift.

<table>
<thead>
<tr>
<th>VERTICAL NAIL SPACING</th>
<th>8D @ 6” EDGE AND 12” INTERMEDIATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate nail spacing at top and bottom edges</td>
<td>6”</td>
</tr>
<tr>
<td>Uplift capacity (plf) nails – double row</td>
<td>240</td>
</tr>
</tbody>
</table>

TABLE R4508.4
UPLIFT CAPACITY OF WOOD STRUCTURAL PANEL SHEATHING USED TO RESIST BOTH LATERAL LOAD AND UPLIFT*
For SI: 1 inch = 25.4 mm.
a. Tabulated values are for Spruce-Pine-Fir framing.

**FIGURE R4503.2(a)**
CONTINUOUS VENEER PIER/CURTAIN WALL
FIGURE R4503.2(b)
CONTINUOUS VENEER PIER/CURTAIN WALL

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FIGURE R4503.2(c)
VENEER SHIRT WALL
PIER/CURTAIN WALL
FIGURE R4503.2(d)
VENEER SHIRT WALL PIER/CURTAIN WALL
FIGURE R4504.2(a)
FOUNDATION WALL WITH BOND BEAM

- **Exterior Wall**: See R4502
- **Foundation Wall**: See R4503.1
- **Lap Reinforcement**: 24" at All Splices
- **Grout Fill Voids**: Solid at Reinforcement
- **Wall Footing**: See R4503.1
- **6"x6" Bond Beam**: With Horizontal #5 Bar. See R4504.2.1.1
- **2x2x6 Pressure Treated Sill Plate**: See R4504.2.1.1
- **L-Anchor Bolt or Inverted Anchor Bolt**
  - With Nut and Washer
  - See R4504.2.1.1.1 and Table R4504.2.1.1
- **8d Nails at 3 Inches On Center or Use Approved Anchor**
- **Single Rim Band**
- **Single Rim Band**
- **Wall Sheathing and Nail Pattern**
  - See R4506.2 and R4506.4
- **3-#4 or 2-#5 Cont. Lapped 24" at All Splices**
FIGURE R4504.2(b)
FOUNDATION WALL WITH UPLIFT ANCHOR BOLTS FROM FOOTING TO SILL PLATE
FIGURE R4504.2(c)
FOUNDATION WALL WITH UPLIFT ANCHOR BOLTS
CONTINUOUS FROM FOOTING TO EXTERIOR WALL FRAMING
FIGURE R4504.2(d)
EXTERIOR CONCRETE SLAB ON GRADE FOOTING – DOUBLE SOLE PLATE

FIGURE R4504.2(e)
EXTERIOR CONCRETE SLAB ON GRADE FOOTING – SINGLE SOLE PLATE
FIGURE R4504.2(f)
GROUND SUPPORTED SLAB WITH MASONRY STEM WALL
FIGURE R4506.5
GABLE ENDWALL BALLOON FRAMING PREFERRED METHOD
FIGURE R4506.7(a)
OVERHANG AT ENDWALLS
FIGURE R4506.7a—continued
OVERHANG AT ENDWALLS
FIGURE R4506.7(b)
GABLE END OVERHANG
FIGURE R4506.7(c)
GABLE END OVERHANG
FIGURE R4506.8
ROOF SHEATHING ATTACHMENT PLAN

ATTACH PANELS TO GABLE END FRAMING WITH 8d NAILS AT 4" O.C.
2x4 SPRUCE OR BETTER BLOCKING (FLAT OR VERTICAL) AT END TWO TRUSS/RAFTER SPACES (TYPICAL)

8d NAILS AT 12" O.C. ON INTERIOR OF PANELS INTERMEDIATE EXCEPT ON GABLE TRUSS (TYPICAL)

8d NAILS AT 6" O.C. AT ALL PANEL EDGES EXCEPT ON GABLE TRUSS (TYPICAL)

NOTES:
1. ALL NAILS AT MINIMUM, ARE TO BE COMMON NAILS
2. IF BUILDING WIDTH EXCEEDS 40 FEET OR HEIGHT IS MORE THAN 2 STORIES, USE 10d NAILS INSTEAD OF 8d NAILS FOR ATTACHMENT OF ROOF SHEATHING.
3. ALL STRUCTURAL SHEATHING PANELS TO BE 3/8" MINIMUM THICKNESS

5d NAILS AT 6" O.C. MINIMUM PANEL EDGES AT BLOCKING (TYPICAL)
INDIVIDUAL SHEATHING ATTACHED TO 3 TRUSSES MINIMUM

2x4 CONTINUOUS

2 RIDGE

12" MAX
FIGURE R4507.1(a)
REQUIREMENTS FOR REINFORCED GROUTED MASONRY CONSTRUCTION
WHERE WIND ZONES ARE 140 MPH OR GREATER
FIGURE R4507.1(b)
REQUIREMENTS FOR REINFORCED HOLLOW-UNIT MASONRY CONSTRUCTION
WHERE WIND ZONES ARE 140 MPH OR GREATER
FIGURE R4508.3
ROOF RAFTER/TRUSS ANCHORAGE
FIGURE R4508.4(a)
TWO STORY WALL SECTION - PANEL ATTACHMENT
FIGURE R4508.4(b)
Panel Attachment to Counter Uplift Horizontal or Vertical
CHAPTER 46
COASTAL AND FLOOD PLAIN CONSTRUCTION
STANDARDS

This chapter is a North Carolina addition and not part of the 2015 International Residential Code. There will be no underlined text.

SECTION R4601
PURPOSE, APPLICATION AND SCOPE

R4601.1. General.
The requirements set forth in this section shall apply to all construction located within areas identified by governmental agency (state and federal) as coastal high hazard areas, ocean hazard areas, the regulatory flood plain areas, and all areas designated as 150 mph (67 m/s) wind zone. See Table R301.2(1).

SECTION R4602
DEFINITIONS

BASE FLOOD ELEVATION. The peak water elevation in relation to MSL expected to be reached during a design flood which is established by the North Carolina Building Code Council as a flood having a 1 percent chance of being equaled or exceeded in any given year.

COASTAL HIGH HAZARD AREA. An area subject to coastal flooding and high velocity waters including storm wave wash, as shown by Federal Emergency Management Agency Maps and subject to the approval of the Building Code Council.

FLOOD PLAIN. Land below base flood elevation, which of record has in the past been flooded by storm water-surface runoffs, or tidal influx, and as defined by the Corps of Engineers’ maps, the Federal Emergency Management Agency maps or as approved by the Building Code Council.

LOWEST FLOOR. The lowest floor of the lowest enclosed area (including basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building’s lowest floor: provided

1. That the walls are substantially impermeable to the passage of water and the structural components have the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy, or

2. Construction shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing the entry and exit of flood waters.
MSL. Mean Sea Level as defined by National Geodetic Vertical Datum.

OCEAN HAZARD AREA. An area, as identified by the North Carolina Coastal Resources Commission, and subject to approval by the Building Code Council, near the shoreline of the Atlantic Ocean which has been identified as subject to at least one of the following hazards: (A) Historical or predicted future trends of long-term erosion, (B) erosion expected to occur during a coastal storm reaching the base flood elevation, or (C) shoreline fluctuations due to tidal inlets.

SECTION R4603
PILING STANDARDS

R4603.1. General.
All one- and two-family dwellings in areas identified as coastal high hazard areas or ocean hazard areas shall be constructed on a pile foundation of wood or concrete.

R4603.2 Concrete piles.
Concrete piles are permitted to be used if made and installed in accordance with the North Carolina Building Code, Chapter 18.

R4603.3 Size of wood piles.
Round timber piles shall not be less than 8 inches (203 mm) in diameter at building level and have a minimum tip diameter of 6 inches (152 mm). Square timber piles shall not be less than 8 inches square (0.005 m²), nominal. Piles supporting uncovered stairs, uncovered walkways and uncovered decks shall be 6 inches × 6 inches (153 mm × 153 mm) minimum, or if round, have a minimum tip diameter of 6 inches (153 mm). Piles supporting uncovered stairs, uncovered walkways and uncovered decks less than 5 feet (1524 mm) above grade are permitted to be 4 inches × 4 inches (102 mm × 102 mm) minimum.

R4603.4 Required depth of piles.
Pile tip shall extend to a depth of not less than 8 feet (2438 mm) below the natural grade or finished grade of the lot, whichever is lower. All pilings within the Ocean Hazard Area shall have a tip penetration of at least 5 feet (1524 mm) below mean sea level or 16 feet (4877 mm) below average original grade, whichever is least. Structures within Ocean Hazard Areas which are placed upon the site behind a line 60 times the annual erosion rate away from the most seaward line of stable natural vegetation are exempt from this additional tip penetration requirement.

R4603.5 Spacing of wood piles.
The maximum center-to-center spacing of wood piles shall not be more than 8 feet (2438 mm) on center under load-bearing sills, beams, or girders. For dwellings having more than two stories above piles or where the piling spacing exceeds 8 feet (2438 mm) on center, the pile foundation shall be designed by a registered design professional. Pile spacing in the nonload-bearing direction are permitted to be 12 feet (305 mm).

R4603.6 Tying and bracing of wood piles.
If sills, beams or girders are attached to the piling, a minimum of two 5/8-inch (16 mm) galvanized steel bolts per beam member shall be through bolted at each piling connection in accordance with Figure R4503.6 (a). When piling is notched so that the cross-section is reduced below 50 percent or is top bearing, sills, beams or girders shall be attached using 3/16 × 4 × 18-inch (5 × 102 × 467 mm) hot dip galvanized straps, one each side, bolted with two 5/8 inch (15.9 mm) galvanized through bolts in accordance with Figure R4603.6(b) and Figure R4503.6(c). At corners, girders shall be connected to the pile with a minimum 3/16 × 4 × 18-inch (5 × 102 × 467
mm) hot dip galvanized strap bolted with two 5/8 inch (15.9 mm) galvanized through bolts on the exterior and a minimum L4 x 3/16 x 1-6" (102 x 5 x 467 mm) galvanized steel angle bolted with two 5/8 inch (15.9 mm) galvanized through bolts on the interior in accordance with Figure R4603.6(d).

Bracing of pile foundations is required where the clear height from ground to sill, beam or girder exceeds 10 feet (3048 mm) or the dwelling is more than one story above piles. A line of X-bracing is defined as a row of piles with X-bracing provided in at least two bays. A line of X-bracing shall be provided at all exterior pile lines. Where the perimeter lines of X-bracing exceed 40 feet (12 192 mm), an additional line of X-bracing shall be provided near the center of the building. See Figure R4603.6(e). X-bracing shall be with 2 x 10s through bolted with two 3/4-inch (19.1 mm) bolts at each end. The code official is permitted to accept alternate bracing designs if they bear the seal of a registered design professional.

R4603.7. Protection against decay.
The minimum net retention of preservatives shall be in accordance with AWPA U1.

R4603.8 Piling may be placed by auger, jetting or drop hammer.
Piling shall receive a final set by drop hammer or other approved methods, acceptable to the code official to ensure compaction of material at end bearing.

![FIGURE R4603.6(a)
PILING NOTCHED LESS THAN 50%](image-url)
FIGURE R4603.6(b)
TOP MOUNTED GIRDER

FIGURE R4603.6(c)
PILING NOTCHED MORE THAN 50%

FIGURE R4603.6(d)
CORNER PILE CONNECTION
R4604.1. Lowest structural member.
The lowest structural member, excluding pilings and bracing supporting the lowest habitable floor in the coastal high hazard area and ocean hazard area, shall be elevated above the base flood elevation.

R4604.2. First habitable floor.
The elevation of the first habitable floor of all structures in the regulatory flood plain except in the coastal high hazard areas shall be above the base flood elevation.

**Exception:** This requirement does not apply to the addition, renovation or reconstruction to any building which was constructed prior to the initial Flood Insurance Study for that area if the addition, renovation or reconstruction does not exceed 50 percent of the present market value of the structure.

R4604.3. Walls below flood elevation.
Where walls are constructed below flood elevation in coastal high hazard area and ocean hazard area, they shall be constructed in a manner to eliminate wave forces on the piling.
The requirements of Sections R4605.2 through R4605.8 are applicable in the coastal high-hazard area, the ocean hazard area, and all areas defined as 150 mph (67 m/s) wind zone.

R4605.2. Roof anchorage.
Every rafter or roof truss shall be anchored to the bearing wall as required by Section R4508. At the ridges, rafters shall have a minimum 1 × 6 or 2 × 4 collar or wind beam. Every third rafter not to exceed 4 feet (1219 mm) on center shall be anchored vertically with minimum 1 × 6 or 2 × 4 from its midpoint to ceiling joists below.

R4605.3 Wood frame wall construction.
Maximum stud spacing shall be 16 inches o.c. (406 mm) for 2 × 4s and 24 inches (610 mm) for 2 × 6s. See Section R4505 for wall construction requirements. See Section R4508 for uplift anchorage requirements.

R4605.4. Design by registered design professional.
Equal or better methods of tying structures together and to foundations designed for a specific building by a registered design professional shall be accepted by the code official.

R4605.5. Fastener corrosion resistance.
In the coastal hazard area and the ocean hazard area, all metal connectors and fasteners outside of conditioned spaces shall be hot-dip galvanized steel after fabrication and meet ASTM A 153. Exposed metal connectors, such as tie-down straps on porches, decks, and areas under the structure, shall be a minimum 3/16-inch (5 mm) thick, and shall be hot-dip galvanized after fabrication and meet ASTM A 123 or ASTM A 153. Stainless steel light-gage metal connectors shall be permitted in exposed or partially exposed locations. Metal connectors of approved equivalent corrosion-resistant material are permitted to be accepted. See Table R4605.5.

R4605.6 Building anchorage.

1. For masonry buildings, the roof structure, including rafters and joists, shall be anchored to the wall in accordance with Section R606.11. All mortar used for masonry walls shall be Type M or S.

2. For masonry or wood frame buildings, all sills, beams or girders which resist uplift (including interior sills, beams, girders, and joists where the perimeter is unenclosed) shall be anchored to the footing in accordance with Section R4504. Footing dowel bars shall have an 8-inch (203 mm) hook.

3. Where wood partitions and masonry walls join, the stud abutting the masonry shall be double and bolted to the masonry with three 1/2-inch (13 mm) galvanized bolts.

4. Steel and wooden columns and posts, including porch columns, shall be anchored with metal ties and bolts to their foundations and to the members that they support.

R4605.7 Insulation.
Insulation installed in floors in exposed areas under buildings elevated on pilings shall be held in place with plywood with exterior glue or other material approved by the code official.
R4605.8 Accessory structures.
Detached accessory structures and out buildings shall be bolted to their foundation or otherwise constructed so as to prevent overturning.

<table>
<thead>
<tr>
<th>Table R4605.5a</th>
<th>CORROSION RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPEN (exterior, porches, under house)</td>
<td>EXPOSURE LEVEL VENTED/ENCLOSED (attic, floor trusses, enclosed crawl spaces and stud cavity)</td>
</tr>
<tr>
<td>Nails, staples, screws</td>
<td>Hot-dip galvanized</td>
</tr>
<tr>
<td>Nuts, bolts, washers, tie rods</td>
<td>Hot-dip galvanized</td>
</tr>
<tr>
<td>Steel connection plates &amp; straps (3/16&quot; minimum thickness)</td>
<td>Hot-dip galvanized after fabrication</td>
</tr>
<tr>
<td>Sheet metal connectors, wind anchors, joists hangers, steel joists and beams</td>
<td>Stainless steel or hot-dipped galvanized after fabrication</td>
</tr>
<tr>
<td>Truss plates</td>
<td>Stainless steel or hot-dipped galvanized after fabrication</td>
</tr>
</tbody>
</table>

a. Applies only to structures located in Coastal High-Hazard Area and Ocean High Hazard Area.
b. Triple galvanizing – G185, standard galvanizing – G60, both per ASTM A 653 / A 653M.
APPENDIX A
SIZING AND CAPACITIES OF GAS PIPING

(This appendix is informative and is not part of the code. This appendix is an excerpt from the 2015 International Fuel Gas Code, coordinated with the section numbering of the International Residential Code.)

A.1 General piping considerations.
The first goal of determining the pipe sizing for a fuel gas piping system is to make sure that there is sufficient gas pressure at the inlet to each appliance. The majority of systems are residential and the appliances will all have the same, or nearly the same, requirement for minimum gas pressure at the appliance inlet. This pressure will be about 5-inch water column (w.c.) (1.25 kPa), which is enough for proper operation of the appliance regulator to deliver about 3.5-inches water column (w.c.) (875 kPa) to the burner itself. The pressure drop in the piping is subtracted from the source delivery pressure to verify that the minimum is available at the appliance.

There are other systems, however, where the required inlet pressure to the different appliances may be quite varied. In such cases, the greatest inlet pressure required must be satisfied, as well as the farthest appliance, which is almost always the critical appliance in small systems.

There is an additional requirement to be observed besides the capacity of the system at 100-percent flow. That requirement is that at minimum flow, the pressure at the inlet to any appliance does not exceed the pressure rating of the appliance regulator. This would seldom be of concern in small systems if the source pressure is $\frac{1}{2}$ psi (14-inch w.c.) (3.5 kPa) or less but it should be verified for systems with greater gas pressure at the point of supply.

To determine the size of piping used in a gas piping system, the following factors must be considered:

(1) Allowable loss in pressure from point of delivery to appliance.

(2) Maximum gas demand.

(3) Length of piping and number of fittings.

(4) Specific gravity of the gas.

(5) Diversity factor.

For any gas piping system or special appliance, or for conditions other than those covered by the tables provided in this code such as longer runs, greater gas demands or greater pressure drops, the size of each gas piping system should be determined by standard engineering practices acceptable to the code official.

2018 North Carolina Residential Code
A.2 Description of tables.

A.2.1 General.
The quantity of gas to be provided at each outlet should be determined, whenever possible, directly from the manufacturer’s gas input Btu/h rating of the appliance that will be installed. In case the ratings of the appliances to be installed are not known, Table 402.2 shows the approximate consumption (in Btu per hour) of certain types of typical household appliances.

To obtain the cubic feet per hour of gas required, divide the total Btu/h input of all appliances by the average Btu heating value per cubic feet of the gas. The average Btu per cubic feet of the gas in the area of the installation can be obtained from the serving gas supplier.

A.2.2 Low pressure natural gas tables.
Capacities for gas at low pressure [less than 2.0 psig (13.8 kPa gauge)] in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Tables 402.4(1) and 402.4(2) for iron pipe or equivalent rigid pipe; in Tables 402.4(8) through 402.4(11) for smooth wall semirigid tubing; and in Tables 402.4(15) through 402.4(17) for corrugated stainless steel tubing. Tables 402.4(1) and 402.4(6) are based upon a pressure drop of 0.3-inch w.c. (75 Pa), whereas Tables 402.4(2), 402.4(9) and 402.4(15) are based upon a pressure drop of 0.5-inch w.c. (125 Pa). Tables 402.4(3), 402.4(4), 402.4(10), 402.4(11), 402.4(16) and 402.4(17) are special low-pressure applications based upon pressure drops greater than 0.5-inch w.c. (125 Pa). In using these tables, an allowance (in equivalent length of pipe) should be considered for any piping run with four or more fittings (see Table A.2.2).

### TABLE A.2.2
**EQUIVALENT LENGTHS OF PIPE FITTINGS AND VALVES**

<table>
<thead>
<tr>
<th>Nominal pipe size, inches</th>
<th>45°/Ell 90°/Ell 180° close return bends</th>
<th>Tee</th>
<th>90° WELDING ELBOWS AND SMOOTH BENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>k factor =</td>
<td>0.42</td>
<td>0.90</td>
<td>2.00</td>
</tr>
<tr>
<td>L/d’ ratio n =</td>
<td>1/4</td>
<td>30</td>
<td>67</td>
</tr>
<tr>
<td>Inside diameter, inches, Schedule 40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>0.622</td>
<td>0.73</td>
<td>1.55</td>
</tr>
<tr>
<td>3/4</td>
<td>0.824</td>
<td>0.96</td>
<td>2.06</td>
</tr>
<tr>
<td>1</td>
<td>1.049</td>
<td>1.22</td>
<td>2.62</td>
</tr>
<tr>
<td>1/4</td>
<td>1.380</td>
<td>1.61</td>
<td>3.45</td>
</tr>
</tbody>
</table>

L = Equivalent Length in Feet of Schedule 40 (Standard-weight) Straight Pipe
### TABLE A.2.2—continued

**EQUIVALENT LENGTHS OF PIPE FITTINGS AND VALVES**

<table>
<thead>
<tr>
<th>MIRROR ELBOWS (3) (No. of miters)</th>
<th>WELDING TEES</th>
<th>VALVES (screwed, flanged, or welded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-(45^\circ)</td>
<td>1-(60^\circ)</td>
<td>1-(90^\circ)</td>
</tr>
<tr>
<td>k factor =</td>
<td>(0.45)</td>
<td>(0.90)</td>
</tr>
<tr>
<td>L/d' ratio (4) (n = )</td>
<td>(15)</td>
<td>(30)</td>
</tr>
<tr>
<td>L = Equivalent Length In Feet of Schedule 40 (Standard-weight) Straight Pipe (6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nominal pipe size, inches</th>
<th>Inside diameter (d), inches, Schedule 40</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1/4</th>
<th>1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.622</td>
<td>0.78</td>
<td>1.55</td>
<td>3.10</td>
<td>1.04</td>
<td>0.78</td>
</tr>
<tr>
<td>3/4</td>
<td>0.824</td>
<td>1.03</td>
<td>2.06</td>
<td>4.12</td>
<td>1.37</td>
<td>1.03</td>
</tr>
<tr>
<td>1</td>
<td>1.049</td>
<td>1.31</td>
<td>2.62</td>
<td>5.24</td>
<td>1.75</td>
<td>1.31</td>
</tr>
<tr>
<td>1/4</td>
<td>1.380</td>
<td>1.72</td>
<td>3.45</td>
<td>6.90</td>
<td>2.30</td>
<td>1.72</td>
</tr>
<tr>
<td>1/2</td>
<td>1.610</td>
<td>2.01</td>
<td>4.02</td>
<td>8.04</td>
<td>2.68</td>
<td>2.01</td>
</tr>
<tr>
<td>2</td>
<td>2.067</td>
<td>2.58</td>
<td>5.17</td>
<td>10.3</td>
<td>3.45</td>
<td>2.58</td>
</tr>
<tr>
<td>1/2</td>
<td>2.469</td>
<td>3.08</td>
<td>6.16</td>
<td>12.3</td>
<td>4.11</td>
<td>3.08</td>
</tr>
<tr>
<td>3</td>
<td>3.068</td>
<td>3.84</td>
<td>7.67</td>
<td>15.3</td>
<td>5.11</td>
<td>3.84</td>
</tr>
<tr>
<td>4</td>
<td>4.026</td>
<td>5.04</td>
<td>10.1</td>
<td>20.2</td>
<td>6.71</td>
<td>5.04</td>
</tr>
</tbody>
</table>

**Note:**

- Values are approximate and may vary depending on specific application and conditions.
- Forged and mitered valves may have different equivalent lengths than screwed, flanged, or welded valves.
- The equivalent length is calculated using the formula provided in the table.

---

2018 North Carolina Residential Code
For SI: 1 foot = 305 mm, 1 degree = 0.01745 rad.

Note: Values for welded fittings are for conditions where bore is not obstructed by weld spatter or backing rings. If appreciably obstructed, use values for "Screwed Fittings."

1. Flanged fittings have three-fourths the resistance of screwed elbows and tees.
2. Tabular figures give the extra resistance due to curvature alone to which should be added the full length of travel.
3. Small size socket-welding fittings are equivalent to miter elbows and miter tees.
4. Equivalent resistance in number of diameters of straight pipe computed for a value of \((f - 0.0075)\) from the relation \((n - k/4)\).
5. For condition of minimum resistance where the centerline length of each miter is between \(d\) and \(2^{1/2} d\).
6. For pipe having other inside diameters, the equivalent resistance can be computed from the above \(n\) values.


### A.2.3 Undiluted liquefied petroleum tables.

Capacities in thousands of Btu per hour of undiluted liquefied petroleum gases based on a pressure drop of 0.5-inch w.c. (125 Pa) for different sizes and lengths are shown in Table 402.4(28) for iron pipe or equivalent rigid pipe, in Table 402.4(30) for smooth wall semi-rigid tubing, in Table 402.4(32) for corrugated stainless steel tubing, and in Tables 402.4(35) and 402.4(37) for polyethylene plastic pipe and tubing. Tables 402.4(33) and 402.4(34) for corrugated stainless steel tubing and Table 402.4(36) for polyethylene plastic pipe are based on operating pressures greater than \(1^{1/2}\) pounds per square inch (psi) (3.5 kPa) and pressure drops greater than 0.5-inch w.c. (125 Pa). In using these tables, an allowance (in equivalent length of pipe) should be considered for any piping run with four or more fittings [see Table A.2.2].

### A.2.4 Natural gas specific gravity.

Gas piping systems that are to be supplied with gas of a specific gravity of 0.70 or less can be sized directly from the tables provided in this code, unless the code official specifies that a gravity factor be applied. Where the specific gravity of the gas is greater than 0.70, the gravity factor should be applied.

Application of the gravity factor converts the figures given in the tables provided in this code to capacities for another gas of different specific gravity. Such application is accomplished by multiplying the capacities given in the tables by the multipliers shown in Table A.2.4. In case the exact specific gravity does not appear in the table, choose the next higher value specific gravity shown.

#### TABLE A.2.4

| Multipliers to be Used with Tables 402.4(1) |

2018 North Carolina Residential Code
A.2.5 Higher pressure natural gas tables.
Capacities for gas at pressures 2.0 psig (13.8 kPa) or greater in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Tables 402.4(5) through 402.4(7) for iron pipe or equivalent rigid pipe; Tables 402.4(12) to 402.4(14) for semirigid tubing; Tables 402.4(18) and 402.4(19) for corrugated stainless steel tubing; and Table 402.4(22) for polyethylene plastic pipe.

A.3 Use of capacity tables.

A.3.1 Longest length method.
This sizing method is conservative in its approach by applying the maximum operating conditions in the system as the norm for the system and by setting the length of pipe used to size any given part of the piping system to the maximum value.

To determine the size of each section of gas piping in a system within the range of the capacity tables, proceed as follows (also see sample calculations included in this Appendix):

1. Divide the piping system into appropriate segments consistent with the presence of tees, branch lines and main runs. For each segment, determine the gas load (assuming all appliances operate simultaneously) and its overall length. An allowance (in equivalent length of pipe) as determined from Table A.2.2 shall be considered for piping segments that include four or more fittings.

2. Determine the gas demand of each appliance to be attached to the piping system. Where Tables 402.4(1) through 402.4(24) are to be used to select the piping size, calculate the gas demand in terms of cubic feet per hour for each piping system outlet. Where Tables 402.4(25) through 402.4(37) are to be used to select the piping size, calculate the gas demand in terms of thousands of Btu per hour for each piping system outlet.
Where the *piping* system is for use with other than undiluted liquefied petroleum gases, determine the design system pressure, the allowable loss in pressure (pressure drop), and specific gravity of the gas to be used in the *piping* system.

Determine the length of *piping* from the *point of delivery* to the most remote *outlet* in the building/piping system.

In the appropriate capacity table, select the row showing the measured length or the next longer length if the table does not give the exact length. This is the only length used in determining the size of any section of gas *piping*. If the gravity factor is to be applied, the values in the selected row of the table are multiplied by the appropriate multiplier from Table A.2.4.

Use this horizontal row to locate ALL gas demand figures for this particular system of *piping*.

Starting at the most remote *outlet*, find the gas demand for that *outlet* in the horizontal row just selected. If the exact figure of demand is not shown, choose the next larger figure left in the row.

Opposite this demand figure, in the first row at the top, the correct size of gas *piping* will be found.

Proceed in a similar manner for each *outlet* and each section of gas *piping*. For each section of *piping*, determine the total gas demand supplied by that section.

Where a large number of *piping* components (such as elbows, tees and valves) are installed in a pipe run, additional pressure loss can be accounted for by the use of equivalent lengths. Pressure loss across any *piping* component can be equated to the pressure drop through a length of pipe. The equivalent length of a combination of only four elbows/tees can result in a jump to the next larger length row, resulting in a significant reduction in capacity. The equivalent lengths in feet shown in Table A.2.2 have been computed on a basis that the inside diameter corresponds to that of Schedule 40 (standard-weight) steel pipe, which is close enough for most purposes involving other schedules of pipe. Where a more specific solution for equivalent length is desired, this can be made by multiplying the actual inside diameter of the pipe in inches by \( \frac{n}{12} \), or the actual inside diameter in feet by \( n \) (\( n \) can be read from the table heading). The equivalent length values can be used with reasonable accuracy for copper or brass fittings and bends although the resistance per foot of copper or brass pipe is less than that of steel. For copper or brass valves, however, the equivalent length of pipe should be taken as 45 percent longer than the values in the table, which are for steel pipe.

**A.3.2 Branch length method.**

This sizing method reduces the amount of conservatism built into the traditional Longest Length Method. The longest length as measured from the meter to the furthest remote *appliance* is only used to size the initial parts of the overall *piping* system. The Branch Length Method is applied in the following manner:

1. Determine the gas load for each of the connected appliances.
(2) Starting from the meter, divide the piping system into a number of connected segments, and determine the length and amount of gas that each segment would carry assuming that all appliances were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table A.2.2 should be considered for piping segments that include four or more fittings.

(3) Determine the distance from the outlet of the gas meter to the appliance furthest removed from the meter.

(4) Using the longest distance (found in Step 3), size each piping segment from the meter to the most remote appliance outlet.

(5) For each of these piping segments, use the longest length and the calculated gas load for all of the connected appliances for the segment and begin the sizing process in Steps 6 through 8.

(6) Referring to the appropriate sizing table (based on operating conditions and piping material), find the longest length distance in the first column or the next larger distance if the exact distance is not listed. The use of alternative operating pressures and/or pressure drops will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or pressure drops will require the approval of both the code official and the local gas serving utility.

(7) Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.

(8) Read up the table column and select the appropriate pipe size in the top row. Repeat Steps 6, 7 and 8 for each pipe segment in the longest run.

(9) Size each remaining section of branch piping not previously sized by measuring the distance from the gas meter location to the most remote outlet in that branch, using the gas load of attached appliances and following the procedures of Steps 2 through 8.

A.3.3 Hybrid pressure method.
The sizing of a 2 psi (13.8 kPa) gas piping system is performed using the traditional Longest Length Method but with modifications. The 2 psi (13.8 kPa) system consists of two independent pressure zones, and each zone is sized separately. The Hybrid Pressure Method is applied as follows:

The sizing of the 2 psi (13.8 kPa) section (from the meter to the line regulator) is as follows:

1) Calculate the gas load (by adding up the name plate ratings) from all connected appliances. (In certain circumstances the installed gas load can be increased up to 50 percent to accommodate future addition of appliances.) Ensure that the line regulator capacity is adequate for the calculated gas load and that the required pressure drop (across the regulator) for that capacity does not exceed \( \frac{3}{4} \) psi (5.2 kPa) for a 2 psi (13.8 kPa) system. If the pressure drop across the regulator is too high (for the connected gas load), select a larger regulator.
(2) Measure the distance from the meter to the line regulator located inside the building.

(3) If there are multiple line regulators, measure the distance from the meter to the regulator furthest removed from the meter.

(4) The maximum allowable pressure drop for the 2 psi (13.8 kPa) section is 1 psi (6.9 kPa).

(5) Referring to the appropriate sizing table (based on piping material) for 2 psi (13.8 kPa) systems with a 1 psi (6.9 kPa) pressure drop, find this distance in the first column, or the closest larger distance if the exact distance is not listed.

(6) Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.

(7) Read up the table column to the top row and select the appropriate pipe size.

(8) If there are multiple regulators in this portion of the piping system, each line segment must be sized for its actual gas load, but using the longest length previously determined above.

The low pressure section (all piping downstream of the line regulator) is sized as follows:

(1) Determine the gas load for each of the connected appliances.

(2) Starting from the line regulator, divide the piping system into a number of connected segments or independent parallel piping segments, and determine the amount of gas that each segment would carry assuming that all appliances were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table A.2.2 should be considered for piping segments that include four or more fittings.

(3) For each piping segment, use the actual length or longest length (if there are sub-branchlines) and the calculated gas load for that segment and begin the sizing process as follows:

(a) Referring to the appropriate sizing table (based on operating pressure and piping material), find the longest length distance in the first column or the closest larger distance if the exact distance is not listed. The use of alternative operating pressures and/or pressure drops will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or pressure drops can require the approval of the code official.

(b) Trace across this row until the appliance gas load is found or the closest larger capacity if the exact capacity is not listed.

(c) Read up the table column to the top row and select the appropriate pipe size.

(d) Repeat this process for each segment of the piping system.
A.3.4 Pressure drop per 100 feet method.
This sizing method is less conservative than the others, but it allows the designer to immediately see where the largest pressure drop occurs in the system. With this information, modifications can be made to bring the total drop to the critical appliance within the limitations that are presented to the designer.

Follow the procedures described in the Longest Length Method for Steps (1) through (4) and (9).

For each piping segment, calculate the pressure drop based on pipe size, length as a percentage of 100 feet (30 480 mm) and gas flow. Table A.3.4 shows pressure drop per 100 feet (30 480 mm) for pipe sizes from \(\frac{1}{2}\) inch (12.7 mm) through 2 inches (51 mm). The sum of pressure drops to the critical appliance is subtracted from the supply pressure to verify that sufficient pressure will be available. If not, the layout can be examined to find the high drop section(s) and sizing selections modified.

**Note:** Other values can be obtained by using the following equation:

\[
\text{Desired Value} = MBH \times \left(\frac{\text{Desired Drop}}{\text{Table Drop}}\right)
\]

For example, if it is desired to get flow through \(\frac{3}{4}\)-inch (19.1 mm) pipe at 2 inches/100 feet, multiply the capacity of \(\frac{3}{4}\)-inch (19.1 mm) pipe at 1 inch/100 feet by the square root of the pressure ratio:

\[
147 MBH \times \frac{\frac{3}{4}'' \text{ W.C.}}{\frac{1}{2}'' \text{ W.C.}} = 147 \times 1.414 = 208 MBH
\]

**TABLE A.3.4**
THOUSANDS OF BTU/H (MBH) OF NATURAL GAS PER 100 FEET OF PIPE AT VARIOUS PRESSURE DROPS AND PIPE DIAMETERS

<table>
<thead>
<tr>
<th>PRESSURE DROP PER 100 FEET IN INCHES W.C.</th>
<th>PIPE SIZES (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\frac{1}{2})</td>
</tr>
<tr>
<td>0.2</td>
<td>31</td>
</tr>
<tr>
<td>0.3</td>
<td>38</td>
</tr>
<tr>
<td>0.5</td>
<td>50</td>
</tr>
<tr>
<td>1.0</td>
<td>71</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

A.4 Use of sizing equations. Capacities of smooth wall pipe or tubing can also be determined by using the following formulae:
(1) High Pressure [1.5 psi (10.3 kPa) and above]:

\[
Q = 181.6 \sqrt[3]{\frac{D^3 \cdot (P_1^2 - P_2^2) \cdot Y}{C_r \cdot fba \cdot L}}
\]

\[
= 2237 \cdot D^{2.623} \left(\frac{(P_1^2 - P_2^2) \cdot Y}{C_r \cdot L}\right)^{0.541}
\]

(2) Low Pressure [Less than 1.5 psi (10.3 kPa)]:

\[
Q = 187.3 \sqrt[5]{\frac{D^5 \cdot \Delta H}{C_r \cdot fba \cdot L}}
\]

\[
= 2313 \cdot D^{2.623} \left(\frac{\Delta H}{C_r \cdot L}\right)^{0.541}
\]

where:

- \(Q\) = Rate, cubic feet per hour at 60°F and 30-inch mercury column
- \(D\) = Inside diameter of pipe, in.
- \(P_1\) = Upstream pressure, psia
- \(P_2\) = Downstream pressure, psia
- \(Y\) = Superexpansibility factor = 1/supercompressibility factor
- \(C_r\) = Factor for viscosity, density and temperature*

\[
C_r = 0.00354 \cdot S \cdot T \left(\frac{Z}{S}\right)^{0.152}
\]

Note: See Table 402.4 for \(Y\) and \(C_r\) for natural gas and propane.

- \(S\) = Specific gravity of gas at 60°F and 30-inch mercury column (0.60 for natural gas, 1.50 for propane), or = 1488\(\mu\)
- \(T\) = Absolute temperature, °F or = \(t + 460\)
- \(t\) = Temperature, °F
- \(Z\) = Viscosity of gas, centipoise (0.012 for natural gas, 0.008 for propane), or = 1488\(\mu\)
- \(fba\) = Base friction factor for air at 60°F (CF = 1)
- \(L\) = Length of pipe, ft
- \(\Delta H\) = Pressure drop, in. w.c. (27.7 in. \(H_2O = 1\) psi)

(For SI, see Section 402.4)

A.5 Pipe and tube diameters.
Where the internal diameter is determined by the formulas in Section 402.4, Tables A.5.1 and
A.5.2 can be used to select the nominal or standard pipe size based on the calculated internal diameter.

### TABLE A.5.1
SCHEDULE 40 STEEL PIPE STANDARD SIZES

<table>
<thead>
<tr>
<th>NOMINAL SIZE (inch)</th>
<th>INTERNAL DIAMETER (inch)</th>
<th>NOMINAL SIZE (inch)</th>
<th>INTERNAL DIAMETER (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>0.364</td>
<td>1/2</td>
<td>1.610</td>
</tr>
<tr>
<td>3/8</td>
<td>0.493</td>
<td>2</td>
<td>2.067</td>
</tr>
<tr>
<td>1/2</td>
<td>0.622</td>
<td>1/2</td>
<td>2.469</td>
</tr>
<tr>
<td>3/4</td>
<td>0.824</td>
<td>3</td>
<td>3.068</td>
</tr>
<tr>
<td>1</td>
<td>1.049</td>
<td>3/2</td>
<td>3.548</td>
</tr>
<tr>
<td>1 1/4</td>
<td>1.380</td>
<td>4</td>
<td>4.026</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

### TABLE A.5.2
COPPER TUBE STANDARD SIZES

<table>
<thead>
<tr>
<th>TUBE TYPE</th>
<th>NOMINAL OR STANDARD SIZE (inches)</th>
<th>INTERNAL DIAMETER (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>1/4</td>
<td>0.305</td>
</tr>
<tr>
<td>L</td>
<td>1/4</td>
<td>0.315</td>
</tr>
<tr>
<td>ACR (D)</td>
<td>3/8</td>
<td>0.315</td>
</tr>
<tr>
<td>ACR (A)</td>
<td>3/8</td>
<td>0.311</td>
</tr>
<tr>
<td>K</td>
<td>3/8</td>
<td>0.402</td>
</tr>
<tr>
<td>L</td>
<td>3/8</td>
<td>0.430</td>
</tr>
<tr>
<td>ACR (D)</td>
<td>1/2</td>
<td>0.430</td>
</tr>
<tr>
<td>ACR (A)</td>
<td>1/2</td>
<td>0.436</td>
</tr>
<tr>
<td>K</td>
<td>1/2</td>
<td>0.527</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>L</td>
<td>$\frac{1}{2}$</td>
<td></td>
</tr>
<tr>
<td>ACR (D)</td>
<td>$\frac{5}{8}$</td>
<td></td>
</tr>
<tr>
<td>ACR (A)</td>
<td>$\frac{5}{8}$</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>$\frac{5}{8}$</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>$\frac{5}{8}$</td>
<td></td>
</tr>
<tr>
<td>ACR (D)</td>
<td>$\frac{3}{4}$</td>
<td></td>
</tr>
<tr>
<td>ACR (A)</td>
<td>$\frac{3}{4}$</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>$\frac{3}{4}$</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>$\frac{3}{4}$</td>
<td></td>
</tr>
<tr>
<td>ACR</td>
<td>$\frac{7}{8}$</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ACR</td>
<td>$\frac{1}{8}$</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>$\frac{1}{4}$</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>$\frac{1}{4}$</td>
<td></td>
</tr>
<tr>
<td>ACR</td>
<td>$\frac{3}{8}$</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>$\frac{1}{2}$</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>$\frac{1}{2}$</td>
<td></td>
</tr>
<tr>
<td>ACR</td>
<td>$\frac{5}{8}$</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>ACR</td>
<td>$\frac{1}{8}$</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>$\frac{2}{2}$</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>$\frac{2}{2}$</td>
<td></td>
</tr>
<tr>
<td>ACR</td>
<td>$\frac{5}{8}$</td>
<td></td>
</tr>
</tbody>
</table>
A.6 Examples of piping system design and sizing.

A.6.1 Example 1: Longest length method.
Determine the required pipe size of each section and outlet of the piping system shown in Figure A.6.1, with a designated pressure drop of 0.5-inch w.c. (125 Pa) using the Longest Length Method. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft³ (37.5 MJ/m³).

Solution:

(1) Maximum gas demand for Outlet A:

\[
\frac{\text{Consumption (rating plate input, or Table 402.2 if necessary)}}{\text{Btu of gas}} = \frac{35,000}{1,000} = 35 \text{ cubic feet per hour} = 35 \text{ cfh}
\]

Maximum gas demand for Outlet B:

\[
\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{75,000}{1,000} = 75 \text{ cfh}
\]

Maximum gas demand for Outlet C:

\[
\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{35,000}{1,000} = 35 \text{ cfh}
\]

Maximum gas demand for Outlet D:

\[
\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{100,000}{1,000} = 100 \text{ cfh}
\]

(2) The length of pipe from the point of delivery to the most remote outlet (A) is 60 feet (18 288 mm). This is the only distance used.

(3) Using the row marked 60 feet (18 288 mm) in Table 402.4(2):

(a) Outlet A, supplying 35 cfh (0.99 m³/hr), requires \(\frac{3}{8}\)-inch pipe.

For SI: 1 inch = 25.4 mm.
(b) Outlet B, supplying 75 cfh (2.12 m³/hr), requires \( \frac{3}{4} \)-inch pipe.

(c) Section 1, supplying Outlets A and B, or 110 cfh (3.11 m³/hr), requires \( \frac{3}{4} \)-inch pipe.

(d) Section 2, supplying Outlets C and D, or 135 cfh (3.82 m³/hr), requires \( \frac{3}{4} \)-inch pipe.

(e) Section 3, supplying Outlets A, B, C and D, or 245 cfh (6.94 m³/hr), requires 1-inch pipe.

(4) If a different gravity factor is applied to this example, the values in the row marked 60 feet (18 288 mm) of Table 402.4(2) would be multiplied by the appropriate multiplier from Table A.2.4 and the resulting cubic feet per hour values would be used to size the piping.

![Piping Plan Showing a Steel Piping System](image)

**FIGURE A.6.1**

**PIPING PLAN SHOWING A STEEL PIPING SYSTEM**

**A.6.2 Example 2: Hybrid or dual pressure systems.**

Determine the required CSST size of each section of the piping system shown in Figure A.6.2, with a designated pressure drop of 1 psi (6.9 kPa) for the 2 psi (13.8 kPa) section and 3-inch w.c. (0.75 kPa) pressure drop for the 13-inch w.c. (2.49 kPa) section. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft³ (37.5 MJ/ m³).

**Solution:**

(1) Size 2 psi (13.8 kPa) line using Table 402.4(18).

(2) Size 10-inch w.c. (2.5 kPa) lines using Table 402.4(16).
(3) Using the following, determine if sizing tables can be used.

(a) Total gas load shown in Figure A.6.2 equals 110 cfh (3.11 m$^3$/hr).

(b) Determine pressure drop across regulator [see notes in Table 402.4(18)].

(c) If pressure drop across regulator exceeds $\frac{3}{4}$ psi (5.2 kPa), Table 402.4(18) cannot be used. Note: If pressure drop exceeds $\frac{3}{4}$ psi (5.2 kPa), then a larger regulator must be selected or an alternative sizing method must be used.

(d) Pressure drop across the line regulator [for 110 cfh (3.11 m$^3$/hr)] is 4-inch w.c. (0.99 kPa) based on manufacturer’s performance data.

(e) Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23 and 30.

(4) Section A [2 psi (13.8 kPa) zone]

(a) Distance from meter to regulator = 100 feet (30 480 mm).

(b) Total load supplied by A = 110 cfh (3.11 m$^3$/hr) (furnace + water heater + dryer).

(c) Table 402.4(18) shows that EHD size 18 should be used.

Note: It is not unusual to oversize the supply line by 25 to 50 percent of the as-installed load. EHD size 18 has a capacity of 189 cfh (5.35 m$^3$/hr).

(5) Section B (low pressure zone)

(a) Distance from regulator to furnace is 15 feet (4572 mm).

(b) Load is 60 cfh (1.70 m$^3$/hr).

(c) Table 402.4(16) shows that EHD size 13 should be used.

(6) Section C (low pressure zone)

(a) Distance from regulator to water heater is 10 feet (3048 mm).

(b) Load is 30 cfh (0.85 m$^3$/hr).

(c) Table 402.4(16) shows that EHD size 13 should be used.

(7) Section D (low pressure zone)
(a) Distance from regulator to dryer is 25 feet (7620 mm).

(b) Load is 20 cfh (0.57 m$^3$/hr).

(c) Table 402.4(16) shows that EHD size 13 should be used.

A.6.3 Example 3: Branch length method.

Determine the required semirigid copper tubing size of each section of the piping system shown in Figure A.6.3, with a designated pressure drop of 1-inch w.c. (250 Pa) (using the Branch Length Method). The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft$^3$ (37.5 MJ/m$^3$).

Solution:

(1) Section A

(a) The length of tubing from the point of delivery to the most remote appliance is 50 feet (15 240 mm), A + C.

(b) Use this longest length to size Sections A and C.

(c) Using the row marked 50 feet (15 240 mm) in Table 402.4(10), Section A, supplying 220 cfh (6.2 m$^3$/hr) for four appliances requires 1-inch tubing.

(2) Section B
(a) The length of tubing from the point of delivery to the range/oven at the end of Section B is 30 feet (9144 mm), A + B.

(b) Use this branch length to size Section B only.

(c) Using the row marked 30 feet (9144 mm) in Table 402.4(10), Section B, supplying 75 cfh (2.12 m³/hr) for the range/oven requires \( \frac{1}{2} \)-inch tubing.

(3) Section C

(a) The length of tubing from the point of delivery to the dryer at the end of Section C is 50 feet (15 240 mm), A + C.

(b) Use this branch length to size Section C.

(c) Using the row marked 50 feet (15 240 mm) in Table 402.4(10), Section C, supplying 30 cfh (0.85 m³/hr) for the dryer requires \( \frac{3}{8} \)-inch tubing.

(4) Section D

(a) The length of tubing from the point of delivery to the water heater at the end of Section D is 30 feet (9144 mm), A + D.

(b) Use this branch length to size Section D only.

(c) Using the row marked 30 feet (9144 mm) in Table 402.4(10), Section D, supplying 35 cfh (0.99 m³/hr) for the water heater requires \( \frac{3}{8} \)-inch tubing.

(5) Section E

(a) The length of tubing from the point of delivery to the furnace at the end of Section E is 30 feet (9144 mm), A + E.

(b) Use this branch length to size Section E only.

(c) Using the row marked 30 feet (9144 mm) in Table 402.4(10), Section E, supplying 80 cfh (2.26 m³/hr) for the furnace requires \( \frac{1}{2} \)-inch tubing.
A.6.4 Example 4: Modification to existing piping system.

Determine the required CSST size for Section G (retrofit application) of the piping system shown in Figure A.6.4, with a designated pressure drop of 0.5-inch w.c. (125 Pa) using the branch length method. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft\(^3\) (37.5 MJ/m\(^3\)).

Solution:

1. The length of pipe and CSST from the point of delivery to the retrofit appliance (barbecue) at the end of Section G is 40 feet (12 192 mm), A + B + G.

2. Use this branch length to size Section G.

3. Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23 and 30.

4. Using the row marked 40 feet (12 192 mm) in Table 402.4(15), Section G, supplying 40 cfh (1.13 m\(^3\)/hr) for the barbecue requires EHD 18 CSST.

5. The sizing of Sections A, B, F and E must be checked to ensure adequate gas carrying capacity since an appliance has been added to the piping system (see A.6.1 for details).
A.6.5 Example 5: Calculating pressure drops due to temperature changes.
A test piping system is installed on a warm autumn afternoon when the temperature is 70°F (21°C). In accordance with local custom, the new piping system is subjected to an air pressure test at 20 psig (138 kPa). Overnight, the temperature drops and when the inspector shows up first thing in the morning the temperature is 40°F (4°C).

If the volume of the piping system is unchanged, then the formula based on Boyle’s and Charles’ law for determining the new pressure at a reduced temperature is as follows:

\[
\frac{T_1}{T_2} = \frac{P_1}{P_2}
\]

where:

\[
T_1 = \text{Initial temperature, absolute (} T_1 + 459) \]
\[
T_2 = \text{Final temperature, absolute (} T_2 + 459) \]
\[
P_1 = \text{Initial pressure, psia (} P_1 + 14.7) \]
\[
P_2 = \text{Final pressure, psia (} P_2 + 14.7) \]

\[
\frac{(70 + 459)}{(40 + 459)} = \frac{(20 + 14.7)}{(P_2 + 14.7)}
\]

\[
\frac{529}{499} = \frac{34.7}{(P_2 + 14.7)}
\]
\[ (P_2 + 14.7) \times \frac{529}{499} = 34.7 \]

\[ (P_2 + 14.7) \times \frac{34.7}{1.060} \]

\[ P_2 = 32.7 - 14.7 \]
\[ P_2 = 18 \text{ psig} \]

Therefore, the gauge could be expected to register 18 psig (124 kPa) when the ambient temperature is 40°F (4°C).

**A.6.6 Example 6: Pressure drop per 100 feet of pipe method.**
Using the layout shown in Figure A.6.1 and \( \Delta H = \) pressure drop, in w.c. (27.7 in. H\(_2\)O = 1 psi), proceed as follows:

1. Length to A = 20 feet, with 35,000 Btu/hr.
   
   For \( \frac{1}{2} \)-inch pipe, \( \Delta H = \frac{20 \text{ feet}}{100 \text{ feet}} \times 0.3 \text{ inch w.c.} = 0.06 \text{ in w.c.} \)

2. Length to B = 15 feet, with 75,000 Btu/hr.
   
   For \( \frac{3}{4} \)-inch pipe, \( \Delta H = \frac{15 \text{ feet}}{100 \text{ feet}} \times 0.3 \text{ inch w.c.} = 0.045 \text{ in w.c.} \)

3. Section 1 = 10 feet, with 110,000 Btu/hr. Here there is a choice:
   
   For 1-inch pipe: \( \Delta H = \frac{10 \text{ feet}}{100 \text{ feet}} \times 0.2 \text{ inch w.c.} = 0.02 \text{ in w.c.} \)
   
   For \( \frac{3}{4} \)-inch pipe: \( \Delta H = \frac{10 \text{ feet}}{100 \text{ feet}} \times [0.5 \text{ inch w.c.} + \frac{(110,000 \text{ Btu/hr} - 104,000 \text{ Btu/hr})}{(147,000 \text{ Btu/hr} - 104,000 \text{ Btu/hr})} \times (1.0 \text{ inches w.c. - 0.5 inch w.c.})] = 0.1 \times 0.57 \text{ inch w.c.} \approx 0.06 \text{ inch w.c.} \)

*Note that the pressure drop between 104,000 Btu/hr and 147,000 Btu/hr has been interpolated as 110,000 Btu/hr.*

4. Section 2 = 20 feet, with 135,000 Btu/hr. Here there is a choice:
   
   For 1-inch pipe: \( \Delta H = \frac{20 \text{ feet}}{100 \text{ feet}} \times [0.2 \text{ inch w.c.} + \frac{(14,000 \text{ Btu/hr})}{(27,000 \text{ Btu/hr})} \times 0.1 \text{ inch w.c.}] = 0.05 \text{ inch w.c.} \)
   
   For \( \frac{3}{4} \)-inch pipe: \( \Delta H = \frac{20 \text{ feet}}{100 \text{ feet}} \times 1.0 \text{ inch w.c.} = 0.2 \text{ inch w.c.} \)
Note that the pressure drop between 121,000 Btu/hr and 148,000 Btu/hr has been interpolated as 135,000 Btu/hr, but interpolation for the \( \frac{3}{4} \)-inch pipe (trivial for 104,000 Btu/hr to 147,000 Btu/hr) was not used.

(5) Section 3 = 30 feet, with 245,000 Btu/hr. Here there is a choice:

For 1-inch pipe: \( \Delta H = \frac{30 \text{ feet}}{100 \text{ feet}} \times 1.0 \text{ inches w.c.} = 0.3 \text{ inch w.c.} \)

For \( 1 \frac{1}{4} \)-inch pipe: \( \Delta H = \frac{30 \text{ feet}}{100 \text{ feet}} \times 0.2 \text{ inch w.c.} = 0.06 \text{ inch w.c.} \)

Note that interpolation for these options is ignored since the table values are close to the 245,000 Btu/hr carried by that section.

(6) The total pressure drop is the sum of the section approaching A, Sections 1 and 3, or either of the following, depending on whether an absolute minimum is needed or the larger drop can be accommodated.

Minimum pressure drop to farthest appliance:

\[ \Delta H = 0.06 \text{ inch w.c.} + 0.02 \text{ inch w.c.} + 0.06 \text{ inch w.c.} = 0.14 \text{ inch w.c.} \]

Larger pressure drop to the farthest appliance:

\[ \Delta H = 0.06 \text{ inch w.c.} + 0.06 \text{ inch w.c.} + 0.3 \text{ inch w.c.} = 0.42 \text{ inch w.c.} \]

Notice that Section 2 and the run to B do not enter into this calculation, provided that the appliances have similar input pressure requirements.

For SI units: 1 Btu/hr = 0.293 W, 1 cubic foot = 0.028 m\(^3\), 1 foot = 0.305 m, 1 inch w.c. = 249 Pa.
APPENDIX B
SIZING OF VENTING SYSTEMS SERVING
APPLIANCES EQUIPPED WITH DRAFT HOODS,
CATEGORY I APPLIANCES, AND
APPLIANCES LISTED FOR USE WITH TYPE B VENTS

(This appendix is informative and is not part of the code. This appendix is an excerpt from the 2015 International Fuel Gas Code, coordinated with the section numbering of the International Residential Code.)

EXAMPLES USING SINGLE
APPLIANCE VENTING TABLES

Example 1: Single draft-hood-equipped appliance.

An installer has a 120,000 British thermal unit (Btu) per hour input appliance with a 5-inch-diameter draft hood outlet that needs to be vented into a 10-foot-high Type B vent system. What size vent should be used assuming (a) a 5-foot lateral single-wall metal vent connector is used with two 90-degree elbows, or (b) a 5-foot lateral single-wall metal vent connector is used with three 90-degree elbows in the vent system?

Solution:

Table 504.2(2) should be used to solve this problem, because single-wall metal vent connectors are being used with a Type B vent.

(a) Read down the first column in Table 504.2(2) until the row associated with a 10-foot height and 5-foot lateral is found. Read across this row until a vent capacity greater than 120,000 Btu per hour is located in the shaded columns labeled “NAT Max” for draft-hood-equipped appliances. In this case, a 5-inch-diameter vent has a capacity of 122,000 Btu per hour and can be used for this application.

(b) If three 90-degree elbows are used in the vent system, then the maximum vent capacity listed in the tables must be reduced by 10 percent (see Section 504.2.3 for single appliance vents). This implies that the 5-inch-diameter vent has an adjusted capacity of only 110,000 Btu per hour. In this case, the vent system must be increased to 6 inches in diameter (see calculations below).

$$122,000 \times (0.90) = 110,000$$ for 5-inch vent
From Table 504.2(2), Select 6-inch vent 186,000 (0.90) = 167,000; This is greater than the required 120,000. Therefore, use a 6-inch vent and connector where three elbows are used.

**Example 2: Single fan-assisted appliance.**

An installer has an 80,000 Btu per hour input fan-assisted *appliance* that must be installed using 10 feet of lateral connector attached to a 30-foot-high Type B vent. Two 90-degree elbows are needed for the installation. Can a single-wall metal vent connector be used for this application?

**Solution:**

Table 504.2(2) refers to the use of single-wall metal vent connectors with Type B vent. In the first column find the row associated with a 30-foot height and a 10-foot lateral. Read across this row, looking at the FAN Min and FAN Max columns, to find that a 3-inch-diameter single-wall metal vent connector is not recommended. Moving to the next larger size single wall connector (4 inches), note that a 4-inch-diameter single-wall metal connector has a recommended minimum vent capacity of 91,000 Btu per hour and a recommended maximum vent capacity of 144,000 Btu per hour. The 80,000 Btu per hour fan-assisted *appliance* is outside this range, so the conclusion is that a single-wall metal vent connector cannot be used to vent this *appliance* using 10 feet of lateral for the connector.

However, if the 80,000 Btu per hour input *appliance* could be moved to within 5 feet of the vertical vent, then a 4-inch single-wall metal connector could be used to vent the *appliance*. Table 504.2(2) shows the acceptable range of vent capacities for a 4-inch vent with 5 feet of lateral to be between 72,000 Btu per hour and 157,000 Btu per hour.

If the *appliance* cannot be moved closer to the vertical vent, then Type B vent could be used as the connector material. In this case, Table 504.2(1) shows that for a 30-foot-high vent with 10 feet of lateral, the acceptable range of vent capacities for a 4-inch-diameter vent attached to a fan-assisted *appliance* is between 37,000 Btu per hour and 150,000 Btu per hour.

**Example 3: Interpolating between table values.**

An installer has an 80,000 Btu per hour input *appliance* with a 4-inch-diameter draft hood outlet that needs to be vented into a 12-foot-high Type B vent. The vent connector has a 5-foot lateral length and is also Type B. Can this *appliance* be vented using a 4-inch-diameter vent?

**Solution:**

Table 504.2(1) is used in the case of an all Type B vent system. However, since there is no entry in Table 504.2(1) for a height of 12 feet, interpolation must be used. Read down the 4-inch diameter NAT Max column to the row associated with 10-foot height and 5-foot lateral to find the capacity value of 77,000 Btu per hour. Read further down to the 15-foot height, 5-foot lateral row to find the capacity value of 87,000 Btu per hour. The difference between the 15-foot height capacity value and the 10-foot height capacity value is 10,000 Btu per hour. The capacity for a vent system with a 12-foot height is equal to the capacity for a 10-foot height plus \( \frac{2}{5} \) of the
difference between the 10-foot and 15-foot height values, or $77,000 + \frac{2}{5} (10,000) = 81,000$ Btu per hour. Therefore, a 4-inch-diameter vent can be used in the installation.

**EXAMPLES USING COMMON VENTING TABLES**

**Example 4: Common venting two draft-hood-equipped appliances.**

A 35,000 Btu per hour water heater is to be common vented with a 150,000 Btu per hour furnace using a common vent with a total height of 30 feet. The connector rise is 2 feet for the water heater with a horizontal length of 4 feet. The connector rise for the furnace is 3 feet with a horizontal length of 8 feet. Assume single-wall metal connectors will be used with Type B vent. What size connectors and combined vent should be used in this installation?

**Solution:**

Table 504.3(2) should be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 504.3(2), find the row associated with a 30-foot vent height. For a 2-foot rise on the vent connector for the water heater, read the shaded columns for draft-hood-equipped appliances to find that a 3-inch-diameter vent connector has a capacity of 37,000 Btu per hour. Therefore, a 3-inch single-wall metal vent connector can be used with the water heater. For a draft-hood-equipped furnace with a 3-foot rise, read across the appropriate row to find that a 5-inch-diameter vent connector has a maximum capacity of 120,000 Btu per hour (which is too small for the furnace) and a 6-inch-diameter vent connector has a maximum vent capacity of 172,000 Btu per hour. Therefore, a 6-inch-diameter vent connector should be used with the 150,000 Btu per hour furnace. Since both vent connector horizontal lengths are less than the maximum lengths listed in Section 504.3.2, the table values can be used without adjustments.

In the common vent capacity portion of Table 504.3(2), find the row associated with a 30-foot vent height and read over to the NAT + NAT portion of the 6-inch-diameter column to find a maximum combined capacity of 257,000 Btu per hour. Since the two appliances total only 185,000 Btu per hour, a 6-inch common vent can be used.

**Example 5a: Common venting a draft-hood-equipped water heater with a fan-assisted furnace into a Type B vent.**

In this case, a 35,000 Btu per hour input draft-hood-equipped water heater with a 4-inch-diameter draft hood outlet, 2 feet of connector rise, and 4 feet of horizontal length is to be common vented with a 100,000 Btu per hour fan-assisted furnace with a 4-inch-diameter flue collar, 3 feet of connector rise, and 6 feet of horizontal length. The common vent consists of a 30-foot height of Type B vent. What are the recommended vent diameters for each connector and the common vent? The installer would like to use a single-wall metal vent connector.

**Solution:** [Table 504.3(2)].

Water Heater Vent Connector Diameter. Since the water heater vent connector horizontal length of 4 feet is less than the maximum value listed in Section 504.3.2, the venting table values can be used without adjustments. Using the Vent Connector Capacity portion of Table 504.3(2),
read down the Total Vent Height \((H)\) column to 30 feet and read across the 2-foot Connector Rise \((R)\) row to the first Btu per hour rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3-inch vent connector has a maximum input rating of 37,000 Btu per hour. Although this is greater than the water heater input rating, a 3-inch vent connector is prohibited by Section 504.3.21. A 4-inch vent connector has a maximum input rating of 67,000 Btu per hour and is equal to the draft hood outlet diameter. A 4-inch vent connector is selected. Since the water heater is equipped with a draft hood, there are no minimum input rating restrictions.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 504.3(2), read down the Total Vent Height \((H)\) column to 30 feet and across the 3-foot Connector Rise \((R)\) row. Since the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu per hour rating greater than the furnace input rating. The 4-inch vent connector has a maximum input rating of 119,000 Btu per hour and a minimum input rating of 85,000 Btu per hour. The 100,000 Btu per hour furnace in this example falls within this range, so a 4-inch connector is adequate. Since the furnace vent connector horizontal length of 6 feet does not exceed the maximum value listed in Section 504.3.2, the venting table values can be used without adjustment. If the furnace had an input rating of 80,000 Btu per hour, then a Type B vent connector [see Table 504.3(1)] would be needed in order to meet the minimum capacity limit.

Common Vent Diameter. The total input to the common vent is 135,000 Btu per hour. Using the Common Vent Capacity portion of Table 504.3(2), read down the Total Vent Height \((H)\) column to 30 feet and across this row to find the smallest vent diameter in the FAN + NAT column that has a Btu per hour rating equal to or greater than 135,000 Btu per hour. The 4-inch common vent has a capacity of 132,000 Btu per hour and the 5-inch common vent has a capacity of 202,000 Btu per hour. Therefore, the 5-inch common vent should be used in this example.

Summary. In this example, the installer can use a 4-inch-diameter, single-wall metal vent connector for the water heater and a 4-inch-diameter, single-wall metal vent connector for the furnace. The common vent should be a 5-inch-diameter Type B vent.

Example 5b: Common venting into a masonry chimney.

In this case, the water heater and fan-assisted furnace of Example 5a are to be common vented into a clay tile-lined masonry chimney with a 30-foot height. The chimney is not exposed to the outdoors below the roof line. The internal dimensions of the clay tile liner are nominally 8 inches by 12 inches. Assuming the same vent connector heights, laterals, and materials found in Example 5a, what are the recommended vent connector diameters, and is this an acceptable installation?

Solution:

Table 504.3(4) is used to size common venting installations involving single-wall connectors into masonry chimneys.

Water Heater Vent Connector Diameter. Using Table 504.3(4), Vent Connector Capacity, read down the Total Vent Height \((H)\) column to 30 feet, and read across the 2-foot Connector Rise \((R)\) row to the first Btu per hour rating in the NAT Max column that is equal to or greater
than the water heater input rating. The table shows that a 3-inch vent connector has a maximum input of only 31,000 Btu per hour while a 4-inch vent connector has a maximum input of 57,000 Btu per hour. A 4-inch vent connector must therefore be used.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 504.3(4), read down the Total Vent Height \((H)\) column to 30 feet and across the 3-foot Connector Rise \((R)\) row. Since the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu per hour rating greater than the furnace input rating. The 4-inch vent connector has a maximum input rating of 127,000 Btu per hour and a minimum input rating of 95,000 Btu per hour. The 100,000 Btu per hour furnace in this example falls within this range, so a 4-inch connector is adequate.

Masonry Chimney. From Table B-1, the equivalent area for a nominal liner size of 8 inches by 12 inches is 63.6 square inches. Using Table 504.3(4), Common Vent Capacity, read down the FAN + NAT column under the Minimum Internal Area of Chimney value of 63 to the row for 30-foot height to find a capacity value of 739,000 Btu per hour. The combined input rating of the furnace and water heater, 135,000 Btu per hour, is less than the table value, so this is an acceptable installation.

Section 504.3.17 requires the common vent area to be no greater than seven times the smallest listed appliance categorized vent area, flue collar area, or draft hood outlet area. Both appliances in this installation have 4-inch-diameter outlets. From Table B-1, the equivalent area for an inside diameter of 4 inches is 12.2 square inches. Seven times 12.2 equals 85.4, which is greater than 63.6, so this configuration is acceptable.

Example 5c: Common venting into an exterior masonry chimney.

In this case, the water heater and fan-assisted furnace of Examples 5a and 5b are to be common vented into an exterior masonry chimney. The chimney height, clay tile liner dimensions, and vent connector heights and laterals are the same as in Example 5b. This system is being installed in Charlotte, North Carolina. Does this exterior masonry chimney need to be relined? If so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended?

Solution:

In accordance with Section 504.3.20, Type B vent connectors are required to be used with exterior masonry chimneys. Use Tables 504.3(7a), (7b) to size FAN+NAT common venting installations involving Type-B double wall connectors into exterior masonry chimneys.

The local 99-percent winter design temperature needed to use Table 504.3(7b) can be found in the ASHRAE Handbook of Fundamentals. For Charlotte, North Carolina, this design temperature is 19°F.

Chimney Liner Requirement. As in Example 5b, use the 63 square inch Internal Area columns for this size clay tile liner. Read down the 63 square inch column of Table 504.3(7a) to the 30-foot height row to find that the combined appliance maximum input is 747,000 Btu per hour. The combined input rating of the appliances in this installation, 135,000 Btu per hour, is less than the maximum value, so this criterion is satisfied. Table 504.3(7b), at a 19°F design temperature, and at the same vent height and internal area used above, shows that the
minimum allowable input rating of a space-heating appliance is 470,000 Btu per hour. The
furnace input rating of 100,000 Btu per hour is less than this minimum value. So this criterion is
not satisfied, and an alternative venting design needs to be used, such as a Type B vent shown
in Example 5a or a listed chimney liner system shown in the remainder of the example.

In accordance with Section 504.3.19, Table 504.3(1) or 504.3(2) is used for sizing
corrugated metallic liners in masonry chimneys, with the maximum common vent capacities
reduced by 20 percent. This example will be continued assuming Type B vent connectors.

Water Heater Vent Connector Diameter. Using Table 504.3(1), Vent Connector Capacity,
read down the Total Vent Height (H) column to 30 feet, and read across the 2-foot Connector
Rise (R) row to the first Btu/h rating in the NAT Max column that is equal to or greater than the
water heater input rating. The table shows that a 3-inch vent connector has a maximum capacity
of 39,000 Btu/h. Although this rating is greater than the water heater input rating, a 3-inch vent
connector is prohibited by Section 504.3.21. A 4-inch vent connector has a maximum input
rating of 70,000 Btu/h and is equal to the draft hood outlet diameter. A 4-inch vent connector is
selected.

Furnace Vent Connector Diameter. Using Table 504.3(1), Vent Connector Capacity, read
down the Total Vent Height (H) column to 30 feet, and read across the 3-foot Connector Rise (R) row
to the first Btu per hour rating in the FAN Max column that is equal to or greater than the furnace
input rating. The 100,000 Btu per hour furnace in this example falls within this range, so a 4-inch
connector is adequate.

Chimney Liner Diameter. The total input to the common vent is 135,000 Btu per hour. Using
the Common Vent Capacity Portion of Table 504.3(1), read down the Vent Height (H) column to
30 feet and across this row to find the smallest vent diameter in the FAN+NAT column that has
a Btu per hour rating greater than 135,000 Btu per hour. The 4-inch common vent has a
capacity of 138,000 Btu per hour. Reducing the maximum capacity by 20 percent (Section
504.3.19) results in a maximum capacity for a 4-inch corrugated liner of 110,000 Btu per hour,
less than the total input of 135,000 Btu per hour. So a larger liner is needed. The 5-inch
common vent capacity listed in Table 504.3(1) is 210,000 Btu per hour, and after reducing by 20
percent is 168,000 Btu per hour. Therefore, a 5-inch corrugated metal liner should be used in
this example.

Single-Wall Connectors. Once it has been established that relining the chimney is
necessary, Type B double-wall vent connectors are not specifically required. This example
could be redone using Table 504.3(2) for single-wall vent connectors. For this case, the vent
connector and liner diameters would be the same as found above with Type B double-wall
connectors.
Table 504.2(1) is used when sizing Type B double-wall gas vent connected directly to the appliance. **Note:** The appliance may be either Category I draft hood equipped or fanassisted type.

**FIGURE B-1**
TYPE B DOUBLE-WALL VENT SYSTEM SERVING A SINGLE APPLIANCE WITH A TYPE B DOUBLE-WALL VENT

Table 504.2(2) is used when sizing a single-wall metal vent connector attached to a Type B double-wall gas vent. **Note:** The appliance may be either Category I draft hood equipped or fanassisted type.
Table 504.2(3) is used when sizing a Type B double-wall gas vent connector attached to a tile-lined masonry chimney.

Note: “A” is the equivalent cross-sectional area of the tile liner.

Note: The appliance can be either Category I draft hood equipped or fanassisted type.

FIGURE B-3
VENT SYSTEM SERVING A SINGLE APPLIANCE WITH A MASONRY CHIMNEY OF TYPE B DOUBLE-WALL VENT CONNECTOR
Table 504.2(4) is used when sizing a single-wall vent connector attached to a tile-lined masonry chimney.

**Note:** "A" is the equivalent cross-sectional area of the tile liner.

**Note:** The appliance can be either Category I draft hood equipped or fanassisted type.

**FIGURE B-4**  
VENT SYSTEM SERVING A SINGLE APPLIANCE USING A MASONRY CHIMNEY AND A SINGLE-WALL METAL VENT CONNECTOR
Asbestos cement Type B or single-wall metal vent serving a single drafthood-equipped appliance [see Table 504.2(5)].

**FIGURE B-5**

**ASBESTOS CEMENT TYPE B OR SINGLE-WALL METAL VENT SYSTEM SERVING A SINGLE DRAFT-HOOD-EQUIPPED APPLIANCE**

Table 504.3(1) is used when sizing Type B double-wall vent connectors attached to a Type B double-wall common vent.

**Note:** Each appliance can be either Category I draft hood equipped or fanassisted type.

**FIGURE B-6**

**VENT SYSTEM SERVING TWO OR MORE APPLIANCES WITH TYPE B DOUBLE-WALL VENT AND TYPE B DOUBLE-WALL VENT CONNECTOR**
Table 504.3(2) is used when sizing single-wall vent connectors attached to a Type B double-wall common vent. **Note:** Each appliance can be either Category I draft hood equipped or fan-assisted type.

**FIGURE B-7**
VENT SYSTEM SERVING TWO OR MORE APPLIANCES WITH TYPE B DOUBLE-WALL VENT AND SINGLE-WALL METAL VENT CONNECTORS
Table 504.3(3) is used when sizing Type B double-wall vent connectors attached to a tile-lined masonry chimney. 
**Note:** “A” is the equivalent cross-sectional area of the tile liner.  
**Note:** Each appliance can be either Category I draft hood equipped or fanassisted type.

**FIGURE B-8**  
MASONRY CHIMNEY SERVING TWO OR MORE APPLIANCES  
WITH TYPE B DOUBLE-WALL VENT CONNECTOR

![Diagram of masonry chimney serving two or more appliances with Type B double-wall vent connector](image)

Table 504.3(4) is used when sizing single-wall metal vent connectors attached to a tile-lined masonry chimney.  
**Note:** “A” is the equivalent cross-sectional area of the tile liner.  
**Note:** Each appliance can be either Category I draft hood equipped or fanassisted type.

**FIGURE B-9**  
MASONRY CHIMNEY SERVING TWO OR MORE APPLIANCES  
WITH SINGLE-WALL METAL VENT CONNECTORS
Asbestos cement Type B or single-wall metal pipe vent serving two or more draft-hood-equipped appliances [see Table 504.3(5)].

FIGURE B-10
ASBESTOS CEMENT TYPE B OR SINGLE-WALL METAL VENT SYSTEM SERVING TWO OR MORE DRAFT-HOOD-EQUIPPED APPLIANCES
Example: Manifolded Common Vent Connector \( L \) shall be no greater than 18 times the common vent connector manifold inside diameter; i.e., a 4-inch (102 mm) inside diameter common vent connector manifold shall not exceed 72 inches (1829 mm) in length (see Section 504.3.4).

**Note:** This is an illustration of a typical manifolded vent connector. Different appliance, vent connector, or common vent types are possible. Consult Section 502.3.

![FIGURE B-11 USE OF MANIFOLD COMMON VENT CONNECTOR](image)

Example: Offset Common Vent

**Note:** This is an illustration of a typical offset vent. Different appliance, vent connector, or vent types are possible. Consult Sections 504.2 and 504.3.

![FIGURE B-12 USE OF OFFSET COMMON VENT](image)
Vent connector size depends on:
• Input
• Rise
• Available total height “H”
• Table 504.3(1) connectors

Common vent size depends on:
• Combined inputs
• Available total height “H”
• Table 504.3(1) common vent

FIGURE B-13
MULTISTORY GAS VENT DESIGN PROCEDURE
FOR EACH SEGMENT OF SYSTEM
Principles of design of multistory vents using vent connector and common vent design tables (see Sections 504.3.11 through 504.3.17).

FIGURE B-14
MULTISTORY VENT SYSTEMS
FIGURE B-15 (EXAMPLE 1)
SINGLE DRAFT-HOOD-EQUIPPED APPLIANCE

For SI: 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.
For SI: 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

**FIGURE B-16 (EXAMPLE 2)**
SINGLE FAN-ASSISTED APPLIANCE
FIGURE B-17 (EXAMPLE 4)
COMMON VENTING TWO DRAFT HOOD-EQUIPPED APPLIANCES
# FIGURE B-18 (EXAMPLE 5A)
COMMON VENTING A DRAFT HOOD WITH A FAN-ASSISTED FURNACE INTO A TYPE B DOUBLE-WALL COMMON VENT

## TABLE B-1
MASONRY CHIMNEY LINER DIMENSIONS WITH CIRCULAR EQUIVALENTS

<table>
<thead>
<tr>
<th>NOMINAL LINER SIZE (inches)</th>
<th>INSIDE DIMENSIONS OF LINER (inches)</th>
<th>INSIDE DIAMETER OR EQUIVALENT DIAMETER (inches)</th>
<th>EQUIVALENT AREA (square inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 × 8</td>
<td>(\frac{1}{2} × \frac{6}{2})</td>
<td>4</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>19.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>38.3</td>
</tr>
<tr>
<td>8 × 8</td>
<td>(\frac{3}{6} × \frac{3}{6})</td>
<td>7.4</td>
<td>42.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>50.3</td>
</tr>
<tr>
<td>8 × 12</td>
<td>(\frac{1}{2} × \frac{10}{2})</td>
<td>9</td>
<td>63.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>78.5</td>
</tr>
<tr>
<td>12 × 12</td>
<td>(\frac{9}{4} × \frac{9}{4})</td>
<td>10.4</td>
<td>83.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>95</td>
</tr>
<tr>
<td>12 × 16</td>
<td>(\frac{9}{2} × \frac{13}{2})</td>
<td>11.8</td>
<td>107.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>113.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>153.9</td>
</tr>
<tr>
<td>16 × 16</td>
<td>(\frac{13}{4} × \frac{13}{4})</td>
<td>14.5</td>
<td>162.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>176.7</td>
</tr>
<tr>
<td>16 × 20</td>
<td>(\frac{13}{4} × \frac{17}{4})</td>
<td>16.2</td>
<td>206.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>254.4</td>
</tr>
<tr>
<td>20 × 20</td>
<td>(\frac{3}{4} × \frac{16}{4})</td>
<td>18.2</td>
<td>260.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>314.1</td>
</tr>
<tr>
<td>20 × 24</td>
<td>(\frac{16}{2} × \frac{20}{2})</td>
<td>20.1</td>
<td>314.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 × 20</td>
<td>380.1</td>
</tr>
<tr>
<td>24 × 24</td>
<td>(\frac{20}{4} × \frac{20}{4})</td>
<td>22.1</td>
<td>380.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>452.3</td>
</tr>
<tr>
<td>24 × 28</td>
<td>(\frac{20}{4} × \frac{20}{4})</td>
<td>24.1</td>
<td>456.2</td>
</tr>
<tr>
<td>28 × 28</td>
<td>(\frac{24}{4} × \frac{24}{4})</td>
<td>26.4</td>
<td>543.3</td>
</tr>
<tr>
<td>30 × 30</td>
<td>(\frac{1}{2} × \frac{25}{2})</td>
<td>27</td>
<td>572.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.9</td>
<td>607</td>
</tr>
<tr>
<td>30 × 36</td>
<td>(\frac{1}{2} × \frac{31}{2})</td>
<td>30</td>
<td>706.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30.9</td>
<td>749.9</td>
</tr>
<tr>
<td>36 × 36</td>
<td>(\frac{31}{2} × \frac{31}{2})</td>
<td>33</td>
<td>855.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34.4</td>
<td>929.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
<td>1017.9</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 m².
a. Where liner sizes differ dimensionally from those shown in Table B-1, equivalent diameters can be determined from published tables for square and rectangular ducts of equivalent carrying capacity or by other engineering methods.

FIGURE B-19
APPENDIX C
EXIT TERMINALS OF MECHANICAL DRAFT AND DIRECT-VENT VENTING SYSTEMS

(This appendix is informative and is not part of the code. This appendix is an excerpt from the 2015 International Fuel Gas Code, coordinated with the section numbering of the International Residential Code.)

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

APPENDIX C
EXIT TERMINALS OF MECHANICAL DRAFT AND DIRECT-VENT VENTING SYSTEMS
APPENDIX D
RECOMMENDED PROCEDURE FOR SAFETY INSPECTION OF AN EXISTING APPLIANCE INSTALLATION

Deleted

(This appendix is not a part of the requirements of this code and is included for informational purposes only.)

(This appendix is an excerpt from the 2015 International Fuel Gas Code, coordinated with the section numbering of the International Residential Code.)

D.1 General.
The following procedure is intended as a guide to aid in determining that an appliance is properly installed and is in a safe condition for continued use. Where a gas supplier performs an inspection, their written procedures should be followed.

D.1.1 Application.
This procedure is intended for existing residential installations of a furnace, boiler, room heater, water heater, cooking appliance, fireplace appliance and clothes dryer. This procedure should be performed prior to any attempt to modify the appliance installation or building envelope.

D.1.2 Weatherization Programs.
Before a building envelope is to be modified as part of a weatherization program, the existing appliance installation should be inspected in accordance with these procedures. After all unsafe conditions are repaired, and immediately after the weatherization is complete, the appliance inspections in D.5.2 are to be repeated.

D.1.3 Inspection Procedure.
The safety of the building occupant and inspector are to be determined as the first step as described in D.2. Only after the ambient environment is found to be safe should inspections of gas piping and appliances be undertaken. It is recommended that all inspections described in D.3, D.4, and D.6, where the appliance is in the off mode, be completed and any unsafe conditions repaired or corrected before continuing with inspections of an operating appliance described in D.5 and D.6.

D.1.4 Manufacturer Instructions.
Where available, the manufacturer’s installation and operating instructions for the installed appliances should be used as part of these inspection procedures to determine if it is installed correctly and is operating properly.

D.1.5 Instruments.
The inspection procedures include measuring for fuel gas and carbon monoxide (CO) and will require the use of a combustible gas detector (CGD) and a CO detector. It is recommended that both types of detectors be listed. Prior to any inspection, the detectors should be calibrated or
tested in accordance with the manufacturer’s instructions. In addition, it is recommended that
the detectors have the following minimum specifications.

(1) **Gas Detector:** The CGD should be capable of indicating the presence of the type of fuel
gas for which it is to be used (e.g. natural gas or propane). The combustible gas detector
should be capable of the following:

   a. **PPM:** Numeric display with a parts per million (ppm) scale from 1ppm to 900 ppm in
      1-ppm increments.

   b. **LEL:** Numeric display with a percent lower explosive limit (% LEL) scale from 0
      percent to 100 percent in 1 percent increments.

   c. **Audio:** An audio sound feature to locate leaks.

(2) **CO Detector:** The CO detector should be capable of the following functions and have a
numeric display scale as follows:

   a. **PPM:** For measuring ambient room and appliance emissions a display scale in parts
      per million (ppm) from 0 to 1,000 ppm in 1 ppm increments.

   b. **Alarm:** A sound alarm function where hazardous levels of ambient CO is found (see
      D.2 for alarm levels)

   c. **Air Free:** Capable of converting CO measurements to an air free level in ppm. Where
      a CO detector is used without an air free conversion function, the CO air free can be
      calculated in accordance with footnote 3 in Table D.6.

D.2 Occupant and Inspector Safety.
Prior to entering a building, the inspector should have both a combustible gas detector (CGD)
and CO detector turned on, calibrated, and operating. Immediately upon entering the building, a
sample of the ambient atmosphere should be taken. Based on CGD and CO detector readings,
the inspector should take the following actions:

(1) The CO detector indicates a carbon monoxide level of 70 ppm or greater. The
    inspector should immediately notify the occupant of the need for themselves and any
    building occupant to evacuate; the inspector shall immediately evacuate and call 911.

(2) Where the CO detector indicates a reading between 30 ppm and 70 ppm. The inspector
    should advise the occupant that high CO levels have been found and recommend that
    all possible sources of CO should be turned off immediately and windows and doors
    opened. Where it appears that the source of CO is a permanently installed appliance,
    advise the occupant to keep the appliance off and have the appliance serviced by a
    qualified servicing agent.

(3) Where CO detector indicates CO below 30 ppm. The inspection can continue.
(4) The CGD indicates a combustible gas level of 20% LEL or greater. The inspector should immediately notify the occupant of the need for themselves and any building occupant to evacuate; the inspector shall immediately evacuate and call 911.

(5) The CGD indicates a combustible gas level below 20% LEL, the inspection can continue.

If during the inspection process it is determined a condition exists that could result in unsafe appliance operation, shut off the appliance and advise the owner of the unsafe condition. Where a gas leak is found that could result in an unsafe condition, advise the owner of the unsafe condition and call the gas supplier to turn off the gas supply. The inspector should not continue a safety inspection on an operating appliance, venting system, and piping system until repairs have been made.

D.3 Gas Piping and Connection Inspections.

(1) Leak Checks. Conduct a test for gas leakage using either a non-corrosive leak detection solution or a CGD confirmed with a leak detection solution.

   The preferred method for leak checking is by use of gas leak detection solution applied to all joints. This method provides a reliable visual indication of significant leaks.

   The use of a CGD in its audio sensing mode can quickly locate suspect leaks but can be overly sensitive indicating insignificant and false leaks. All suspect leaks found through the use of a CGD should be confirmed using a leak detection solution.

   Where gas leakage is confirmed, the owner should be notified that repairs must be made. The inspection should include the following components:

   a. All gas piping fittings located within the appliance space.

   b. Appliance connector fittings.

   c. Appliance gas valve/regulator housing and connections.

(2) Appliance Connector. Verify that the appliance connection type is compliant with Section G2422 of the International Fuel Gas Code. Inspect flexible appliance connections to determine if they are free of cracks, corrosion and signs of damage. Verify that there are no uncoated brass connectors. Where connectors are determined to be unsafe or where an uncoated brass connector is found, the appliance shutoff valve should be placed in the off position and the owner notified that the connector must be replaced.

(3) Piping Support. Inspect piping to determine that it is adequately supported, that there is no undue stress on the piping, and if there are any improperly capped pipe openings.

(4) Bonding. Verify that the electrical bonding of gas piping is compliant with Section G2411 of the International Fuel Gas Code.
D.4 Inspections to be performed with the Appliance Not Operating.
The following safety inspection procedures are performed on appliances that are not operating. These inspections are applicable to all appliance installations.

(1) Preparing for Inspection. Shut off all gas and electrical power to the appliances located in the same room being inspected. For gas supply, use the shutoff valve in the supply line or at the manifold serving each appliance. For electrical power, place the circuit breaker in the off position or remove the fuse that serves each appliance. A lock type device or tag should be installed on each gas shutoff valve and at the electrical panel to indicate that the service has been shut off for inspection purposes.

(2) Vent System Size and Installation. Verify that the existing venting system size and installation are compliant with Chapter 5 of the International Fuel Gas Code. The size and installation of venting systems for other than natural draft and Category I appliances should be in compliance with the manufacturer’s installation instructions. Inspect the venting system to determine that it is free of blockage, restriction, leakage, corrosion, and other deficiencies that could cause an unsafe condition. Inspect masonry chimneys to determine if they are lined. Inspect plastic venting system to determine that it is free of sagging and it is sloped in an upward direction to the outdoor vent termination.

(3) Combustion Air Supply. Inspect provisions for combustion air as follows:

a. Non-Direct Vent Appliances. Determine that non-direct vent appliance installations are compliant with the combustion air requirements in Section G2407 of the International Fuel Gas Code. Inspect any interior and exterior combustion air openings and any connected combustion air ducts to determine that there is no blockage, restriction, corrosion or damage. Inspect to determine that the upper horizontal combustion air duct is not sloped in a downward direction toward the air supply source.

b. Direct Vent Appliances. Verify that the combustion air supply ducts and pipes are securely fastened to direct vent appliance and determine that there are no separations, blockage, restriction, corrosion or other damage. Determine that the combustion air source is located in the outdoors or to areas that freely communicate to the outdoors.

c. Unvented Appliances. Verify that the total input of all unvented room heaters and gas-fired refrigerators installed in the same room or rooms that freely communicate with each other does not exceed 20 Btu/hr/ft$^2$.

(4) Flooded Appliances. Inspect the appliance for signs that the appliance may have been damaged by flooding. Signs of flooding include a visible water submerge line on the appliance housing, excessive surface or component rust, deposited debris on internal components, and mildew-like odor. Inform the owner that any part of the appliance control system and any appliance gas control that has been under water must be replaced. All flood-damaged plumbing, heating, cooling and electrical appliances should be replaced.

(5) Flammable Vapors. Inspect the room/space where the appliance is installed to determine if the area is free of the storage of gasoline or any flammable products such
as oil-based solvents, varnishes or adhesives. Where the appliance is installed where flammable products will be stored or used, such as a garage, verify that the appliance burner(s) is a minimum of 18” above the floor unless the appliance is listed as flammable vapor ignition resistant.

(6) Clearances to Combustibles. Inspect the immediate location where the appliance is installed to determine if the area is free of rags, paper or other combustibles. Verify that the appliance and venting system are compliant with clearances to combustible building components in accordance with Sections G2408.5, G2425.15.4, G2426.5, G2427.6.1, G2427.10.5 and other applicable sections of Section G2427.

(7) Appliance Components. Inspect internal components by removing access panels or other components for the following:

a. Inspect burners and crossovers for blockage and corrosion. The presence of soot, debris, and signs of excessive heating may indicate incomplete combustion due to blockage or improper burner adjustments.

b. Metallic and non-metallic hoses for signs of cracks, splitting, corrosion, and lose connections.

c. Signs of improper or incomplete repairs

de. Modifications that override controls and safety systems

f. Electrical wiring for loose connections; cracks, missing or worn electrical insulation; and indications of excessive heat or electrical shorting. Appliances requiring an external electrical supply should be inspected for proper electrical connection in accordance with the National Electric Code.

(8) Placing Appliances Back in Operation. Return all inspected appliances and systems to their preexisting state by reinstalling any removed access panels and components. Turn on the gas supply and electricity to each appliance found in safe condition. Proceed to the operating inspections in D.5 through D.6.

D.5 Inspections to be performed with the Appliance Operating.
The following safety inspection procedures are to be performed on appliances that are operating where there are no unsafe conditions or where corrective repairs have been completed.

D.5.1 General Appliance Operation.

(1) Initial Startup. Adjust the thermostat or other control device to start the appliance. Verify that the appliance starts up normally and is operating properly.

-Determine that the pilot(s), where provided, is burning properly and that the main burner ignition is satisfactory, by interrupting and re-establishing the electrical supply to the appliance in any convenient manner. If the appliance is equipped with a continuous pilot(s), test all pilot safety devices to determine whether they are operating properly by
extinguishing the pilot(s) when the main burner(s) is off and determining, after 3 minutes, that the main burner gas does not flow upon a call for heat. If the appliance is not provided with a pilot(s), test for proper operation of the ignition system in accordance with the appliance manufacturer’s lighting and operating instructions.

(2) Flame Appearance. Visually inspect the flame appearance for proper color and appearance. Visually determine that the main burner gas is burning properly (i.e., no floating, lifting, or flashback). Adjust the primary air shutter as required. If the appliance is equipped with high and low flame controlling or flame modulation, check for proper main burner operation at low flame.

(3) Appliance Shutdown. Adjust the thermostat or other control device to shut down the appliance. Verify that the appliance shuts off properly.

D.5.2 Test for Combustion Air and Vent Drafting for Natural Draft and Category I Appliances.
Combustion air and vent draft procedures are for natural draft and category I appliances equipped with a draft hood and connected to a natural draft venting system.

(1) Preparing for Inspection. Close all exterior building doors and windows and all interior doors between the space in which the appliance is located and other spaces of the building that can be closed. Turn on any clothes dryer. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers and any fireplace doors.

(2) Placing the Appliance in Operation. Place the appliance being inspected in operation. Adjust the thermostat or control so the appliance will operate continuously.

(3) Spillage Test. Verify that all appliances located within the same room are in their standby mode and ready for operation. Follow lighting instructions for each appliance as necessary. Test for spillage at the draft hood relief opening as follows:

a. After 5 minutes of main burner operation, check for spillage using smoke.

b. Immediately after the first check, turn on all other fuel gas burning appliances within the same room so they will operate at their full inputs and repeat the spillage test.

c. Shut down all appliances to their standby mode and wait for 15 minutes.

d. Repeat the spillage test steps a through c on each appliance being inspected.

(4) Additional Spillage Tests: Determine if the appliance venting is impacted by other door and air handler settings by performing the following tests:

a. Set initial test condition in accordance with D.5.2 (1).

b. Place the appliance(s) being inspected in operation. Adjust the thermostat or control so the appliance(s) will operate continuously.
c. Open the door between the space in which the appliance(s) is located and the rest of the building. After 5 minutes of main burner operation, check for spillage at each appliance using smoke.

d. Turn on any other central heating or cooling air handler fan that is located outside of the area where the appliances are being inspected. After 5 minutes of main burner operation, check for spillage at each appliance using smoke. The test should be conducted with the door between the space in which the appliance(s) is located and the rest of the building in the open and in the closed position.

(5) Return doors, windows, exhaust fans, fireplace dampers, and any other fuel gas burning appliance to their previous conditions of use.

(6) If, after completing the spillage test it is believed sufficient combustion air is not available, the owner should be notified that an alternative combustion air source is needed in accordance with Section G2407 of the International Fuel Gas Code. Where it is believed that the venting system does not provide adequate natural draft, the owner should be notified that alternative vent sizing, design or configuration is needed in accordance with Chapter 24 of the International Fuel Gas Code. If spillage occurs, the owner should be notified as to its cause, be instructed as to which position of the door (open or closed) would lessen its impact, and that corrective action by a HVAC professional should be taken.

D.6 Appliance-Specific Inspections.
The following appliance-specific inspections are to be performed as part of a complete inspection. These inspections are performed either with the appliance in the off or standby mode (indicated by “OFF”) or on an appliance that is operating (indicated by “ON”). The CO measurements are to be undertaken only after the appliance is determined to be properly venting. The CO detector should be capable of calculating CO emissions in ppm air free.

(1) Forced Air Furnaces:

a. OFF. Verify that an air filter is installed and that it is not excessively blocked with dust.

b. OFF. Inspect visible portions of the furnace combustion chamber for cracks, ruptures, holes, and corrosion. A heat exchanger leakage test should be conducted.

c. ON. Verify both the limit control and the fan control are operating properly. Limit control operation can be checked by blocking the circulating air inlet or temporarily disconnecting the electrical supply to the blower motor and determining that the limit control acts to shut off the main burner gas.

d. ON. Verify that the blower compartment door is properly installed and can be properly re-secured if opened. Verify that the blower compartment door safety switch operates properly.

e. ON. Check for flame disturbance before and after blower comes on which can indicate heat exchanger leaks.
f. **ON.** Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table D.6.

**Boilers:**

a. **OFF** and **ON.** Inspect for evidence of water leaks around boiler and connected piping.

b. **ON.** Verify that the water pumps are in operating condition. Test low water cutoffs, automatic feed controls, pressure and temperature limit controls, and relief valves in accordance with the manufacturer's recommendations to determine that they are in operating condition.

c. **ON.** Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table D.6.

**Water Heaters:**

a. **OFF.** Verify that the pressure-temperature relief valve is in operating condition. Water in the heater should be at operating temperature.

b. **OFF.** Verify that inspection covers, glass, and gaskets are intact and in place on a flammable vapor-ignition resistant (FVIR) type water heater.

c. **ON.** Verify that the thermostat is set in accordance with the manufacturer's operating instructions and measure the water temperature at the closest tub or sink to verify that it is no greater than 120°F.

d. **OFF.** Where required by the local building code in earthquake prone locations, inspect that the water heater is secured to the wall studs in two locations (high and low) using appropriate metal strapping and bolts.

e. **ON.** Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table D.6.

**Cooking Appliances**

a. **OFF.** Inspect oven cavity and range-top exhaust vent for blockage with aluminum foil or other materials.

b. **OFF.** Inspect cook top to verify that it is free from a build-up of grease.

c. **ON.** Measure the CO above each burner and at the oven exhaust vents after 5 minutes of burner operation. The CO should not exceed threshold in Table D.6.

**Vented Room Heaters**

a. **OFF.** For built-in room heaters and wall furnaces, inspect that the burner compartment is free of lint and debris.
b. **OFF.** Inspect that furnishings and combustible building components are not blocking the heater.

a. **ON.** Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table D.6.

(6) Vent-Free (unvented) Heaters

a. **OFF.** Verify that the heater input is a maximum of 40,000 Btu input, but not more than 10,000 Btu where installed in a bedroom, and 6,000 Btu where installed in a bathroom.

b. **OFF.** Inspect the ceramic logs provided with gas log type vent free heaters that they are properly located and aligned.

c. **OFF.** Inspect the heater that it is free of excess lint build-up and debris.

e. **OFF.** Verify that the oxygen depletion safety shutoff system has not been altered or bypassed.

d. **ON.** Verify that the main burner shuts down within 3 minutes by extinguishing the pilot light. The test is meant to simulate the operation of the oxygen depletion system (ODS).

e. **ON.** Measure the CO after 5 minutes of main burner operation. The CO should not exceed threshold in Table D.6.

(7) Gas Log Sets and Gas Fireplaces

a. **OFF.** For gas logs installed in wood burning fireplaces equipped with a damper, verify that the fireplace damper is in a fixed open position.

b. **ON.** Measure the CO in the firebox (log sets installed in wood burning fireplaces or in the vent (gas fireplace) after 5 minutes of main burner operation. The CO should not exceed threshold in Table D.6.

(8) Gas Clothes Dryer

a. **OFF.** Where installed in a closet, verify that a source of make-up air is provided and inspect that any make-up air openings, louvers, and ducts are free of blockage.

b. **OFF.** Inspect for excess amounts of lint around the dryer and on dryer components. Inspect that there is a lint trap properly installed and it does not have holes or tears. Verify that it is in a clean condition.

c. **OFF.** Inspect visible portions of the exhaust duct and connections for loose fittings and connections, blockage, and signs of corrosion. Verify that the duct termination is not blocked and that it terminates in an outdoor location. Verify that only approved
metal vent ducting material is installed (plastic and vinyl materials are not approved for gas dryers).

d. ON. Verify mechanical components including drum and blower are operating properly.

e. ON. Operate the clothes dryer and verify that exhaust system is intact and exhaust is exiting the termination.

f. ON. Measure the CO at the exhaust duct or termination after 5 minutes of main burner operation. The CO should not exceed threshold in Table D.6.

### TABLE D.6
**CO THRESHOLDS**

<table>
<thead>
<tr>
<th>Category</th>
<th>CO Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Furnace (all categories)</td>
<td>400 ppm air free</td>
</tr>
<tr>
<td>Floor Furnace</td>
<td>400 ppm air free</td>
</tr>
<tr>
<td>Gravity Furnace</td>
<td>400 ppm air free</td>
</tr>
<tr>
<td>Wall Furnace (BIV)</td>
<td>200 ppm air free</td>
</tr>
<tr>
<td>Wall Furnace (Direct Vent)</td>
<td>400 ppm air free</td>
</tr>
<tr>
<td>Vented Room Heater</td>
<td>200 ppm air free</td>
</tr>
<tr>
<td>Vent-Free Room Heater</td>
<td>200 ppm air free</td>
</tr>
<tr>
<td>Water Heater</td>
<td>200 ppm air free</td>
</tr>
<tr>
<td>Oven/Boiler</td>
<td>225 ppm as measured</td>
</tr>
<tr>
<td>Top Burner</td>
<td>25 ppm as measured (per burner)</td>
</tr>
<tr>
<td>Clothes Dryer</td>
<td>400 ppm air free</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>25 ppm as measured</td>
</tr>
<tr>
<td>Gas Log (gas fireplace)</td>
<td>25 ppm as measured in vent</td>
</tr>
<tr>
<td>Gas Log (installed in wood burning fireplace)</td>
<td>400 ppm air free in firebox</td>
</tr>
</tbody>
</table>

1. Parts per million

2. Air free emission levels are based on a mathematical equation (involving carbon monoxide and oxygen or carbon dioxide readings) to convert an actual diluted flue gas carbon monoxide testing sample to an undiluted air free flue gas carbon monoxide level utilized in the appliance certification standards. For natural gas or propane, using as-measured CO ppm and O2 percentage:

   \[
   CO_{AFppm} = \left( \frac{20.9}{20.9 - O_2} \right) \times CO_{ppm}
   \]

   Where:
   
   \[
   \begin{align*}
   CO_{AFppm} & = \text{Carbon monoxide, air-free ppm} \\
   CO_{ppm} & = \text{As-measured combustion gas carbon monoxide ppm} \\
   O_2 & = \text{Percentage of oxygen in combustion gas, as a percentage}
   \end{align*}
   \]

3. An alternate method of calculating the CO air free when access to an oxygen meter is not available:
Where:

$UOCO_2$  =  Ultimate concentration of carbon dioxide for the fuel being burned in percent for natural gas (12.2 percent) and propane (14.0 percent)

$CO_2$  =  Measured concentration of carbon dioxide in combustion products in percent

$CO$  =  Measured concentration of carbon monoxide in combustion products in percent

$$CO_{AFppn} = \left(\frac{UOCO_2}{CO_2}\right) \times CO$$
APPENDIX E

(E-1 THROUGH E-4)

MANUFACTURED HOUSING USED AS DWELLINGS

RESIDENTIAL REQUIREMENTS FOR ENERGY CONSERVATION

This appendix is a North Carolina addition and not part of the 2015 International Residential Code. There will be no underlined text.

(The provisions contained in this appendix are adopted as part of this code.)

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AE101

SCOPE

AE101.1 General.
These provisions shall be applicable only to a manufactured home used as a single dwelling unit installed on privately owned (nonrental) lots and shall apply to the following:

1. Construction, alteration and repair of any foundation system that is necessary to provide for the installation of a manufactured home unit.

2. Construction, installation, addition, alteration, repair or maintenance of the building service equipment that is necessary for connecting manufactured homes to water, fuel, or power supplies and sewage systems.

3. Alterations, additions or repairs to existing manufactured homes. The construction, alteration, moving, demolition, repair and use of accessory buildings and structures, and their building service equipment, shall comply with the requirements of the codes adopted by this jurisdiction.

These provisions shall not be applicable to the design and construction of manufactured homes and shall not be deemed to authorize either modifications or additions to manufactured homes where otherwise prohibited.

Exception: In addition to these provisions, new and replacement manufactured homes to be located in flood hazard areas as established in Table R301.2(1) of the International Residential Code shall meet the applicable requirements of Section R322 of the International Residential Code.
SECTION AE102
APPLICATION TO EXISTING MANUFACTURED HOMES AND BUILDING SERVICE EQUIPMENT

AE102.1 General.
Manufactured homes and their building service equipment to which additions, alterations or repairs are made shall comply with all the requirements of these provisions for new facilities, except as specifically provided in this section.

AE102.2 Additions, alterations or repairs.
Additions made to a manufactured home shall conform to one of the following:


2. Be designed and constructed to comply with the applicable provisions of the National Manufactured Housing Construction and Safety Standards Act of 1974 (42 U.S.C. Section 5401, et seq.).

3. Be designed and constructed in compliance with the code adopted by this jurisdiction.

Additions shall be structurally separated from the manufactured home.

Exception: A structural separation need not be provided when structural calculations are provided to justify the omission of such separation.

Alterations or repairs may be made to any manufactured home or to its building service equipment without requiring the existing manufactured home or its building service equipment to comply with all the requirements of these provisions, provided the alteration or repair conforms to that required for new construction, and provided further that no hazard to life, health or safety will be created by such additions, alterations or repairs.

Alterations or repairs to an existing manufactured home, which are nonstructural and do not adversely affect any structural member or any part of the building or structure having required fire protection, may be made with materials equivalent to those of which the manufactured home structure is constructed, subject to approval by the building official.

Exception: The installation or replacement of glass shall be required for new installations.

Minor additions, alterations and repairs to existing building service equipment installations may be made in accordance with the codes in effect at the time the original installation was made, subject to the approval of the building official, and provided such additions, alterations and repairs will not cause the existing building service equipment to become unsafe, insanitary or overloaded.

AE102.3 Existing installations.
Building service equipment lawfully in existence at the time of the adoption of the applicable codes may have their use, maintenance or repair continued if the use, maintenance or repair is
in accordance with the original design and no hazard to life, health or property has been created by such building service equipment.

AE102.4 Existing occupancy. Manufactured homes that are in existence at the time of the adoption of these provisions may have their existing use or occupancy continued if such use or occupancy was legal at the time of the adoption of these provisions, provided such continued use is not dangerous to life, health and safety.

The use or occupancy of any existing manufactured home shall not be changed unless evidence satisfactory to the building official is provided to show compliance with all applicable provisions of the codes adopted by this jurisdiction. Upon any change in use or occupancy, the manufactured home shall cease to be classified as such within the intent of these provisions.

AE102.5 Maintenance. All manufactured homes and their building service equipment, existing and new, and all parts thereof, shall be maintained in a safe and sanitary condition. All devices or safeguards which are required by applicable codes or by the Manufactured Home Standards shall be maintained in conformance to the code or standard under which it was installed. The owner or the owner's designated agent shall be responsible for the maintenance of manufactured homes, accessory buildings, structures and their building service equipment. To determine compliance with this section, the building official may cause any manufactured home, accessory building or structure to be reinspected.

AE102.6 Relocation. Manufactured homes which are to be relocated within this jurisdiction shall comply with these provisions.

SECTION AE201
DEFINITIONS

AE201.1 General. For the purpose of these provisions, certain abbreviations, terms, phrases, words and their derivatives shall be construed as defined or specified herein.

ACCESSORY BUILDING. Any building or structure or portion thereto, located on the same property as a manufactured home, which does not qualify as a manufactured home as defined herein.

BUILDING SERVICE EQUIPMENT. Refers to the plumbing, mechanical and electrical equipment, including piping, wiring, fixtures and other accessories which provide sanitation, lighting, heating, ventilation, cooling, fire protection and facilities essential for the habitable occupancy of a manufactured home or accessory building or structure for its designated use and occupancy.

MANUFACTURED HOME. A structure transportable in one or more sections which, in the traveling mode, is 8 body feet (2438 body mm) or more in width or 40 body feet (12 192 body mm) or more in length or, when erected on site, is 320 or more square feet (30 m²), and which is built on a permanent chassis and designed to be used as a dwelling with or without a permanent foundation when connected to the required utilities, and includes the plumbing,
heating, air-conditioning and electrical systems contained therein; except that such term shall include any structure which meets all the requirements of this paragraph, except the size requirements and with respect to which the manufacturer voluntarily files a certification required by the Secretary of the U.S. Department of Housing and Urban Development (HUD) and complies with the standards established under this title.

For mobile homes built prior to June 15, 1976, a label certifying compliance with the Standard for Mobile Homes, NFPA 501, ANSI 119.1, in effect at the time of manufacture, is required. For the purpose of these provisions, a mobile home shall be considered a manufactured home.

MANUFACTURED HOME INSTALLATION. Construction which is required for the installation of a manufactured home, including the construction of the foundation system, required structural connections thereto and the installation of on-site water, gas, electrical and sewer systems and connections thereto which are necessary for the normal operation of the manufactured home.

MANUFACTURED HOME STANDARDS. The Manufactured Home Construction and Safety Standards as promulgated by the HUD.

PRIVATELY OWNED (NONRENTAL) LOT. A parcel of real estate outside of a manufactured home rental community (park) where the land and the manufactured home to be installed thereon are held in common ownership.

SECTION AE301
PERMITS

AE301.1 Initial installation.
A manufactured home shall not be installed on a foundation system, reinstalled or altered without first obtaining a permit from the building official. A separate permit shall be required for each manufactured home installation. When approved by the building official, such permit may include accessory buildings and structures, and their building service equipment, when the accessory buildings or structures will be constructed in conjunction with the manufactured home installation.

AE301.2 Additions, alterations and repairs to a manufactured home.
A permit shall be obtained to alter, remodel, repair or add accessory buildings or structures to a manufactured home subsequent to its initial installation. Permit issuance and fees therefor shall be in conformance to the codes applicable to the type of work involved.

An addition made to a manufactured home, as defined in these provisions, shall comply with these provisions.

AE301.3 Accessory buildings.
Except as provided in Section AE301.1, permits shall be required for all accessory buildings and structures, and their building service equipment. Permit issuance and fees therefor shall be in conformance to the codes applicable to the types of work involved.

AE301.4 Exempted work.
A permit shall not be required for the types of work specifically exempted by the applicable codes. Exemption from the permit requirements of any of said codes shall not be deemed to
grant authorization for any work to be done in violation of the provisions of said codes or any other laws or ordinances of this jurisdiction.

SECTION AE302
APPLICATION FOR PERMIT

AE302.1 Application.
To obtain a manufactured home installation permit, the applicant shall first file an application, in writing, on a form furnished by the building official for that purpose. At the option of the building official, every such application shall:

1. Identify and describe the work to be covered by the permit for which application is made.

2. Describe the land on which the proposed work is to be done by legal description, street address or similar description that will readily identify and definitely locate the proposed building or work.

3. Indicate the use or occupancy for which the proposed work is intended.

4. Be accompanied by plans, diagrams, computations and specifications, and other data as required in Section AE302.2.

5. Be accompanied by a soil investigation when required by Section AE502.2.

6. State the valuation of any new building or structure; or any addition, remodeling or alteration to an existing building.

7. Be signed by the permittee, or permittee's authorized agent, who may be required to submit evidence to indicate such authority.

8. Give such other data and information as may be required by the building official.

AE302.2 Plans and specifications.
Plans, engineering calculations, diagrams and other data as required by the building official shall be submitted in not less than two sets with each application for a permit. The building official may require plans, computations and specifications to be prepared and designed by an engineer or architect licensed by the state to practice as such.

Where no unusual site conditions exist, the building official may accept approved standard foundation plans and details in conjunction with the manufacturer's approved installation instructions without requiring the submittal of engineering calculations.

AE302.3 Information on plans and specifications.
Plans and specifications shall be drawn to scale on substantial paper or cloth, and shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and shown in detail that it will conform to these provisions and all relevant laws, ordinances, rules and regulations. The building official shall determine what information is required on plans and specifications to ensure compliance.
SECTION AE303
PERMITS ISSUANCE

AE303.1 Issuance.
The application, plans and specifications, and other data filed by an applicant for permit shall be reviewed by the building official. Such plans may be reviewed by other departments of this jurisdiction to verify compliance with any applicable laws under their jurisdiction. If the building official finds that the work described in an application for a permit, and the plans, specifications and other data filed therewith, conform to the requirements of these provisions, and other data filed therewith conform to the requirements of these provisions and other pertinent codes, laws and ordinances, and that the fees specified in Section AE304 have been paid, the building official shall issue a permit therefor to the applicant.

When the building official issues the permit where plans are required, the building official shall endorse in writing or stamp the plans and specifications APPROVED. Such approved plans and specifications shall not be changed, modified or altered without authorization from the building official, and all work shall be done in accordance with the approved plans.

AE303.2 Retention of plans.
One set of approved plans and specifications shall be returned to the applicant and shall be kept on the site of the building or work at all times during which the work authorized thereby is in progress. One set of approved plans, specifications and computations shall be retained by the building official until final approval of the work.

AE303.3 Validity of permit.
The issuance of a permit or approval of plans and specifications shall not be construed to be a permit for, or an approval of, any violation of any of these provisions or other pertinent codes of any other ordinance of the jurisdiction. No permit presuming to give authority to violate or cancel these provisions shall be valid.

The issuance of a permit based on plans, specifications and other data shall not prevent the building official from thereafter requiring the correction of errors in said plans, specifications and other data, or from preventing building operations being carried on thereunder when in violation of these provisions or of any other ordinances of this jurisdiction.

AE303.4 Expiration.
Every permit issued by the building official under these provisions shall expire by limitation and become null and void if the work authorized by such permit is not commenced within 180 days from the date of such permit, or if the work authorized by such permit is suspended or abandoned at any time after the work is commenced for a period of 180 days. Before such work can be recommenced, a new permit shall be first obtained, and the fee therefor shall be one-half the amount required for a new permit for such work, provided no changes have been made or will be made in the original plans and specifications for such work, and provided further that such suspension or abandonment has not exceeded 1 year. In order to renew action on a permit after expiration, the permittee shall pay a new full permit fee.

Any permittee holding an unexpired permit may apply for an extension of the time within which work may commence under that permit when the permittee is unable to commence work within the time required by this section for good and satisfactory reasons. The building official may extend the time for action by the permittee for a period not exceeding 180 days upon
written request by the permittee showing that circumstances beyond the control of the permittee have prevented action from being taken. No permit shall be extended more than once.

**AE303.5 Suspension or revocation.**
The building official may, in writing, suspend or revoke a permit issued under these provisions whenever the permit is issued in error or on the basis of incorrect information supplied, or in violation of any ordinance or regulation or any of these provisions.

**SECTION AE304 FEES**

**AE304.1 Permit fees.**
The fee for each manufactured home installation permit shall be established by the building official.

When permit fees are to be based on the value or valuation of the work to be performed, the determination of value or valuation under these provisions shall be made by the building official. The value to be used shall be the total value of all work required for the manufactured home installation plus the total value of all work required for the construction of accessory buildings and structures for which the permit is issued, as well as all finish work, painting, roofing, electrical, plumbing, heating, air conditioning, elevators, fire-extinguishing systems and any other permanent equipment which is a part of the accessory building or structure. The value of the manufactured home itself shall not be included.

**AE304.2 Plan review fees.**
When a plan or other data are required to be submitted by Section AE302.2, a plan review fee shall be paid at the time of submitting plans and specifications for review. Said plan review fee shall be as established by the building official. Where plans are incomplete or changed so as to require additional plan review, an additional plan review fee shall be charged at a rate as established by the building official.

**AE304.3 Other provisions.**

**AE304.3.1 Expiration of plan review.**
Applications for which no permit is issued within 180 days following the date of application shall expire by limitation, and plans and other data submitted for review may thereafter be returned to the applicant or destroyed by the building official. The building official may extend the time for action by the applicant for a period not exceeding 180 days upon request by the applicant showing that circumstances beyond the control of the applicant have prevented action from being taken. No application shall be extended more than once. In order to renew action on an application after expiration, the applicant shall resubmit plans and pay a new plan review fee.

**AE304.3.2 Investigation fees—work without a permit.**

**AE304.3.2.1 Investigation.**
Whenever any work for which a permit is required by these provisions has been commenced without first obtaining said permit, a special investigation shall be made before a permit may be issued for such work.
AE304.3.2.2 Fee.
An investigation fee, in addition to the permit fee, shall be collected whether or not a permit is then or subsequently issued. The investigation fee shall be equal to the amount of the permit fee required. The minimum investigation fee shall be the same as the minimum fee established by the building official. The payment of such investigation fee shall not exempt any person from compliance with all other provisions of either these provisions or other pertinent codes or from any penalty prescribed by law.

AE304.3.3 Fee refunds.

AE304.3.3.1 Permit fee erroneously paid or collected.
The building official may authorize the refunding of any fee paid hereunder which was erroneously paid or collected.

AE304.3.3.2 Permit fee paid when no work done.
The building official may authorize the refunding of not more than 80 percent of the permit fee paid when no work has been done under a permit issued in accordance with these provisions.

AE304.3.3.3 Plan review fee.
The building official may authorize the refunding of not more than 80 percent of the plan review fee paid when an application for a permit for which a plan review fee has been paid is withdrawn or canceled before any plan reviewing is done.

The building official shall not authorize the refunding of any fee paid, except upon written application by the original permittee not later than 180 days after the date of the fee payment.

SECTION AE305
INSPECTIONS

AE305.1 General.
All construction or work for which a manufactured home installation permit is required shall be subject to inspection by the building official, and certain types of construction shall have continuous inspection by special inspectors as specified in Section AE306. A survey of the lot may be required by the building official to verify that the structure is located in accordance with the approved plans.

It shall be the duty of the permit applicant to cause the work to be accessible and exposed for inspection purposes. Neither the building official nor this jurisdiction shall be liable for expense entailed in the removal or replacement of any material required to allow inspection.

AE305.2 Inspection requests.
It shall be the duty of the person doing the work authorized by a manufactured home installation permit to notify the building official that such work is ready for inspection. The building official may require that every request for inspection be filed at least one working day before such inspection is desired. Such request may be in writing or by telephone at the option of the building official.
It shall be the duty of the person requesting any inspections required, either by these provisions or other applicable codes, to provide access to and means for proper inspection of such work.

**AE305.3 Inspection record card.**
Work requiring a manufactured home installation permit shall not be commenced until the permit holder or the permit holder’s agent shall have posted an inspection record card in a conspicuous place on the premises and in such position as to allow the building official conveniently to make the required entries thereon regarding inspection of the work. This card shall be maintained in such position by the permit holder until final approval has been issued by the building official.

**AE305.4 Approval required.**
Work shall not be done on any part of the manufactured home installation beyond the point indicated in each successive inspection without first obtaining the approval of the building official. Such approval shall be given only after an inspection has been made of each successive step in the construction as indicated by each of the inspections required in Section AE305.5. There shall be a final inspection and approval of the manufactured home installation, including connections to its building service equipment, when completed and ready for occupancy or use.

**AE305.5 Required inspections.**

**AE305.5.1 Structural inspections for the manufactured home installation.**
Reinforcing steel or structural framework of any part of any manufactured home foundation system shall not be covered or concealed without first obtaining the approval of the building official. The building official, upon notification from the permit holder or the permit holder’s agent, shall make the following inspections and shall either approve that portion of the construction as completed or shall notify the permit holder or the permit holder’s agent wherein the same fails to comply with these provisions or other applicable codes:

1. Foundation inspection: To be made after excavations for footings are completed and any required reinforcing steel is in place. For concrete foundations, any required forms shall be in place prior to inspection. All materials for the foundation shall be on the job, except where concrete from a central mixing plant (commonly termed “transit mixed”) is to be used, the concrete materials need not be on the job. Where the foundation is to be constructed of approved treated wood, additional framing inspections as required by the building official may be required.

2. Concrete slab or under-floor inspection: To be made after all in-slab or under-floor building service equipment, conduit, piping accessories and other ancillary equipment items are in place but before any concrete is poured or the manufactured home is installed.

3. Anchorage inspection: To be made after the manufactured home has been installed and permanently anchored.

**AE305.5.2 Structural inspections for accessory building and structures.**
Inspections for accessory buildings and structures shall be made as set forth in this code.
AE305.5.3 Building service equipment inspections.
All building service equipment which is required as a part of a manufactured home installation, including accessory buildings and structures authorized by the same permit, shall be inspected by the building official. Building service equipment shall be inspected and tested as required by the applicable codes. Such inspections and testing shall be limited to site construction and shall not include building service equipment which is a part of the manufactured home itself. No portion of any building service equipment intended to be concealed by any permanent portion of the construction shall be concealed until inspected and approved. Building service equipment shall not be connected to a water, fuel or power supply, or sewer system, until authorized by the building official.

AE305.5.4 Final inspection.
When finish grading and the manufactured home installation, including the installation of all required building service equipment, is completed and the manufactured home is ready for occupancy, a final inspection shall be made.

AE305.6 Other inspections.
In addition to the called inspections specified in Section AE305.5.4, the building official may make or require other inspections of any construction work to ascertain compliance with these provisions or other codes and laws which are enforced by the code enforcement agency.

SECTION AE306
SPECIAL INSPECTIONS

AE306.1 General.
In addition to the inspections required by Section AE305, the building official may require the owner to employ a special inspector during construction of specific types of work as described in this code.

SECTION AE307
UTILITY SERVICE

AE307.1 General.
Utility service shall not be provided to any building service equipment which is regulated by these provisions or other applicable codes, and for which a manufactured home installation permit is required by these provisions, until approved by the building official.

SECTION AE401
OCCUPANCY CLASSIFICATION

AE401.1 Manufactured homes.
A manufactured home shall be limited in use to a single dwelling unit.

AE401.2 Accessory buildings.
Accessory buildings shall be classified as to occupancy by the building official as set forth in this code.
AE402.1 General.
Manufactured homes and accessory buildings shall be located on the property in accordance with applicable codes and ordinances of this jurisdiction.

SECTION AE501
DESIGN

AE501.1 General.
A manufactured home shall be installed on a foundation system which is designed and constructed to sustain within the stress limitations specified in this code and all loads specified in this code.

Exception: When specifically authorized by the building official, foundation and anchorage systems which are constructed in accordance with the methods specified in Section AE600 of these provisions, or in the HUD, Permanent Foundations for Manufactured Housing, 1984 Edition, Draft, shall be deemed to meet the requirements of this appendix.

AE501.2 Manufacturer’s installation instructions.
The installation instructions as provided by the manufacturer of the manufactured home shall be used to determine permissible points of support for vertical loads and points of attachment for anchorage systems used to resist horizontal and uplift forces.

AE501.3 Rationality.
Any system or method of construction to be used shall submit to a rational analysis in accordance with well-established principles of mechanics.

SECTION AE502
FOUNDATION SYSTEMS

AE502.1 General.
Foundation systems designed and constructed in accordance with this section may be considered a permanent installation.

AE502.2 Soil classification.
The classification of the soil at each manufactured home site shall be determined when required by the building official. The building official may require that the determination be made by an engineer or architect licensed by the state to conduct soil investigations.

The classification shall be based on observation and any necessary tests of the materials disclosed by borings or excavations made in appropriate locations. Additional studies may be necessary to evaluate soil strength, the effect of moisture variation on soil-bearing capacity, compressibility and expansiveness.

When required by the building official, the soil classification design bearing capacity and lateral pressure shall be shown on the plans.
AE502.3 Footings and foundations.
Footings and foundations, unless otherwise specifically provided, shall be constructed of materials specified by this code for the intended use and in all cases shall extend below the frost line. Footings of concrete and masonry shall be of solid material. Foundations supporting untreated wood shall extend at least 8 inches (203 mm) above the adjacent finish grade. Footings shall have a minimum depth below finished grade of 12 inches (305 mm) unless a greater depth is recommended by a foundation investigation.

Piers and bearing walls shall be supported on masonry or concrete foundations or piles, or other approved foundation systems which shall be of sufficient capacity to support all loads.

AE502.4 Foundation design.
When a design is provided, the foundation system shall be designed in accordance with the applicable structural provisions of this code and shall be designed to minimize differential settlement. Where a design is not provided, the minimum foundation requirements shall be as set forth in this code.

AE502.5 Drainage.
Provisions shall be made for the control and drainage of surface water away from the manufactured home.

AE502.6 Under-floor clearances—ventilation and access.
A minimum clearance of 12 inches (305 mm) shall be maintained beneath the lowest member of the floor support framing system. Clearances from the bottom of wood floor joists or perimeter joists shall be as specified in this code.

Under-floor spaces shall be ventilated with openings as specified in this code. If combustion air for one or more heat-producing appliance is taken from within the under-floor spaces, ventilation shall be adequate for proper appliance operation.

Under-floor access openings shall be provided. Such openings shall be not less than 18 inches (457 mm) in any dimension and not less than 3 square feet (0.279 m²) in area, and shall be located so that any water supply and sewer drain connections located under the manufactured home are accessible.

SECTION AE503
SKIRTING AND PERIMETER ENCLOSURES

AE503.1 Skirting and permanent perimeter enclosures.
Skirting and permanent perimeter enclosures shall be installed only where specifically required by other laws or ordinances. Skirting, when installed, shall be of material suitable for exterior exposure and contact with the ground. Permanent perimeter enclosures shall be constructed of materials as required by this code for regular foundation construction.

Skirting shall be installed in accordance with the skirting manufacturer’s installation instructions. Skirting shall be adequately secured to ensure stability, minimize vibration and susceptibility to wind damage, and compensate for possible frost heave.
AE503.2 Retaining walls.
Where retaining walls are used as a permanent perimeter enclosure, they shall resist the lateral displacements of soil or other materials and shall conform to this code as specified for foundation walls. Retaining walls and foundation walls shall be constructed of approved treated wood, concrete, masonry or other approved materials or combination of materials as for foundations as specified in this code. Siding materials shall extend below the top of the exterior of the retaining or foundation wall, or the joint between the siding and enclosure wall shall be flashed in accordance with this code.

SECTION AE504
STRUCTURAL ADDITIONS

AE504.1 General.
Accessory buildings shall not be structurally supported by or attached to a manufactured home unless engineering calculations are submitted to substantiate any proposed structural connection.

Exception: The building official may waive the submission of engineering calculations if it is found that the nature of the work applied for is such that engineering calculations are not necessary to show conformance to these provisions.

SECTION AE505
BUILDING SERVICE EQUIPMENT

AE505.1 General.
The installation, alteration, repair, replacement, addition to or maintenance of the building service equipment within the manufactured home shall conform to regulations set forth in the Manufactured Home Standards. Such work which is located outside the manufactured home shall comply with the applicable codes adopted by this jurisdiction.

SECTION AE506
EXITS

AE506.1 Site development.
Exterior stairways and ramps which provide egress to the public way shall comply with the applicable provisions of this code.

AE506.2 Accessory buildings.
Every accessory building or portion thereof shall be provided with exits as required by this code.

SECTION AE507
OCCUPANCY, FIRE SAFETY AND ENERGY CONSERVATION STANDARDS

AE507.1 General.
Alterations made to a manufactured home subsequent to its initial installation shall conform to the occupancy, fire safety and energy conservation requirements set forth in the Manufactured Home Standards.
SECTION AE600
SPECIAL REQUIREMENTS FOR FOUNDATION SYSTEMS

AE600.1 General.
This section is applicable only where specifically authorized by the building official.

SECTION AE601
FOOTINGS AND FOUNDATIONS

AE601.1 General.
The capacity of individual load-bearing piers and their footings shall be sufficient to sustain all loads specified in this code within the stress limitations specified in this code. Footings, unless otherwise approved by the building official, shall be placed level on firm, undisturbed soil or an engineered fill which is free of organic material, such as weeds and grasses. Where used, an engineered fill shall provide a minimum load-bearing capacity of not less than 1,000 pounds per square foot (48 kN/m²). Continuous footings shall conform to the requirements of this code. Section AE502 of these provisions shall apply to footings and foundations constructed under the provisions of this section.

SECTION AE602
PIER CONSTRUCTION

AE602.1 General.
Piers shall be designed and constructed to distribute loads evenly. Multiple-section homes may have concentrated roof loads which will require special consideration. Load-bearing piers may be constructed utilizing one of the following methods listed. Such piers shall be considered to resist only vertical forces acting in a downward direction. They shall not be considered as providing any resistance to horizontal loads induced by wind or earthquake forces.

1. A prefabricated load-bearing device that is listed and labeled for the intended use.

2. Mortar shall comply with ASTM C 270, Type M, S or N; this may consist of one part Portland cement, one-half part hydrated lime and four parts sand by volume. Lime shall not be used with plastic or waterproof cement.

3. A cast-in-place concrete pier with concrete having specified compressive strength at 28 days of 2,500 pounds per square inch (17,225 kPa).

Alternative materials and methods of construction may be used for piers which have been designed by an engineer or architect licensed by the state to practice as such.

Caps and leveling spacers may be used for leveling of the manufactured home. Spacing of piers shall be as specified in the manufacturer’s installation instructions, if available, or by an approved designer.

SECTION AE603
HEIGHT OF PIERS

2018 North Carolina Residential Code
AE603.1 General.

Piers constructed as indicated in Section AE602 may have heights as follows:

1. Except for corner piers, piers 36 inches (914 mm) or less in height may be constructed of masonry units, placed with cores or cells vertically. Piers shall be installed with their long dimension at right angles to the main frame member they support and shall have a minimum cross-sectional area of 128 square inches (82560 mm$^2$). Piers shall be capped with minimum 4-inch (102 mm) solid masonry units or equivalent.

2. Piers between 36 and 80 inches (914 and 2032 mm) in height and all corner piers greater than 24 inches (610 mm) in height shall be at least 16 inches by 16 inches (406 mm by 406 mm) consisting of interlocking masonry units and shall be fully capped with minimum 4-inch (102 mm) solid masonry units or equivalent.

3. Piers greater than 80 inches (2032 mm) in height may be constructed in accordance with the provisions of Item 2, provided the piers shall be filled solid with grout and reinforced with four continuous No. 5 bars. One bar shall be placed in each corner cell of hollow masonry unit piers or in each corner of the grouted space of piers constructed of solid masonry units.

4. Cast-in-place concrete piers meeting the same size and height limitations of Items 1, 2 and 3 may be substituted for piers constructed of masonry units.

SECTION AE604
ANCHORAGE INSTALLATIONS

AE604.1 Ground anchors.

Ground anchors shall be designed and installed to transfer the anchoring loads to the ground. The load-carrying portion of the ground anchors shall be installed to the full depth called for by the manufacturer’s installation instructions and shall extend below the established frost line into undisturbed soil.

Manufactured ground anchors shall be listed and installed in accordance with the terms of their listing and the anchor manufacturer’s instructions, and shall include the means of attachment of ties meeting the requirements of Section AE605. Ground anchor manufacturer’s installation instructions shall include the amount of preload required and load capacity in various types of soil. These instructions shall include tensioning adjustments which may be needed to prevent damage to the manufactured home, particularly damage that can be caused by frost heave. Each ground anchor shall be marked with the manufacturer’s identification and listed model identification number which shall be visible after installation. Instructions shall accompany each listed ground anchor specifying the types of soil for which the anchor is suitable under the requirements of this section.

Each approved ground anchor, when installed, shall be capable of resisting an allowable working load at least equal to 3,150 pounds (14 kN) in the direction of the tie plus a 50-percent overload (4,725 pounds (21 kN) total) without failure. Failure shall be considered to have occurred when the anchor moves more than 2 inches (51 mm) at a load of 4,725 pounds (21 kN) in the direction of the tie installation. Those ground anchors which are designed to be
installed so that loads on the anchor are other than direct withdrawal shall be designed and installed to resist an applied design load of 3,150 pounds (14 kN) at 40 to 50 degrees from vertical or within the angle limitations specified by the home manufacturer without displacing the tie end of the anchor more than 4 inches (102 mm) horizontally. Anchors designed for the connection of multiple ties shall be capable of resisting the combined working load and overload consistent with the intent expressed herein.

When it is proposed to use ground anchors and the building official has reason to believe that the soil characteristics at a given site are such as to render the use of ground anchors advisable, or when there is doubt regarding the ability of the ground anchors to obtain their listed capacity, the building official may require that a representative field installation be made at the site in question and tested to demonstrate ground-anchor capacity. The building official shall approve the test procedures.

AE604.2 Anchoring equipment.
Anchoring equipment, when installed as a permanent installation, shall be capable of resisting all loads as specified within these provisions. When the stabilizing system is designed by an engineer or architect licensed by the state to practice as such, alternative designs may be used, providing the anchoring equipment to be used is capable of withstanding a load equal to 1.5 times the calculated load. All anchoring equipment shall be listed and labeled as being capable of meeting the requirements of these provisions. Anchors as specified in this code may be attached to the main frame of the manufactured home by an approved 3/16-inch-thick (4.76 mm) slotted steel plate anchoring device. Other anchoring devices or methods meeting the requirements of these provisions may be permitted when approved by the building official.

Anchoring systems shall be so installed as to be permanent. Anchoring equipment shall be so designed to prevent self-disconnection with no hook ends used.

AE604.3 Resistance to weather deterioration.
All anchoring equipment, tension devices and ties shall have a resistance to deterioration as required by this code.

AE604.4 Tensioning devices.
Tensioning devices, such as turnbuckles or yoke-type fasteners, shall be ended with clevis or welded-eyes.

SECTION AE605
TIES, MATERIALS AND INSTALLATION

AE605.1 General.
Steel strapping, cable, chain or other approved materials shall be used for ties. All ties shall be fastened to ground anchors and drawn tight with turnbuckles or other adjustable tensioning devices or devices supplied with the ground anchor. Tie materials shall be capable of resisting an allowable working load of 3,150 pounds (14 kN) with no more than 2-percent elongation and shall withstand a 50-percent overload (4,750 pounds (21 kN)). Ties shall comply with the weathering requirements of Section AE604.3. Ties shall connect the ground anchor and the main structural frame. Ties shall not connect to steel outrigger beams which fasten to and intersect the main structural frame unless specifically stated in the manufacturer’s installation.
instructions. Connection of cable ties to main frame members shall be 5/8-inch (15.9 mm) closed-eye bolts affixed to the frame member in an approved manner. Cable ends shall be secured with at least two U-bolt cable clamps with the “U” portion of the clamp installed on the short (dead) end of the cable to ensure strength equal to that required by this section.

Wood floor support systems shall be fixed to perimeter foundation walls in accordance with provisions of this code. The minimum number of ties required per side shall be sufficient to resist the wind load stated in this code. Ties shall be as evenly spaced as practicable along the length of the manufactured home with the distance from each end of the home and the tie nearest that end not exceeding 8 feet (2438 mm). When continuous straps are provided as vertical ties, such ties shall be positioned at rafters and studs. Where a vertical tie and diagonal tie are located at the same place, both ties may be connected to a single anchor, provided the anchor used is capable of carrying both loads. Multiple-section manufactured homes require diagonal ties only. Diagonal ties shall be installed on the exterior main frame and slope to the exterior at an angle of 40 to 50 degrees from the vertical or within the angle limitations specified by the home manufacturer. Vertical ties which are not continuous over the top of the manufactured home shall be attached to the main frame.

SECTION AE606
REFERENCED STANDARDS
ASTM C 270—04 Specification for Mortar for Unit Masonry AE602
NFPA 501—03 Standard on Manufactured Housing AE201

APPENDIX E-1 Energy Efficiency Certificate (Section N1101.14)

ENERGY EFFICIENCY CERTIFICATE
N1101.14

Builder, Permit Holder or Registered Design Professional
Print Name:
Signature:

Property Address:

Date:

<table>
<thead>
<tr>
<th>Insulation Rating - List the value covering largest area to all that apply</th>
<th>R-Value</th>
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<td>R-</td>
</tr>
<tr>
<td>Closed Crawl Space Wall:</td>
<td>R-</td>
</tr>
<tr>
<td>Closed Crawl Space Floor:</td>
<td>R-</td>
</tr>
<tr>
<td>Slab:</td>
<td>R-</td>
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<td>Basement Wall:</td>
<td>R-</td>
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<tr>
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<tr>
<td>Building Air Leakage</td>
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</table>
Visually inspected according to N1102.4.2.1 OR
Building Air Leakage Test Results (Sec. N1102.4.2.2)
ACH50 [Target: 5.0]
or CFM50/SFSA [Target: 0.30]

Name of Tester / Company:
Date: Phone:

Ducts:

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<tr>
<td>Total duct leakage test (CFM25 Total/100SF) [Target: 5]</td>
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<tr>
<td>Or</td>
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<td>Duct leakage to the outside test (CFM25 Total/100SF) [Target: 4]</td>
<td></td>
</tr>
</tbody>
</table>

Name of Tester or Company:
Date: Phone:

Certificate to be displayed permanently
APPENDIX E-2
INSULATION AND AIR SEALING DETAILS

APPENDIX E-2.1

N1102.2.1 Ceilings with attic spaces: Exception for fully enclosed attic floor systems

SECTION VIEW OF CEILING WITH ATTIC SPACE
N1102.2.11 Closed crawl space walls. Insulation illustrations

Foam or porous insulation has 3” to 4” top inspection gap and extends down 3” to 4” above top of wall footing or concrete floor

Foam or porous insulation has 3” to 4” top inspection gap and extends down 24” below grade

Foam or porous insulation has 3” to 4” top inspection gap and extends down 3” to 4” above interior ground surface
APPENDIX E-2.3

N1102.2.14 Framed cavity walls. Insulation enclosure – 1. Tubs

SECTION VIEW OF BATH TUB ON EXTERIOR WALL
N1102.2.14 Framed cavity walls. Insulation enclosure – 2. Showers

SECTION VIEW OF SHOWER ON EXTERIOR WALL
N1102.2.14 Framed cavity walls. Insulation enclosure – 3. Stairs

SECTION VIEW OF INTERIOR STAIRCASE ON EXTERIOR WALL (OPTION 1)
N1102.2.14 Framed cavity walls. Insulation enclosure – 3. Stairs

SECTION VIEW OF INTERIOR STAIRCASE ON EXTERIOR WALL (OPTION 2)
N1102.2.14 Framed cavity wall. Insulation enclosure – 4. Direct vent gas fireplace

SECTION VIEW OF DIRECT VENT GAS FIREPLACE
N1102.2.15 Framed cavity walls. Insulation enclosure – 5. Walls that adjoin attic spaces

SECTION VIEW OF WALL ADJOINING ATTIC SPACE WITH STICK FRAMED ROOF

2018 North Carolina Residential Code
N1102.2.15 Framed cavity walls. Insulation enclosure – 5. Walls that adjoin attic spaces

SECTION VIEW OF WALL ADJOINING ATTIC SPACE WITH TRUSS ROOF
N1102.4.1 Building thermal envelope. – 1. Block and seal floor/ceiling systems

ISOMETRIC VIEW OF DIMENSIONAL LUMBER FLOOR/CEILING SYSTEM ABOVE COMMON WALL BETWEEN UNCONDITIONED AND CONDITIONED SPACE
N1102.4.1 Building thermal envelope. – 1. Block and seal floor/ceiling systems

**ISOMETRIC VIEW OF WOOD TRUSS FLOOR/CEILING SYSTEM ABOVE COMMON WALL BETWEEN UNCONDITIONED AND CONDITIONED SPACE**
N1102.4.1 Building thermal envelope. – 1. Block and seal floor/ceiling systems

ISOMETRIC VIEW OF I-JOIST FLOOR/CEILING SYSTEM ABOVE COMMON WALL BETWEEN UNCONDITIONED AND CONDITIONED SPACE
N1102.4.1 Building thermal envelope – 2. Cap and seal shafts and chases

SECTION VIEWS OF DUCT PENETRATING INTO ATTIC
N1102.4.1 Building thermal envelope. – 3. Cap and seal soffit or dropped ceiling

SECTION VIEW OF SOFFIT OVER CABINET
N1102.4.1 Building thermal envelope. – 4. Seal HVAC boot penetration – floor

SECTION VIEW OF FLOOR HVAC BOOT PENETRATION
N1102.4.1 Building thermal envelope. – 4. Seal HVAC boot penetration – ceiling

SECTION VIEW OF CEILING HVAC BOOT PENETRATION
N1102.4.1 Building thermal envelope. – 5. Sealed exterior air barrier with housewrap

Follow manufacturer’s instructions for sealing air barrier-rated housewrap, including choice of materials, to provide an exterior air barrier at the following locations:
N1102.4.1 Building thermal envelope. – 5. Sealed exterior air barrier with sheathing

1) IF FIRST FLOOR IS SLAB-ON-GRADE, INSTALL SEAL SEALER UNDER BOTTOM PLATE OF EXTERIOR WALL.
2) IF FIRST FLOOR IS OVER UNCONDITIONED CRAWL SPACE OR BASEMENT, INSTALL SEAL SEALER UNDER BOTTOM PLATE AND SEAL SUBFLOOR TO BAND JOIST.
3) IF FIRST FLOOR IS OVER CONDITIONED BASEMENT OR CLOSED CRAWL SPACE WITH CRAWL SPACE WALL INSULATION BELOW, SEAL BETWEEN SUBFLOOR AND BOTTOM PLATE, SEAL BAND JOIST TO SUBFLOOR ABOVE, AND SEAL BAND JOIST TO TOP PLATE BELOW.
N1102.4.2.1 Visual inspection option. – Table N1102.4.2 Seal ceiling mechanical box penetrations

![Diagram showing exhaust fan and flexible sealant on all four sides with ceiling exhaust]
N1102.4.2.1 Visual inspection option. – Table N1102.4.2 Seal ceiling electrical box penetrations
APPENDIX E-3: SAMPLE WORKSHEETS FOR RESIDENTIAL AIR AND DUCT LEAKAGE TESTING

APPENDIX 3A
Air sealing: Visual inspection option (Section N1102.4.2.1)
Sample Worksheet

N1102.4.2 Air sealing. Building envelope air tightness shall be demonstrated by Section N1102.4.2.1 or N1102.4.2.2: N1102.4.2.1 Visual inspection option. Building envelope tightness shall be considered acceptable when items providing insulation enclosure in N1102.2.14 and enclosure and air sealing in N1102.2.15 and air sealing in N1102.4.1 are addressed and when the items listed in Table N1102.4.2, applicable to the method of construction, are certified by the builder, permit holder or registered design professional via the certificate in Appendix E-1.

TABLE N1102.4.2
AIR BARRIER INSPECTION

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>CRITERIA</th>
</tr>
</thead>
</table>
| Ceiling/attic                    | Sealants or gaskets provide a continuous air barrier system joining the top plate of framed walls with either the ceiling drywall or the top edge of wall drywall to prevent air leakage. Top plate penetrations are sealed.  
For ceiling finishes that are not air barrier systems such as tongue-and-groove planks, air barrier systems, (for example, taped house wrap), shall be used above the finish  
Note: It is acceptable that sealants or gaskets applied as part of the application of the drywall will not be observable by the code official |
| Walls                            | Sill plate is gasketed or sealed to subfloor or slab.                                                                                   |
| Windows and doors                | Space between window and exterior door jambs and framing is sealed.                                                                     |
| Floors (including above-garage and cantilevered floors) | Air barrier system is installed at any exposed edge of insulation. |
| Penetrations                     | Utility penetrations through the building thermal envelope, including those for plumbing, electrical wiring, ductwork, security and fire alarm wiring, and control wiring, shall be sealed. |
| Garage separation                | Air sealing is provided between the garage and conditioned spaces.  
An air barrier system shall be installed between the ceiling system above the garage and the ceiling system of interior spaces. |
| Ceiling penetrations             | Ceiling electrical box penetrations and ceiling mechanical box penetrations shall be caulked, gasketed, or sealed at the penetration of the ceiling finish. See Appendix E-2.4.  
**Exception**— ceiling electrical boxes and ceiling mechanical boxes not penetrating the building thermal envelope |

2018 North Carolina Residential Code
Recessed lighting  
Recessed light fixtures are air tight, IC rated, and sealed to drywall.  
Exception— fixtures in conditioned space.

**Property Address:**

**N1102.4.2.1 Visual Inspection Option**
The inspection information including tester name, date, and contact shall be included on the certificate described in Section N1101.14.

_________________________________________________________

Signature                                           Date
N1102.4.2 Air sealing. Building envelope air tightness shall be demonstrated by Section N1102.4.2.1 or N1102.4.2.2:

N1102.4.2.2 Testing option. Building envelope tightness shall be considered acceptable when items providing insulation enclosure in N1102.2.14 and enclosure and air sealing in N1102.2.15 and air sealing in N1102.4.1 are addressed and when tested air leakage is less than or equal to one of the two following performance measurements:
  1. 0.30 CFM50/Square Foot of Surface Area (SFSA) or
  2. Five (5) air changes per hour (ACH50)

When tested with a blower door fan assembly, at a pressure of 33.5 psf (50 Pa). A single point depressurization, not temperature corrected, test is sufficient to comply with this provision, provided that the blower door fan assembly has been certified by the manufacturer to be capable of conducting tests in accordance with ASTM E779-03. Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation and combustion appliances. Testing shall be reported by the permit holder, a NC licensed general contractor, a NC licensed HVAC contractor, a registered design professional, a certified BPI Envelope Professional or a certified HERS rater.

During testing:
  1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed;
  2. Dampers shall be closed, but not sealed, including exhaust, backdraft, and flue dampers;
  3. Interior doors shall be open;
  4. Exterior openings for continuous ventilation systems, air intake ducted to the return side of the conditioning system, and energy or heat recovery ventilators shall be closed and sealed;
  5. Heating and cooling system(s) shall be turned off; and
  6. Supply and return registers shall not be sealed.

The air leakage information, including building air leakage result, tester name, date, and contact information, shall be included on the certificate described in Section N1101.14.

For Test Criteria 1 above, the report shall be produced in the following manner: Perform the blower door test and record the CFM50 ___________. Calculate the total square feet of surface area for the building thermal envelope, all floors, ceilings, and walls (this includes windows and doors) and record the area ___________. Divide CFM50 by the total square feet and record the result below. If the result is less than or equal to [0.30 CFM50/SFSA] the envelope tightness is acceptable; or

For Test Criteria 2 above, the report shall be produced in the following manner: Perform a blower door test and record the CFM50 ___________. Multiply the CFM50 by 60 minutes to create CFHour50 and record ___________. Then calculate the total conditioned volume of the home and record ___________. Divide the CFH50 by the total volume and record the result below. If the result is less than or equal to [5 ACH50] the envelope tightness is acceptable.

Property Address:

Fan attachment location __________________ Company Name _________________________
Contact Information: _____________________________________________________________
__________________________ Signature of Tester ________________________________ Date
Permit Holder, NC Licensed General Contractor, NC Licensed HVAC Contractor, NC Licensed Home Inspector, Registered Design Professional, Certified BPI Envelope Professional, or Certified HERS Rater (circle one)
APPENDIX E-3C
Duct sealing. Duct air leakage test (Section N1103.3.2 & Section N1103.3.3)
Sample Worksheet

**N1103.3.2 Sealing (Mandatory Requirements).** Ducts, air handlers, filter boxes, and building cavities used as ducts shall be sealed. Joints and seams shall comply with either the *International Mechanical Code* or *International Residential Code*, as applicable.

**N1103.3.3 Duct leakage (Prescriptive) and duct testing (Mandatory).** Duct testing and duct leakage shall be verified by compliance with either Section N1103.3.3.1 or N1103.3.3.2. Duct testing shall be verified using one of the two following methods:

**N1103.3.3.1 Total Duct leakage.** Total duct leakage less than or equal to 5 CFM (12 L/min) per 100 ft$^2$ (9.29 m$^2$) of conditioned floor area served by that system when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure.

During testing:
1. Block, if present, ventilation air duct(s) connected to the conditioning system.
2. The duct air leakage testing equipment shall be attached to the largest return in the system or to the air handler.
3. The filter shall be removed and the air handler power shall be turned off.
4. Supply boots or registers and return boxes or grilles shall be taped, plugged, or otherwise sealed air tight.
5. The hose for measuring the 25 Pascals of pressure differential shall be inserted into the boot of the supply that is nominally closest to the air handler.
6. Specific instructions from the duct testing equipment manufacturer shall be followed to reach duct test pressure and measure duct air leakage.

**N1103.3.3.2 Duct Leakage to the Outside.** Conduct the test using fan pressurization of distribution system and building at a fixed reference pressure for combined supply and return leaks. Duct leakage to the outside shall be less than or equal to 4 CFM (12 L/min) per 100 ft$^2$ (9.29 m$^2$) of conditioned floor area served by that system when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, relative to the outside, including the manufacturer’s air handler enclosure.

During testing:
1. Block, if present, the ventilation air duct(s) connected to the conditioning system.
2. The duct air leakage testing equipment shall be attached to the largest return in the system or to the air handler.
3. The filter shall be removed and the air handler power shall be turned off.
4. Supply boots or registers and return boxes or grilles shall be taped, plugged, or otherwise sealed air tight or as tight as possible.
5. The hose for measuring the 25 Pascals of pressure differential shall be inserted into the boot of the supply that is nominally closest to the air handler.
6. Open all interconnecting doors in the building, close dampers for fireplaces and other operable dampers.
7. Set up an envelope air moving/ flow-regulating/ flow measurement assembly, such as a blower door, following the manufacturer’s prescribed procedure.
8. Specific instructions from the duct testing equipment manufacturer shall be followed to reach duct test pressure and measure duct air leakage used in combination with a blower door. Typical steps are as follows:
   a. Depressurize the ductwork system to 25 Pa using the measurement hose in Step 5 above.
   b. Depressurize the house to 25 Pa using an envelope air moving/flow-regulating/flow measurement assembly, such as a blower door.
   c. Correct the duct pressure to measure 0 Pa of pressure differential between the house and the ductwork system.
   d. Read the CFM of duct leakage using the procedures for the specific equipment being used. (Note that most automatically calculating pressure gauges cannot compute the CFM automatically with a duct-to-house difference in pressure of 0 Pa, so the gauge setting should be set to read CFM instead of CFM25).

Testing shall be performed and reported by the permit holder, a NC licensed general contractor, a NC licensed HVAC contractor, a NC licensed Home Inspector, a registered design professional, a certified BPI Envelope Professional or a certified HERS rater. A single point depressurization, not temperature corrected, test is sufficient to comply with this provision, provided that the duct testing fan assembly(s) has been certified by the manufacturer to be capable of conducting tests in accordance with ASTM E1554-07.

The duct leakage information, including duct leakage test selected and result, tester name, date, and contact information, shall be included on the certificate described in Section N1101.14.

For the Test Criteria, the report shall be produced in the following manner: perform the HVAC system air leakage test and record the CFM25. Calculate the total square feet of Conditioned Floor Area (CFA) served by that system. Multiply CFM25 by 100, divide the result by the CFA and record the result. If the result is less than or equal to 5 CFM25/100SF for the “Total duct leakage test” or less than or equal to 4 CFM25/100SF for the “Duct leakage to the outside” test, then the HVAC system air tightness is acceptable.

Complete one duct leakage report for each HVAC system serving the home:

Property Address: ________________________________________________________________

Test Performed: Total duct leakage or Duct leakage to the outside (circle one)  

HVAC System Number: _________ Describe area of home served: ________________________

CFM25 Total _________. Conditioned Floor Area (CFA) served by system: ________ s.f.

CFM25 x 100 divided by CFA = _____ CFM25/100SF (e.g. 100 CFM25x100/2,000 CFA = 5 CFM25/100SF)

Fan attachment location ________________________________

Company Name __________________________________________________________________

Contact Information:_______________________________________________________________

_________________________________________________

_______________________________________________

Signature of Tester ___________________________ Date ____________________________

Permit Holder, NC Licensed General Contractor, NC Licensed HVAC Contractor, NC Licensed Home Inspector, Registered Design Professional, Certified BPI Envelope Professional, or Certified HERS Rater (circle one)

2018 North Carolina Residential Code
APPENDIX E-4 ADDITIONAL VOLUNTARY CRITERIA FOR INCREASING ENERGY EFFICIENCY (High Efficiency Residential Option)

1. **Introduction.** The increased energy efficiency measures identified in this appendix are strictly voluntary at the option of the permit holder and have been evaluated to be the most cost effective measures for achieving an additional 10-15% energy efficiency beyond the code minimums.

2. **Requirements:** Follow all sections of Chapter 11 of the North Carolina Residential Code, Chapter 11, except the following.
   
a. Instead of using Table N1102.1.2 in Section N1102.1.2, use Table E-4A shown below.

### TABLE E-4A

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<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR</th>
<th>SKYLIGHT U-FACTOR</th>
<th>GLAZED FENESTRATION SHGC</th>
<th>CEILING R-VALUE</th>
<th>WOOD FRAME WALL R-VALUE</th>
<th>MASS WALL R-VALUE</th>
<th>FLOOR R-VALUE</th>
<th>BASEMENT WALL R-VALUE</th>
<th>SLAB R-VALUE</th>
<th>CRAWL SPACE WALL R-VALUE</th>
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<td>0.55</td>
<td>0.25</td>
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<td>19, 13+5, or 15+3h</td>
<td>5/13 or 5/10cl</td>
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<td>5</td>
<td>5/13</td>
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<tr>
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<td>0.32</td>
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<td>0.25</td>
<td>38 or 30 cl</td>
<td>19, 13+5, or 15+3h</td>
<td>5/13 or 5/10cl</td>
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<td>0.55</td>
<td>(NR)</td>
<td>38 or 30 cl</td>
<td>19, 13+5, or 15+3h</td>
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<td>30</td>
<td>10/15</td>
<td>10</td>
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</tbody>
</table>

For SI: 1 foot = 304.8 mm.

a. R-values are minimums. U-factors and SHGC are maximums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed R-value of the insulation shall not be less than the R-value specified in the table.

b. The fenestration U-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

c. “10/15” means R-10 continuous insulated sheathing on the interior or exterior of the home or R-15 cavity insulation at the interior of the basement wall or crawl space wall.

d. For monolithic slabs, insulation shall be applied from the inspection gap downward to the bottom of the footing or a maximum of 24 inches below grade whichever is less. For floating slabs, insulation shall extend to the bottom of the foundation wall or 24 inches, whichever is less. (See Appendix O). R-5 shall be added to the required slab edge R-values for heated slabs.

e. Deleted.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure N1101.7 and Table N1101.7.

g. Or insulation sufficient to fill the framing cavity. R-19 minimum.

h. The first value is cavity insulation, the second value is continuous insulation, so “13+5” means R-13 cavity insulation plus R-5 continuous insulation. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

i. The second R-value applies when more than half the insulation is on the interior of the mass wall.

j. In addition to the exemption in Section N1102.3.3, a maximum of two glazed fenestration product assemblies having a U-factor no greater than 0.55 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.

k. In addition to the exemption in Section N1102.3.3, a maximum of two glazed fenestration product assemblies having a SHGC no greater than 0.70 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.
l. R-30 shall be deemed to satisfy the ceiling insulation requirement wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Otherwise R-38 insulation is required where adequate clearance exists or insulation must extend to either the insulation baffle or within 1" of the attic roof deck.

m. Table value required except for roof edge where the space is limited by the pitch of the roof, there the insulation must fill the space up to the air baffle.

n. R-19 fiberglass batts compressed and installed in a nominal 2 x 6 framing cavity is deemed to comply. Fiberglass batts rated R-19 or higher compressed and installed in a 2x4 wall is not deemed to comply.

o. Basement wall meeting the minimum mass wall specific heat content requirement may use the mass wall R-value as the minimum requirement.

b. Instead of using Table N1102.1.4 in Section N1102.1.4, use Table E-4B to find the maximum U-factors for building components.

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>FENESTRATION U-FACTOR</th>
<th>SKYLIGHT U-FACTOR</th>
<th>CEILING U-FACTOR</th>
<th>FRAME WALL U-FACTOR</th>
<th>MASS WALL U-FACTOR</th>
<th>FLOOR U-FACTOR</th>
<th>BASEMENT WALL U-FACTOR</th>
<th>CRAWL SPACE WALL U-FACTOR</th>
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</thead>
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<tr>
<td>3</td>
<td>0.32</td>
<td>0.55</td>
<td>0.030</td>
<td>0.061</td>
<td>0.141</td>
<td>0.047</td>
<td>0.091</td>
<td>0.136</td>
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<td>4</td>
<td>0.32</td>
<td>0.55</td>
<td>0.030</td>
<td>0.061</td>
<td>0.141</td>
<td>0.047</td>
<td>0.059</td>
<td>0.065</td>
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<tr>
<td>5</td>
<td>0.32</td>
<td>0.55</td>
<td>0.030</td>
<td>0.082</td>
<td></td>
<td>0.053</td>
<td>0.059</td>
<td>0.065</td>
</tr>
</tbody>
</table>

a. Nonfenestration U-factors shall be obtained from measurement, calculation or an approved source.

b. When more than half the insulation is on the interior, the mass wall U-factors shall be a maximum of 0.07 in Climate Zone 3, 0.07 in Climate Zone 4, and 0.054 in Climate Zone 5.

c. Basement wall U-factor of 0.360 in warm-humid locations as defined by Figure N1101.10 (R301.1) and Table N1101.10 (R301.1).

d. A maximum of two glazed fenestration product assemblies having a U-factor no greater than 0.55 and a SHGC no greater than 0.70 shall be permitted to be substituted for minimum code compliant fenestration product assemblies without penalty.

c. For compliance with Section N1102.4 Air leakage control (Mandatory Requirements), Sections N1102.4.1 (Building thermal envelope) and N1102.4.2.2 (Testing option) must be followed, with the maximum leakage rate shown below. Section N1102.4.2.1 (Visual inspection option) cannot be used to show compliance.

i. 0.24 CFM50/Square Foot of Surface Area (SFSA) or

ii. Four (4) air changes per hour (ACH50)

d. Instead of using the duct leakage value for maximum leakage shown in Section N1103.3.3 use the following:

1. **N1103.3.3.1 Total Duct Leakage.** Total duct leakage less than or equal to 4 CFM (113 L/min) per 100 ft² (9.29 m²) of conditioned floor area served by that system when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure.

2. **N1103.3.3.2 Duct Leakage to the Outside.** Conduct the test using fan pressurization of distribution system and building at a fixed reference pressure for combined supply and return leak. Duct leakage to the outside shall be less than or equal to 3 CFM (85 L/min) per 100 ft² (9.29 m²) of conditioned floor area served by that system when tested at a

2018 North Carolina Residential Code
pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, relative to the outside, including the manufacturer's air handler enclosure.

e. For compliance with Section N1104.1 (Lighting equipment), the home must comply with the following:

Not less than 90 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 90 percent of the permanently installed lighting fixtures shall contain only high-efficacy lamps.

*Table E-4C: Sample Confirmation Form for ADDITIONAL VOLUNTARY CRITERIA FOR INCREASING ENERGY EFFICIENCY (High Efficiency Residential Option)*
### North Carolina Energy Conservation Code: High Efficiency Residential Option

#### Insulation and Fenestration Values (Notes correlate to Table N1102.1.2)

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Proposed Project Values</th>
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<tr>
<td>Fenestration U-Factor</td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
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<td>Skylight U-Factor</td>
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<td>Glazed Fenestration SHGC</td>
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<td>0.25</td>
<td>(NR)</td>
<td>-</td>
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<tr>
<td>Ceiling R-value</td>
<td>38 or 30 ci</td>
<td>38 or 30 ci</td>
<td>38 or 30 ci</td>
<td>-</td>
</tr>
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<td>Wood Frame Wall R-value</td>
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<td>19, 13+5, or</td>
<td>19, 13+5, or</td>
<td>-</td>
</tr>
<tr>
<td>Mass Wall R-value</td>
<td>5/13 or 5/10ci</td>
<td>5/13 or 5/10ci</td>
<td>13/17 or 13/12.5 ci</td>
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</tr>
<tr>
<td>Floor R-value</td>
<td>19</td>
<td>19</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Basement Wall R-value</td>
<td>5/13</td>
<td>10/15</td>
<td>10/15</td>
<td>-</td>
</tr>
<tr>
<td>Slab R-value and Depth</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Crawl Space Wall R-value</td>
<td>5/13</td>
<td>10/15</td>
<td>10/19</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note: ci = continuous insulation*

#### High Efficacy Lighting

% of lighting that is high efficacy according to N1104.1. (90% required)

- |

#### Building Air Leakage

Building Air Leakage Test according to N1102.4.2.2 (check box). Show test value:

- |

**_ACH50 [Target: 4.0], or_**

- |

**_CFM50/SFSA [Target: 0.24]_**

- |

Name of Tester / Company:

- |

Date: Phone:

- |

#### Duct Insulation and Sealing

Insulation Value R-

Duct Leakage Test Result (Sect. N1103.3.3)

- Total duct leakage or - Duct leakage to the exterior

(CFM25 Total/100SF) [Target: 4 Total/ 3 To exterior]

- |

Name of Tester or Company

- |

Date: Phone:

- |
E-4D:

SAMPLE WORKSHEETS FOR RESIDENTIAL AIR AND DUCT LEAKAGE TESTING
Air sealing. Building envelope air tightness shall be demonstrated by Section N1102.4.2.2:

**Air sealing: Testing option (Section N1102.4.2.2)**

Sample Worksheet for Alternative Residential Energy Code for Higher Efficiency

**N1102.4.2.2 Testing.** Building envelope tightness shall be considered acceptable when items providing insulation enclosure in N1102.2.14 and enclosure air sealing in N1102.2.15 and air sealing in N1102.4.1 are addressed and when tested air leakage is less than or equal to one of the two following performance measurements:

1. 0.24 CFM50 (6.8 L/min)/Square Foot of Surface Area (SFSA) or
2. Four (4) air changes per hour (ACH50)

When tested with a blower door fan assembly, at a pressure of 0.2 inches water gauge (50 Pa), a single point depressurization, not temperature corrected, test is sufficient to comply with this provision, provided that the blower door fan assembly has been certified by the manufacturer to be capable of conducting tests in accordance with ASTM E779-03. Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation and combustion appliances. Testing shall be reported by the permit holder, a NC licensed general contractor, a NC licensed HVAC contractor, a NC licensed Home Inspector, a registered design professional, a certified BPI Envelope Professional or a certified HERS rater.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed;
2. Dampers shall be closed, but not sealed, including exhaust, backdraft, and flue dampers;
3. Interior doors shall be open;
4. Exterior openings for continuous ventilation systems, air intake ducted to the return side of the conditioning system, and energy or heat recovery ventilators shall be closed and sealed;
5. Heating and cooling system(s) shall be turned off; and
6. Supply and return registers shall not be sealed.

The air leakage information, including building air leakage result, tester name, date, and contact information, shall be included on the certificate described in Section N1101.14.

**For Test Criteria 1** above, the report shall be produced in the following manner: Perform the blower door test and record the CFM50 _______. Calculate the total square feet of surface area for the building thermal envelope, all floors, ceilings, and walls (this includes windows and doors) and record the area _________. Divide CFM50 by the total square feet and record the result below. If the result is less than or equal to \[0.24 \text{ CFM50/SFSA}\] the envelope tightness is acceptable; or

**For Test Criteria 2** above, the report shall be produced in the following manner: Perform a blower door test and record the CFM50 = _______. Multiply the CFM50 by 60 minutes to create CF/ Hour50 and record = __________. Then calculate the total conditioned volume of the home and record = ________ cubic feet. Divide the CF/ Hour50 by the total volume and record the result = ________________ ACH50. If the result is less than or equal to \[4 \text{ ACH50}\] the envelope tightness is acceptable.

**Property Address:**

<table>
<thead>
<tr>
<th>Property Address:</th>
<th>Company Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan attachment location</td>
<td>Company Name</td>
</tr>
<tr>
<td>Contact Information:</td>
<td></td>
</tr>
<tr>
<td>____________________________________________________________________________</td>
<td></td>
</tr>
<tr>
<td>____________________________________________________________________________</td>
<td></td>
</tr>
</tbody>
</table>

Signature of Tester                                      Date
Permit Holder, NC Licensed General Contractor, NC Licensed HVAC Contractor, NC Licensed Home Inspector, Registered Design Professional, Certified BPI Envelope Professional, or Certified HERS Rater (circle one)
E-4D.2
Duct sealing. Duct air leakage test (Section N1103.3.3)
Sample Worksheet for Alternative Residential Energy Code for Higher Efficiency

N1103.3.3 Duct leakage (Prescriptive) and Duct Testing (Mandatory). Duct testing and duct leakage shall be verified by compliance with either Section N1103.3.3.1 or N1103.3.3.2. Duct testing shall be performed and reported by the permit holder, a NC licensed general contractor, a NC licensed HVAC contractor, a NC licensed Home Inspector, a registered design professional, a certified BPI Envelope Professional or a certified HERS rater. A single point depressurization, not temperature corrected, test is sufficient to comply with this provision, provided that the duct testing fan assembly(s) has been certified by the manufacturer to be capable of conducting tests in accordance with ASTM E1554-07.

The duct leakage information, including duct leakage test selected and result, tester name, date, and contact information, shall be included on the certificate described in Section N1101.3.

For the Test Criteria, the report shall be produced in the following manner: perform the HVAC system air leakage test and record the CFM25. Calculate the total square feet of Conditioned Floor Area (CFA) served by that system. Multiply CFM25 by 100, divide the result by the CFA and record the result. If the result is less than or equal to 4 CFM25/100SF for the “Total duct leakage test or less than or equal to 3 CFM25/100SF for the ‘Duct leakage to the outside” test, then the HVAC system air tightness is acceptable.

Exceptions to testing requirements:
1. Duct systems or portions thereof inside the building thermal envelope shall not be required to be leak tested.
2. Installation of a partial system as part of replacement, renovation or addition does not require a duct leakage test.

1103.3.3.1 Total Duct Leakage. Total duct leakage less than or equal to 4 CFM (113 L/min) per 100 ft² (9.29 m²) of conditioned floor area served by that system when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. During testing:
1. Block, if present, ventilation air duct(s) connected to the conditioning system.
2. The duct air leakage testing equipment shall be attached to the largest return in the system or to the air handler.
3. The filter shall be removed and the air handler power shall be turned off.
4. Supply boots or registers and return boxes or grilles shall be taped, plugged, or otherwise sealed air tight.
5. The hose for measuring the 25 Pascals of pressure differential shall be inserted into the boot of the supply that is nominally closest to the air handler.
6. Specific instructions from the duct testing equipment manufacturer shall be followed to reach duct test pressure and measure duct air leakage.

1103.3.3.2 Duct Leakage to the Outside. Conduct the test using fan pressurization of distribution system and building at a fixed reference pressure for combined supply and return leak. Duct leakage to the outside shall be less than or equal to 3 CFM (85 L/min) per 100 ft² (9.29 m²) of conditioned floor area served by that system when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, relative to the outside, including the manufacturer’s air handler enclosure.

During testing:
1. Block, if present, the ventilation air duct(s) connected to the conditioning system.
2. The duct air leakage testing equipment shall be attached to the largest return in the system or to the air handler.
3. The filter shall be removed and the air handler power shall be turned off.
4. Supply boots or registers and return boxes or grilles shall be taped, plugged, or otherwise sealed air tight or as tight as possible.
5. The hose for measuring the 25 Pascals of pressure differential shall be inserted into the boot of the supply that is nominally closest to the air handler.
6. Open all interconnecting doors in the building, close dampers for fireplaces and other operable dampers.
7. Set up an envelope air moving/ flow-regulating/ flow measurement assembly, such as a blower door, following
the manufacturer's prescribed procedure.

8. Specific instructions from the duct testing equipment manufacturer shall be followed to reach duct test pressure and measure duct air leakage used in combination with a blower door. Typical steps are as follows:

   a. Depressurize the ductwork system to 25 Pa using the measurement hose in Step 5 above.
   b. Depressurize the house to 25 Pa using an envelope air moving/flow-regulating/flow measurement assembly, such as a blower door.
   c. Correct the duct pressure to measure 0 Pa of pressure differential between the house and the ductwork system.
   d. Read the CFM of duct leakage using the procedures for the specific equipment being used. (Note that most automatically calculating pressure gauges cannot compute the CFM25 automatically with a duct-to-house difference in pressure of 0 Pa, so the gauge setting should be set to read CFM instead of CFM25).

Complete one duct leakage report for each HVAC system serving the home:

Property Address: ________________________________________________________________

HVAC System Number: ______________  Describe area of home served: _____________________

CFM25 Total _________. Conditioned Floor Area (CFA) served by system: __________ s.f.

CFM25 x 100 divided by CFA = ________ CFM25/100 SF

(e.g. 50 CFM25 x 100/ 2,000 CFA = 2.5 CFM25/100SF)

Fan attachment location ___________________

Company Name __________________________________________________________________

Contact Information: _______________________________________________________________

_______________________________________________________________________________

Signature of Tester ___________________________  Date __________________________

Permit Holder, NC Licensed General Contractor, NC Licensed HVAC Contractor, NC Licensed Home Inspector, Registered Design Professional, Certified BPI Envelope Professional, or Certified HERS Rater (circle one)
APPENDIX F

PASSIVE RADON GAS CONTROLS

Deleted

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AF101

SCOPE

---

a—pCi/L standard for picocuries per liter of radon gas. The U.S. Environmental Protection Agency (EPA) recommends that homes that measure 4 pCi/L and greater be mitigated.

The EPA and the U.S. Geological Survey have evaluated the radon potential in the United States and have developed a map of radon zones designed to assist building officials in deciding whether radon-resistant features are applicable in new construction.

The map assigns each of the 3,141 counties in the United States to one of three zones based on radon potential. Each zone designation reflects the average short-term radon measurement that can be expected to be measured in a building without the implementation of radon-control methods. The radon zone designation of highest priority is Zone 1. Table AF101 lists the Zone 1 counties illustrated on the map. More detailed information can be obtained from state-specific booklets (EPA-402-R-93-021 through 070) available through State Radon Offices or from EPA Regional Offices.
## FIGURE AF101
EPA MAP OF RADON ZONES

### TABLE AF101(1)
HIGH RADON-POTENTIAL (ZONE 1) COUNTIES

<table>
<thead>
<tr>
<th>ALABAMA</th>
<th>CONNECTICUT</th>
<th>GEORGIA</th>
<th>IOWA</th>
<th>KENTUCKY</th>
<th>MINNESOTA</th>
<th>MISSOURI</th>
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<td>Calhoun</td>
<td>Fairfield</td>
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<td>Wabash</td>
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<td>Hilledale</td>
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<td>Grant</td>
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<td>in-</td>
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<td>in-</td>
<td>Kandiychi</td>
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<td>Jewell</td>
<td>in-</td>
<td>Kittson</td>
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<td>in-</td>
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<td>Cass</td>
<td>Grant</td>
<td>Kiowa</td>
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a. The EPA recommends that this county listing be supplemented with other available State and local data to further understand the radon potential of a Zone 1 area.

**AF101.1 General.**

This appendix contains requirements for new construction in *jurisdictions* where radon-resistant construction is required. These requirements are intended to provide a passive means of resisting radon gas entry and prepare the *dwelling* for post-construction radon mitigation, if necessary (see Figure AF102). Active construction techniques, rather than passive techniques, shall be permitted to be used where approved.

Inclusion of this appendix by *jurisdictions* shall be determined through the use of locally available data or determination of Zone 1 designation in Figure AF101 and Table AF101(1).

**SECTION AF102**

**DEFINITIONS**
FIGURE AF102
RADON-RESISTANT CONSTRUCTION DETAILS FOR FOUR FOUNDATION TYPES

AF102.1 General.
For the purpose of these requirements, the terms used shall be defined as follows:
DRAIN TILE LOOP. A continuous length of drain tile or perforated pipe extending around all or part of the internal or external perimeter of a basement or crawl space footing.

ENCLOSED CRAWL SPACE. A crawl space that is enclosed with foundation walls inclusive of any windows, doors, access openings and required vents.

GAS-PERMEABLE LAYER. A gas-permeable layer shall consist of one of the following:

1. A uniform layer of clean aggregate that is not less than 4 inches (102 mm) thick. The aggregate shall consist of material that will pass through a 2-inch (51 mm) sieve and be retained by a 1/4-inch (6.4 mm) sieve.

2. A uniform layer of sand (native or fill) that is not less than 4 inches (102 mm) thick and that is overlain by a soil gas collection mat or soil gas matting installed in accordance with the manufacturer’s instructions.

RADON GAS. A naturally occurring, chemically inert, radioactive gas.

SOIL-GAS-RETARDER. A continuous membrane of 6-mil (0.15 mm) polyethylene used to retard the flow of soil gases into a dwelling.

SUBMEMBRANE DEPRESSURIZATION SYSTEM. A system designed to achieve lower submembrane air pressure relative to basement or crawl space air pressure by use of a vent drawing air from beneath the soil-gas-retarder membrane.

SUBSLAB DEPRESSURIZATION SYSTEM (Passive). A system designed to achieve lower subslab air pressure relative to indoor air pressure by use of a vent pipe drawing air from beneath concrete floor slabs or other floor assemblies that are in contact with the ground.

VENT PIPE. Not less than a 3-inch-diameter (76 mm) ABS or PVC gas-tight pipe extending from the gas permeable layer through the roof.

SECTION AF103
PASSIVE RADON-RESISTANT SYSTEM REQUIREMENTS

AF103.1 General.
The following components of a passive submembrane or subslab depressurization system shall be installed during construction.

AF103.2 Entry routes.
Potential radon entry routes shall be closed in accordance with Sections AF103.2.1 through AF103.2.8.

AF103.2.1 Floor openings.
Openings around bathtubs, showers, water closets, pipes, wires or other objects that
penetrate concrete slabs, or other floor assemblies, shall be filled with a polyurethane caulk or expanding foam applied in accordance with the manufacturer’s instructions.

**AF103.2.2 Sumps.**
Sumps open to soil or serving as the termination point for subslab or exterior drain tile loops shall be covered with a gasketed or sealed lid. Sumps used as the suction point in a subslab depressurization system shall have a lid designed to accommodate the vent pipe. Sumps used as a floor drain shall have a lid equipped with a trapped inlet.

**AF103.2.3 Foundation walls.**
Hollow block masonry foundation walls shall be constructed with a continuous course of solid masonry, one course of masonry grouted solid, or a solid concrete beam at or above grade. Where a brick veneer or other masonry ledge is installed, the course immediately below that ledge shall be solid masonry, one course of masonry grouted solid, or a solid concrete beam. Joints, cracks or other openings around penetrations of both exterior and interior surfaces of foundation walls below grade shall be filled with polyurethane caulk.

**AF103.2.4 Dampproofing.**
The exterior surfaces of foundation walls below grade shall be dampproofed in accordance with Section R406.

**AF103.2.5 Air-conditioning systems.**
Entry points, joints or other openings into air-conditioning systems in enclosed crawl spaces shall be sealed.

**Exception:** Systems with gasketed seams or that are otherwise sealed by the manufacturer.

**AF103.2.6 Ducts.**
Ductwork passing through or beneath a slab within a dwelling shall be of seamless material unless the air-conditioning system is designed to maintain continuous positive pressure within such ducting. Joints in such ductwork shall be sealed.

Ductwork located in enclosed crawl spaces shall have seams and joints sealed by closure systems in accordance with Section M1601.4.1.

**AF103.2.7 Crawl space access.**
Access doors and other openings or penetrations between basements and adjoining crawl spaces shall be closed, gasketed or sealed.

**AF103.3 Basements or enclosed crawl spaces with soil floors.**
In dwellings with basements or enclosed crawl spaces with soil floors, the following components of a passive submembrane depressurization system shall be installed during construction.

**Exception:** Basements or enclosed crawl spaces that are provided with a continuously operated mechanical exhaust system in accordance with Section R408.3.

**AF103.3.1 Soil-gas-retarder.**
The soil in basements and enclosed crawl spaces shall be covered with a soil-gas-retarder. The soil-gas-retarder shall be lapped not less than 12 inches (305 mm) at joints and shall...
extend to foundation walls enclosing the basement or crawl space. The soil-gas-retarder shall fit closely around any pipe, wire or other penetrations of the material. Punctures or tears in the material shall be sealed or covered with additional sheeting.

**AF103.3.2 “T” fitting and vent pipe.**
A 3- or 4-inch “T” fitting shall be inserted beneath the soil-gas-retarder and be connected to a vent pipe. The vent pipe shall extend through the conditioned space of the dwelling and terminate not less than 12 inches (305 mm) above the roof in a location not less than 10 feet (3048 mm) away from any window or other opening into the conditioned spaces of the building that is less than 2 feet (610 mm) below the exhaust point.

**AF103.4 Basements or enclosed crawl spaces with concrete floors or other floor systems and slab-on-grade dwellings.**
The following components of a passive subslab depressurization system shall be installed during construction in slab-on-grade dwellings or in dwellings with basements or crawl spaces with concrete or other floor systems.

**AF103.4.1 Sub-slab preparation.**
A layer of gas-permeable material shall be placed under concrete slabs and other floor systems that directly contact the ground and are within the walls of the dwelling.

**AF103.4.2 Soil-gas-retarder.**
A soil-gas-retarder shall be placed on top of the gas-permeable layer prior to casting the slab or placing the floor assembly. The soil-gas-retarder shall cover the entire floor area with separate sections lapped not less than 12 inches (305 mm). The soil-gas-retarder shall fit closely around any pipe, wire, or other penetrations of the material. Punctures or tears in the material shall be sealed or covered.

**AF103.4.3 “T” fitting and vent pipe.**
Before a slab is cast or other floor system is installed, a “T” fitting shall be inserted below the slab or other floor system and the soil-gas-retarder. The “T” fitting shall be connected to a vent pipe. The vent pipe shall extend through the conditioned space of the dwelling and terminate not less than 12 inches (305 mm) above the roof in a location not less than 10 feet (3048 mm) away from any window or other opening into the conditioned spaces of the building that is less than 2 feet (610 mm) below the exhaust point.

**AF103.5 Drain tile and sump used for depressurization.**
As an alternative to inserting a vent pipe into a “T” fitting, a vent pipe shall be permitted to be inserted directly into an interior perimeter drain tile loop or through a sump cover where the drain tile or sump is exposed to the gas-permeable layer.

**AF103.6 Multiple vent pipes.**
In dwellings where interior footings or other barriers separate the gas-permeable layer, each area shall be fitted with an individual vent pipe. Vent pipes shall connect to a single vent that terminates above the roof or each individual vent pipe shall terminate separately above the roof.

**AF103.7 Combination foundations.**
Where basement or crawl space floors are on different levels, each level shall have a separate vent pipe. Multiple vent pipes shall be permitted to be connected to a single vent pipe that terminates above the roof.
AF103.8 Vent pipe drainage.
Components of the radon vent pipe system shall be installed to provide positive drainage to the ground beneath the soil-gas retarder.

AF103.9 Vent pipe identification.
Exposed and visible interior vent pipes shall be identified with not less than one label on each floor and in accessible attics. The label shall read: “Radon Reduction System.”

AF103.10 Power source and access for future radon fan.
To provide for future installation of a radon fan, an electrical circuit terminated in an approved box shall be installed during construction in the anticipated location of the radon fans. An accessible clear space 24 inches (610 mm) in diameter by 3 feet (914 mm) in height adjacent to the vent pipe shall be provided at the anticipated location of a future radon fan.
APPENDIX G

PIPING STANDARDS FOR VARIOUS APPLICATIONS

(The provisions contained in this appendix are adopted as part of this code.)

SECTION AG101

PLASTIC PIPING STANDARDS

AG101.1 Plastic piping.
Table AG101.1 provides a list of plastic piping product standards for various applications.

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**TABLE AG101.1—continued**

PLASTIC PIPING STANDARDS FOR VARIOUS APPLICATIONS\(^{a,b}\)
<p>| Radiant cooling | Loop piping | ASTM D 2846 | ASTM F 441 | ASTM F 442 | ASTM F 2855 | | ASTM D 2239 | ASTM D 2737 | ASTM D 3035 | ASTM F 1282 | ASTM F 2623 | ASTM F 2769 | ASTM F 876 | CSA B137.5 | ASTM F 1281 | ASTM F 2389 | CSA B137.11 | | | |
| Radiant heating | Loop piping | ASTM D 2846 | ASTM F 441 | ASTM F 442 | ASTM F 2855 | | | | | ASTM F 1282 | ASTM F 2623 | ASTM F 2769 | ASTM F 876 | CSA B137.5 | ASTM F 1281 | ASTM F 2389 | CSA B137.11 | | | |
| Rainwater harvesting | Nonpressure/collection | ASTM F 628 | | | | | ASTM F 1901 | | | | | | | | | | ASTM F 2389 | CSA B137.11 | ASTM D 1785 | ASTM D 2729 | ASTM D 2949 | ASTM F 891 | ASTM F 1760 | CSA B137.3 |</p>
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(continued)

TABLE AG101.1—continued

PLASTIC PIPING STANDARDS FOR VARIOUS APPLICATIONS\(^a,b\)

\(^a\) Plastic piping standards are subject to change based on updated code revisions.

\(^b\) Consult local building codes for specific requirements.
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ASTM F 442  
ASTM F 2855  
CSA B137.6 |
|                                   | ASTM D 2239  
ASTM D 2737  
ASTM D 3035  
ASTM F 1282  
ASTM F 2623  
ASTM F 2769 |
|                                   | ASTM F 876  
CSA B137.5  
ASTM F 1281  
ASTM F 2389  
AWWA C900  
CSA B137.11  
ASTM D 1785  
ASTM D 2241  
AWWA C900 |
| Residential fire sprinklersc       | ASTM F 441  
ASTM F 442  
CSA B137.6  
UL 1821 |
|                                   | ASTM F 2769  
ASTM F 876  
CSA B137.5  
UL 1821  
ASTM F 2389  
CSA B137.11 |
| Solar heating                      | ASTM D 2846  
ASTM F 441  
ASTM F 442  
ASTM F 2855 |
|                                   | ASTM F 2623  
ASTM F 2769 |
|                                   | ASTM F 876  
CSA B137.5  
ASTM F 1281  
ASTM F 2389  
CSA B137.11 |

a. This table indicates manufacturing standards for plastic piping materials that are suitable for use in the applications indicated. Such applications support green and sustainable building practices. The system designer or the installer of piping shall verify that the piping chosen for an application complies with local codes and the recommendations of the manufacturer of the piping.

b. Fittings applicable for the piping shall be as recommended by the manufacturer of the piping.

c. Piping systems for fire sprinkler applications shall be listed for the application.

SECTION AG102
REFERENCED STANDARDS

AG102.1 General.

F1901—10 Standard Specification for Polyethylene (PE) Pipe and Fittings for Roof Drain Systems

F2158—08 Standard Specification for Residential Central-Vacuum Tube and Fittings

F2306—08 12” to 60” Annular Corrugated Profile-wall Polyethylene (PE) Pipe and Fittings for Gravity Flow Storm Sewer and Sub-surface Drainage Applications

**AWWA**

900—07 Polyvinyl chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. through 12 in. (350 mm through 1200 mm), for Water Transmission and Distribution

905—10 Polyvinyl chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 in. through 48 in. (100 mm through 300 mm)

**UL**

1821—2011 Standard for Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service
APPENDIX H
PATIO COVERS

Deleted

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AH101
GENERAL

AH101.1 Scope.
Patio covers shall conform to the requirements of Sections AH101 through AH106.

AH101.2 Permitted uses.
Patio covers shall be permitted to be detached from or attached to dwelling units. Patio covers shall be used only for recreational, outdoor living purposes, and not as carports, garages, storage rooms or habitable rooms.

SECTION AH102
DEFINITION

AH102.1 General.
The following word and term shall, for the purposes of this appendix, have the meaning shown herein.

PATIO COVER. A structure with open or glazed walls that is used for recreational, outdoor living purposes associated with a dwelling unit.

SECTION AH103
EXTERIOR WALLS AND OPENINGS

AH103.1 Enclosure walls.
Enclosure walls shall be permitted to be of any configuration, provided the open or glazed area of the longer wall and one additional wall is equal to at least 65 percent of the area below a minimum of 6 feet, 8 inches (2032 mm) of each wall, measured from the floor. Openings shall be permitted to be enclosed with any of the following:

1. Insect screening.

2. Approved translucent or transparent plastic not more than 0.125 inch (3.2 mm) in thickness.

3. Glass conforming to the provisions of Section R308.

4. Any combination of the foregoing.
AH103.2 Light, ventilation and emergency egress.
Exterior openings required for light and ventilation shall be permitted to open into a patio structure conforming to Section AH101, provided that the patio structure shall be unenclosed if such openings are serving as emergency egress or rescue openings from sleeping rooms. Where such exterior openings serve as an exit from the dwelling unit, the patio structure, unless unenclosed, shall be provided with exits conforming to the provisions of Section R311 of this code.

SECTION AH104
HEIGHT

AH104.1 Height.
Patio covers are limited to one-story structures not exceeding 12 feet (3657 mm) in height.

SECTION AH105
STRUCTURAL PROVISIONS

AH105.1 Design loads.
Patio covers shall be designed and constructed to sustain, within the stress limits of this code, all dead loads plus a vertical live load of not less than 10 pounds per square foot (0.48 kN/m²), except that snow loads shall be used where such snow loads exceed this minimum. Such covers shall be designed to resist the minimum wind loads set forth in Section R301.2.1.

AH105.2 Footings.
In areas with a frostline depth of zero as specified in Table R301.2(1), a patio cover shall be permitted to be supported on a slab-on-grade without footings, provided the slab conforms to the provisions of Section R506, is not less than 3.5 inches (89 mm) thick and the columns do not support live and dead loads in excess of 750 pounds (3.34 kN) per column.

SECTION AH106
SPECIAL PROVISIONS FOR ALUMINUM SCREEN ENCLOSURES IN HURRICANE-PRONE REGIONS

AH106.1 General.
Screen enclosures in hurricane-prone regions shall be in accordance with the provisions of this section.

AH106.1.1 Habitable spaces.
Screen enclosures shall not be considered habitable spaces.

AH106.1.2 Minimum ceiling height.
Screen enclosures shall have a ceiling height of not less than 7 feet (2134 mm).

AH106.2 Definition.
The following word and term shall, for the purposes of this appendix, have the meaning shown herein:
SCREEN ENCLOSURE. A building or part thereof, in whole or in part self-supporting, and having walls of insect screening, and a roof of insect screening, plastic, aluminum or similar lightweight material.

AH106.3 Screen enclosures.
Screen enclosures shall comply with Sections AH106.3.1 and AH106.3.2.

AH106.3.1 Thickness.
Actual wall thickness of extruded aluminum members shall be not less than 0.040 inch (1.02 mm).

AH106.3.2 Density.
Screen density shall be not more than 20 threads per inch by 20 threads per inch mesh.

AH106.4 Design.
The structural design of screen enclosures shall comply with Sections AH106.4.1 through AH106.4.3.

**TABLE AH106.4(1)**

<table>
<thead>
<tr>
<th>LOAD CASE</th>
<th>WALL</th>
<th>ULTIMATE DESIGN WIND SPEED, $V_{ult}$ (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td>Windward and leeward walls (flow thru) and windward wall (nonflow thru) $L/W = 0.1$</td>
<td>6</td>
</tr>
<tr>
<td>A</td>
<td>Windward and leeward walls (flow thru) and windward wall (nonflow thru) $L/W = 2$</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>Windward: Nongable roof</td>
<td>9</td>
</tr>
<tr>
<td>B</td>
<td>Windward: Gable roof</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>ROOF</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>Roof-screen</td>
<td>2</td>
</tr>
<tr>
<td>All</td>
<td>Roof-solid</td>
<td>7</td>
</tr>
</tbody>
</table>

For SI: 1 mile per hour = 0.44 m/s, 1 pound per square foot = 0.0479 kPa, 1 foot = 304.8 mm.

a. Design pressure shall be not less than 10 psf in accordance with Section AH106.4.1.
b. Loads are applicable to screen enclosures with a mean roof height of 30 feet or less in Exposure B. For screen enclosures of different heights or exposure, the pressures given shall be adjusted by multiplying the table pressure by the adjustment factor given in Table AH106.4(2).
c. For Load Case A, flow thru condition, the pressure given shall be applied simultaneously to both the upwind and downwind screen walls acting in the same direction as the wind. The structure shall also be analyzed for wind...
coming from the opposite direction. For the nonflow thru condition, the screen enclosure wall shall be analyzed for the load applied acting toward the interior of the enclosure.

d. For Load Case B, the table pressure multiplied by the projected frontal area of the screen enclosure is the total drag force, including drag on screen surfaces parallel to the wind, that must be transmitted to the ground. Use Load Case A for members directly supporting the screen surface perpendicular to the wind. Load Case B loads shall be applied only to structural members that carry wind loads from more than one surface.

e. The roof structure shall be analyzed for the pressure given occurring both upward and downward.

f. Table pressures are MWERS loads. The design of solid roof panels and their attachments shall be based on component and cladding loads for enclosed or partially enclosed structures as appropriate.

g. Table pressures apply to 20-inch by 20-inch by 0.013-inch mesh screen. For 18-inch by 14-inch by 0.013-inch mesh screen, pressures on screen surfaces shall be permitted to be multiplied by 0.88. For screen densities greater than 20 inches by 20 inches by 0.013-inch, pressures for enclosed buildings shall be used.

h. Linear interpolation shall be permitted.

### TABLE AH106.4(2)

<table>
<thead>
<tr>
<th>MEAN ROOF HEIGHT (feet)</th>
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<tr>
<td></td>
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<td>C</td>
</tr>
<tr>
<td>15</td>
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<td>1.21</td>
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<tr>
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<tr>
<td>60</td>
<td>1.22</td>
<td></td>
<td>1.62</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.

### AH106.4.1 Wind load.

Structural members supporting screen enclosures shall be designed to support the minimum wind loads given in Tables AH106.4(1) and AH106.4(2) for the ultimate design wind speed, $V_{ult}$, determined from Figure AH106.4.1. Where any value is less than 10 pounds per square foot (0.479 kN/m$^2$), 10 pounds per square foot (0.479 kN/m$^2$) use 10 pounds per square foot (0.479 kN/m$^2$).
AH106.2 Deflection limit.
For members supporting screen surfaces only, the total load deflection shall not exceed \( \frac{l}{60} \).
Screen surfaces shall be permitted to include not more than 25-percent solid flexible finishes.

AH106.3 Roof live load.
The roof live load shall be not less than 10 psf (0.479 kN/m\(^2\)).

AH106.5 Footings.
In areas with a frost line depth of zero, a screen enclosure shall be permitted to be supported on a concrete slab on grade without footings, provided the slab conforms to the provisions of Section R506, is not less than \( 3\frac{1}{2} \) inches (89 mm) thick and the columns do not support loads in excess of 750 pounds (3.36 kN) per column.
APPENDIX I
PRIVATE SEWAGE DISPOSAL

Deleted

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AI101
GENERAL

AI101.1 Scope.
Private sewage disposal systems shall conform to the International Private Sewage Disposal Code.
APPENDIX J

EXISTING BUILDINGS AND STRUCTURES

Deleted. See North Carolina Existing Building Code.

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AJ101
PURPOSE AND INTENT

AJ101.1 General.
The purpose of these provisions is to encourage the continued use or reuse of legally existing buildings and structures. These provisions are intended to permit work in existing buildings that is consistent with the purpose of this code. Compliance with these provisions shall be deemed to meet the requirements of this code.

AJ101.2 Classification of work.
For purposes of this appendix, work in existing buildings shall be classified into the categories of repair, renovation, alteration and reconstruction. Specific requirements are established for each category of work in these provisions.

AJ101.3 Multiple categories of work.
Work of more than one category shall be part of a single work project. Related work permitted within a 12-month period shall be considered to be a single work project. Where a project includes one category of work in one building area and another category of work in a separate and unrelated area of the building, each project area shall comply with the requirements of the respective category of work. Where a project with more than one category of work is performed in the same area or in related areas of the building, the project shall comply with the requirements of the more stringent category of work.

SECTION AJ102
COMPLIANCE

AJ102.1 General.
Regardless of the category of work being performed, the work shall not cause the structure to become unsafe or adversely affect the performance of the building; shall not cause an existing mechanical or plumbing system to become unsafe, hazardous, insanitary or overloaded; and unless expressly permitted by these provisions, shall not make the building any less compliant with this code or to any previously approved alternative arrangements than it was before the work was undertaken.

AJ102.2 Requirements by category of work.
Repairs shall conform to the requirements of Section AJ301. Renovations shall conform to the requirements of Section AJ401. Alterations shall conform to the requirements of Section AJ501 and the requirements for renovations. Reconstructions shall conform to the requirements of Section AJ601 and the requirements for alterations and renovations.
**AJ102.3 Smoke detectors.**
Regardless of the category of work, smoke detectors shall be provided where required by Section R314.3.1.

**AJ102.4 Replacement windows.**
Regardless of the category of work, where an existing window, including the sash and glazed portion, or safety glazing is replaced, the replacement window or safety glazing shall comply with the requirements of Sections AJ102.4.1 through AJ102.4.3, as applicable.

**AJ102.4.1 Energy efficiency.**
Replacement windows shall comply with the requirements of Chapter 11.

**AJ102.4.2 Safety glazing.**
Replacement glazing in hazardous locations shall comply with the safety glazing requirements of Section R308.

**AJ102.4.3 Emergency escape and rescue openings.**
Where windows are required to provide emergency escape and rescue openings, replacement windows shall be exempt from the maximum sill height requirements of Section R310.1 and the requirements of Sections R310.1.1, R310.1.2, R310.1.3 and R310.2 provided that the replacement window meets the following conditions:

1. The replacement window is the manufacturer’s largest standard size window that will fit within the existing frame or existing rough opening. The replacement window shall be permitted to be of the same operating style as the existing window or a style that provides for an equal or greater window opening area than the existing window.

2. The replacement window is not part of a change of occupancy.

3. Window opening control devices complying with ASTM F 2090 shall be permitted for use on windows required to provide emergency escape and rescue openings.

**AJ102.4.4 Window control devices.**
Where window fall prevention devices complying with ASTM F 2090 are not provided, window opening control devices complying with ASTM F 2090 shall be installed where an existing window is replaced and where all of the following apply to the replacement window:

1. The window is operable.

2. The window replacement includes replacement of the sash and the frame.

3. The top of the sill of the window opening is at a height less than 24 inches (610 mm) above the finished floor.

4. The window will permit openings that will allow passage of a 4-inch-diameter (102 mm) sphere where the window is in its largest opened position.
5. The vertical distance from the top of the sill of the window opening to the finished grade or other surface below, on the exterior of the building, is greater than 72 inches (1829 mm).

The window opening control device, after operation to release the control device allowing the window to fully open, shall not reduce the minimum net clear opening area of the window unit.

AJ102.5 Flood hazard areas.
Work performed in existing buildings located in a flood hazard area as established by Table R301.2(1) shall be subject to the provisions of Section R105.3.1.1.

AJ102.6 Equivalent alternatives.
Work performed in accordance with the International Existing Building Code shall be deemed to comply with the provisions of this appendix. These provisions are not intended to prevent the use of any alternative material, alternative design or alternative method of construction not specifically prescribed herein, provided that any alternative has been deemed to be equivalent and its use authorized by the building official.

AJ102.7 Other alternatives.
Where compliance with these provisions or with this code as required by these provisions is technically infeasible or would impose disproportionate costs because of construction or dimensional difficulties, the building official shall have the authority to accept alternatives. These alternatives include materials, design features and operational features.

AJ102.8 More restrictive requirements.
Buildings or systems in compliance with the requirements of this code for new construction shall not be required to comply with any more restrictive requirement of these provisions.

AJ102.9 Features exceeding code requirements.
Elements, components and systems of existing buildings with features that exceed the requirements of this code for new construction, and are not otherwise required as part of approved alternative arrangements or deemed by the building official to be required to balance other building elements not complying with this code for new construction, shall not be prevented by these provisions from being modified as long as they remain in compliance with the applicable requirements for new construction.

SECTION AJ103
PRELIMINARY MEETING

AJ103.1 General.
If a building permit is required at the request of the prospective permit applicant, the building official or his or her designee shall meet with the prospective applicant to discuss plans for any proposed work under these provisions prior to the application for the permit. The purpose of this preliminary meeting is for the building official to gain an understanding of the prospective applicant’s intentions for the proposed work, and to determine, together with the prospective applicant, the specific applicability of these provisions.

SECTION AJ104
EVALUATION OF AN EXISTING BUILDING
AJ104.1 General.
The building official shall have the authority to require an existing building to be investigated and evaluated by a registered design professional in the case of proposed reconstruction of any portion of a building. The evaluation shall determine the existence of any potential nonconformities to these provisions, and shall provide a basis for determining the impact of the proposed changes on the performance of the building. The evaluation shall use the following sources of information, as applicable:

1. Available documentation of the existing building.
   1.1 Field surveys.
   1.2 Tests (nondestructive and destructive).
   1.3 Laboratory analysis.

Exception: Detached one- or two-family dwellings that are not irregular buildings under Section R301.2.2.5 and are not undergoing an extensive reconstruction shall not be required to be evaluated.

SECTION AJ105
PERMIT

AJ105.1 Identification of work area.
The work area shall be clearly identified on the permits issued under these provisions.

SECTION AJ201
DEFINITIONS

AJ201.1 General.
For purposes of this appendix, the terms used are defined as follows.

ALTERATION. The reconfiguration of any space; the addition or elimination of any door or window; the reconfiguration or extension of any system; or the installation of any additional equipment.

CATEGORIES OF WORK. The nature and extent of construction work undertaken in an existing building. The categories of work covered in this appendix, listed in increasing order of stringency of requirements, are repair, renovation, alteration and reconstruction.

DANGEROUS. Where the stresses in any member; the condition of the building, or any of its components or elements or attachments; or other condition that results in an overload exceeding 150 percent of the stress allowed for the member or material in this code.

EQUIPMENT OR FIXTURE. Any plumbing, heating, electrical, ventilating, air-conditioning, refrigerating and fire protection equipment; and elevators, dumb waiters, boilers, pressure vessels, and other mechanical facilities or installations that are related to building services.
LOAD-BEARING ELEMENT. Any column, girder, beam, joist, truss, rafter, wall, floor or roof sheathing that supports any vertical load in addition to its own weight, or any lateral load.

MATERIALS AND METHODS REQUIREMENTS. Those requirements in this code that specify material standards; details of installation and connection; joints; penetrations; and continuity of any element, component or system in the building. The required quantity, fire resistance, flame spread, acoustic or thermal performance, or other performance attribute is specifically excluded from materials and methods requirements.

RECONSTRUCTION. The reconfiguration of a space that affects an exit, a renovation or alteration where the work area is not permitted to be occupied because existing means-of-egress and fire protection systems, or their equivalent, are not in place or continuously maintained; or there are extensive alterations as defined in Section AJ501.3.

REHABILITATION. Any repair, renovation, alteration or reconstruction work undertaken in an existing building.

RENOVATION. The change, strengthening or addition of load-bearing elements; or the refinishing, replacement, bracing, strengthening, upgrading or extensive repair of existing materials, elements, components, equipment or fixtures. Renovation does not involve reconfiguration of spaces. Interior and exterior painting are not considered refinishing for purposes of this definition, and are not renovation.

REPAIR. The patching, restoration or minor replacement of materials, elements, components, equipment or fixtures for the purposes of maintaining those materials, elements, components, equipment or fixtures in good or sound condition.

WORK AREA. That portion of a building affected by any renovation, alteration or reconstruction work as initially intended by the owner and indicated as such in the permit. Work area excludes other portions of the building where incidental work entailed by the intended work must be performed, and portions of the building where work not initially intended by the owner is specifically required by these provisions for a renovation, alteration or reconstruction.

SECTION AJ301
REPAIRS

AJ301.1 Materials.
Except as otherwise required herein, work shall be done using like materials or materials permitted by this code for new construction.

AJ301.1.1 Hazardous materials.
Hazardous materials no longer permitted, such as asbestos and lead-based paint, shall not be used.

AJ301.1.2 Plumbing materials and supplies.
The following plumbing materials and supplies shall not be used:

1. All-purpose solvent cement, unless listed for the specific application.
2. Flexible traps and tailpieces, unless listed for the specific application.

3. Solder having more than 0.2 percent lead in the repair of potable water systems.

**AJ301.2 Water closets.**
Where any water closet is replaced with a newly manufactured water closet, the replacement water closet shall comply with the requirements of Section P2903.2.

**AJ301.3 Electrical.**
Repair or replacement of existing electrical wiring and equipment undergoing repair with like material shall be permitted.

**Exceptions:**

1. Replacement of electrical receptacles shall comply with the requirements of Chapters 34 through 43.

2. Plug fuses of the Edison-base type shall be used for replacements only where there is not evidence of overfusing or tampering in accordance with the applicable requirements of Chapters 34 through 43.

3. For replacement of nongrounding-type receptacles with grounding-type receptacles and for branch circuits that do not have an equipment grounding conductor in the branch circuitry, the grounding conductor of a grounding-type receptacle outlet shall be permitted to be grounded to any accessible point on the grounding electrode system, or to any accessible point on the grounding electrode conductor, as allowed and described in Chapters 34 through 43.

**SECTION AJ401**
**RENOVATIONS**

**AJ401.1 Materials and methods.**
The work shall comply with the materials and methods requirements of this code.

**AJ401.2 Door and window dimensions.**
Minor reductions in the clear opening dimensions of replacement doors and windows that result from the use of different materials shall be allowed, whether or not they are permitted by this code.

**AJ401.3 Interior finish.**
Wood paneling and textile wall coverings used as an interior finish shall comply with the flame spread requirements of Section R302.9.

**AJ401.4 Structural.**
Unreinforced masonry buildings located in Seismic Design Category D_2_ or E shall have parapet bracing and wall anchors installed at the roofline whenever a reroofing permit is issued. Such parapet bracing and wall anchors shall be of an approved design.
SECTION AJ501
ALTERATIONS

AJ501.1 Newly constructed elements.
Newly constructed elements, components and systems shall comply with the requirements of this code.

Exceptions:

1. Openable windows may be added without requiring compliance with the light and ventilation requirements of Section R303.

2. Newly installed electrical equipment shall comply with the requirements of Section AJ501.5.

AJ501.2 Nonconformities.
The work shall not increase the extent of noncompliance with the requirements of Section AJ601, or create nonconformity to those requirements that did not previously exist.

AJ501.3 Extensive alterations.
Where the total area of all of the work areas included in an alteration exceeds 50 percent of the area of the dwelling unit, the work shall be considered to be a reconstruction and shall comply with the requirements of these provisions for reconstruction work.

Exception: Work areas in which the alteration work is exclusively plumbing, mechanical or electrical shall not be included in the computation of the total area of all work areas.

AJ501.4 Structural.
The minimum design loads for the structure shall be the loads applicable at the time the building was constructed, provided that a dangerous condition is not created. Structural elements that are uncovered during the course of the alteration and that are found to be unsound or dangerous shall be made to comply with the applicable requirements of this code.

AJ501.5 Electrical equipment and wiring.

AJ501.5.1 Materials and methods.
Newly installed electrical equipment and wiring relating to work done in any work area shall comply with the materials and methods requirements of Chapters 34 through 43.

Exception: Electrical equipment and wiring in newly installed partitions and ceilings shall comply with the applicable requirements of Chapters 34 through 43.

AJ501.5.2 Electrical service.
Service to the dwelling unit shall be not less than 100 ampere, three-wire capacity and service equipment shall be dead front having no live parts exposed that could allow accidental contact. Type “S” fuses shall be installed where fused equipment is used.
Exception: Existing service of 60 ampere, three-wire capacity, and feeders of 30 ampere or larger two- or three-wire capacity shall be accepted if adequate for the electrical load being served.

AJ501.5.3 Additional electrical requirements.
Where the work area includes any of the following areas within a dwelling unit, the requirements of Sections AJ501.5.3.1 through AJ501.5.3.5 shall apply.

AJ501.5.3.1 Enclosed areas.
Enclosed areas other than closets, kitchens, basements, garages, hallways, laundry areas and bathrooms shall have not less than two duplex receptacle outlets, or one duplex receptacle outlet and one ceiling- or wall-type lighting outlet.

AJ501.5.3.2 Kitchen and laundry areas.
Kitchen areas shall have not less than two duplex receptacle outlets. Laundry areas shall have not less than one duplex receptacle outlet located near the laundry equipment and installed on an independent circuit.

AJ501.5.3.3 Ground-fault circuit-interruption.
Ground-fault circuit-interruption shall be provided on newly installed receptacle outlets if required by Chapters 34 through 43.

AJ501.5.3.4 Lighting outlets.
Not less than one lighting outlet shall be provided in every bathroom, hallway, stairway, attached garage and detached garage with electric power to illuminate outdoor entrances and exits, and in utility rooms and basements where these spaces are used for storage or contain equipment requiring service.

AJ501.5.3.5 Clearance.
Clearance for electrical service equipment shall be provided in accordance with Chapters 34 through 43.

AJ501.6 Ventilation.
Reconfigured spaces intended for occupancy and spaces converted to habitable or occupiable space in any work area shall be provided with ventilation in accordance with Section R303.

AJ501.7 Ceiling height.
Habitable spaces created in existing basements shall have ceiling heights of not less than 6 feet, 8 inches (2032 mm), except that the ceiling height at obstructions shall be not less than 6 feet 4 inches (1930 mm) from the basement floor. Existing finished ceiling heights in nonhabitable spaces in basements shall not be reduced.

AJ501.8 Stairs.

AJ501.8.1 Stair width.
Existing basement stairs and handrails not otherwise being altered or modified shall be permitted to maintain their current clear width at, above and below existing handrails.

AJ501.8.2 Stair headroom.
Headroom height on existing basement stairs being altered or modified shall not be reduced.
AJ501.8.3 Stair landing.
Landings serving existing basement stairs being altered or modified shall not be reduced below the existing stairway landing depth and width. Existing basement stairs not otherwise being altered shall be permitted to maintain the current landing depth and width.

SECTION AJ601
RECONSTRUCTION

AJ601.1 Stairways, handrails and guards.

AJ601.1.1 Stairways.
Stairways within the work area shall be provided with illumination in accordance with Section R303.6.

AJ601.1.2 Handrails.
Every required exit stairway that has four or more risers, is part of the means of egress for any work area, and is not provided with at least one handrail, or in which the existing handrails are judged to be in danger of collapsing, shall be provided with handrails designed and installed in accordance with Section R311 for the full length of the run of steps on not less than one side.

AJ601.1.3 Guards.
Every open portion of a stair, landing or balcony that is more than 30 inches (762 mm) above the floor or grade below, is part of the egress path for any work area, and does not have guards, or in which the existing guards are judged to be in danger of collapsing, shall be provided with guards designed and installed in accordance with Section R312.

AJ601.2 Wall and ceiling finish.
The interior finish of walls and ceilings in any work area shall comply with the requirements of Section R302.9. Existing interior finish materials that do not comply with those requirements shall be removed or shall be treated with an approved fire-retardant coating in accordance with the manufacturer’s instructions to secure compliance with the requirements of this section.

AJ601.3 Separation walls.
Where the work area is in an attached dwelling unit, walls separating dwelling units that are not continuous from the foundation to the underside of the roof sheathing shall be constructed to provide a continuous fire separation using construction materials consistent with the existing wall or complying with the requirements for new structures. Performance of work shall be required only on the side of the wall of the dwelling unit that is part of the work area.

AJ601.4 Ceiling height.
Habitable spaces created in existing basements shall have ceiling heights of not less than 6 feet, 8 inches (2032 mm), except that the ceiling height at obstructions shall be not less than 6 feet 4 inches (1930 mm) from the basement floor. Existing finished ceiling heights in nonhabitable spaces in basements shall not be reduced.
APPENDIX K
SOUND TRANSMISSION

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

(The provisions contained in this appendix are adopted as part of this code.)

SECTION AK101
GENERAL

AK101.1 General.
Wall and floor-ceiling assemblies separating dwelling units, including those separating adjacent townhouse units, shall provide air-borne sound insulation for walls, and both air-borne and impact sound insulation for floor-ceiling assemblies.

SECTION AK102
AIR-BORNE SOUND

AK102.1 General.
Air-borne sound insulation for wall and floor-ceiling assemblies shall meet a sound transmission class (STC) rating of 45 when tested in accordance with ASTM E 90. Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required ratings. Dwelling unit entrance doors, which share a common space, shall be tight fitting to the frame and sill.

AK102.1.1 Masonry.
The sound transmission class of concrete masonry and clay masonry assemblies shall be calculated in accordance with TMS 0302 or determined through testing in accordance with ASTM E 90.

SECTION AK103
STRUCTURAL-BORNE SOUND

AK103.1 General.
Floor/ceiling assemblies between dwelling units, or between a dwelling unit and a public or service area within a structure, shall have an impact insulation class (IIC) rating of not less than 45 when tested in accordance with ASTM E 492.

SECTION AK104
REFERENCED STANDARDS

ASTM
ASTM E 90—04 Test Method for Laboratory Measurement of Air-borne Sound

2018 North Carolina Residential Code
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<td>ASTM E 492—09</td>
<td>Specification for Laboratory Measurement of Impact Sound Transmission through Floor-ceiling Assemblies Using the Tapping Machine</td>
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<td>The Masonry Society TMS 0302—12</td>
<td>Standard for Determining the Sound Transmission Class Rating for Masonry Walls</td>
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APPENDIX L
PERMIT FEES

(Deleted)

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

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<td>$100,001 to $500,000</td>
<td>$1,027 for the first $100,000; plus $7 for each additional $1,000 or fraction thereof, up to and including $500,000</td>
</tr>
<tr>
<td>$500,001 to $1,000,000</td>
<td>$3,827 for the first $500,000; plus $5 for each additional $1,000 or fraction thereof, up to and including $1,000,000</td>
</tr>
<tr>
<td>$1,000,001 to $5,000,000</td>
<td>$6,327 for the first $1,000,000; plus $3 for each additional $1,000 or fraction thereof, up to and including $5,000,000</td>
</tr>
<tr>
<td>$5,000,001 and over</td>
<td>$18,327 for the first $5,000,000; plus $1 for each additional $1,000 or fraction thereof, up to and including $5,000,000</td>
</tr>
</tbody>
</table>
APPENDIX M

HOME DAY CARE—R-3 OCCUPANCY

WOOD DECKS

This appendix is a North Carolina addition and not part of the 2015 International Residential Code. There will be no underlined text.
(The provisions contained in this appendix are adopted as part of this code.)

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AM101
GENERAL

AM101.1 General.
This appendix shall apply to a home day care operated within a dwelling. It is to include buildings and structures occupied by persons of any age who receive custodial care for less than 24 hours by individuals other than parents or guardians or relatives by blood, marriage, or adoption, and in a place other than the home of the person cared for.

SECTION AM102
DEFINITION

EXIT ACCESS. That portion of a means-of-egress system that leads from any occupied point in a building or structure to an exit.

SECTION AM103
MEANS OF EGRESS

AM103.1 Exits required.
If the occupant load of the residence is more than nine, including those who are residents, during the time of operation of the day care, two exits are required from the ground-level story. Two exits are required from a home day care operated in a manufactured home regardless of the occupant load. Exits shall comply with Section R311.

AM103.1.1 Exit access prohibited.
An exit access from the area of day care operation shall not pass through bathrooms, bedrooms, closets, garages, fenced rear yards or similar areas.

Exception: An exit may discharge into a fenced yard if the gate or gates remain unlocked during day care hours. The gates may be locked if there is an area of refuge.
located within the fenced yard and more than 50 feet (15 240 mm) from the dwelling. The area of refuge shall be large enough to allow 5 square feet (0.5 m²) per occupant.

**AM103.1.2 Basements.**
If the basement of a dwelling is to be used in the day care operation, two exits are required from the basement regardless of the occupant load. One of the exits may pass through the dwelling and the other must lead directly to the exterior of the dwelling.

**Exception:** An emergency and escape window complying with Section R310 and which does not conflict with Section AM103.1.1 may be used as the second means of egress from a basement.

**AM103.1.3 Yards.**
If the yard is to be used as part of the day care operation it shall be fenced.

**AM103.1.3.1 Type of fence and hardware.**
The fence shall be of durable materials and be at least 6 feet (1829 mm) tall, completely enclosing the area used for the day care operations. Each opening shall be a gate or door equipped with a self-closing and self-latching device to be installed at a minimum of 5 feet (1528 mm) above the ground.

**Exception:** The door of any dwelling which forms part of the enclosure need not be equipped with self-closing and self-latching devices.

**AM103.1.3.2 Construction of fence.**
Openings in the fence, wall or enclosure required by this section shall have intermediate rails or an ornamental pattern that do not allow a sphere 4 inches (102 mm) in diameter to pass through. In addition, the following criteria must be met:

1. The maximum vertical clearance between grade and the bottom of the fence, wall or enclosure shall be 2 inches (51 mm).

2. Solid walls or enclosures that do not have openings, such as masonry or stone walls, shall not contain indentations or protrusions, except for tooled masonry joints.

3. Maximum mesh size for chain link fences shall be \[1\frac{1}{4}\] inches (32 mm) square, unless the fence has slats at the top or bottom which reduce the opening to no more than \[1\frac{3}{4}\] inches (44 mm). The wire shall be not less than 9 gage [0.148 inch (3.8 mm)].

**AM103.1.3.3 Decks.**
Decks that are more than 12 inches (305 mm) above grade shall have a guard in compliance with Section R312.
AM103.2 Width and height of an exit.
The minimum width of a required exit is 36 inches (914 mm) with a net clear width of 32 inches (813 mm). The minimum height of a required exit is 6 feet, 8 inches (2032 mm).

AM103.3 Type of lock and latches for exits.
Regardless of the occupant load served, exit doors shall be openable from the inside without the use of a key or any special knowledge or effort. When the occupant load is 10 or less, a night latch, dead bolt or security chain may be used, provided such devices are openable from the inside without the use of a key or tool, and mounted at a height not to exceed 48 inches (1219 mm) above the finished floor.

AM103.4 Landings.
Landings for stairways and doors shall comply with Section R311, except that landings shall be required for the exterior side of a sliding door when a home day care is being operated in a Group R-3 occupancy.

SECTION AM104
SMOKE DETECTION

AM104.1 General.
Smoke detectors shall be installed in dwelling units used for home day care operations. Detectors shall be installed in accordance with the approved manufacturer’s instructions. If the current smoke detection system in the dwelling is not in compliance with the currently adopted code for smoke detection, it shall be upgraded to meet the currently adopted code requirements and Section AM103 before day care operations commence.

AM104.2 Power source.
Required smoke detectors shall receive their primary power from the building wiring when that wiring is served from a commercial source and shall be equipped with a battery backup. The detector shall emit a signal when the batteries are low. Wiring shall be permanent and without a disconnecting switch other than those required for overcurrent protection. Required smoke detectors shall be interconnected so if one detector is activated, all detectors are activated.

AM104.3 Location.
A detector shall be located in each bedroom and any room that is to be used as a sleeping room, and centrally located in the corridor, hallway or area giving access to each separate sleeping area. When the dwelling unit has more than one story, and in dwellings with basements, a detector shall be installed on each story and in the basement. In dwelling units where a story or basement is split into two or more levels, the smoke detector shall be installed on the upper level, except that when the lower level contains a sleeping area, a detector shall be installed on each level. When sleeping rooms are on the upper level, the detector shall be placed at the ceiling of the upper level in close proximity to the stairway. In dwelling units where the ceiling height of a room open to the hallway serving the bedrooms or sleeping areas exceeds that of the hallway by 24 inches (610 mm) or more, smoke detectors shall be installed in the hallway and the adjacent room. Detectors shall sound an alarm audible in all sleeping areas of the dwelling unit in which they are located.
AM101.1 General.
A deck is an exposed exterior wood floor structure which is permitted to be attached to the structure or freestanding. Roofed porches (open or screened-in) are permitted to be constructed using these provisions.

AM101.2 Deck design.
Computer deck design programs are permitted to be accepted by the code official.

SECTION AM102
FOOTINGS

AM102.1 Footings.
Support posts shall be supported by a minimum footing in accordance with Figure AM102.1(1) and Table AM102.1. Minimum footing depth shall be 12 inches (305 mm) below finished grade in accordance with Section R403.1.4. Tributary area is calculated as shown in Figure AM102.1(2).

![Figure AM102.1(1)
SUPPORT POST FOOTING](image)

<table>
<thead>
<tr>
<th>SIZE (inches)</th>
<th>TRIBUTARY AREA (sq. ft.)</th>
<th>THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A x A</td>
<td>B x C</td>
<td></td>
</tr>
<tr>
<td>8 x 16</td>
<td>8 x 16</td>
<td>36</td>
</tr>
<tr>
<td>12 x 12</td>
<td>12 x 12</td>
<td>40</td>
</tr>
<tr>
<td>16 x 16</td>
<td>16 x 16</td>
<td>70</td>
</tr>
<tr>
<td>-</td>
<td>16 x 24</td>
<td>100</td>
</tr>
<tr>
<td>-</td>
<td>24 x 24</td>
<td>150</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929m².
a. Footing values are based on single floor and roof loads.

2018 North Carolina Residential Code
b. Support post must rest in center 1/3 of footing.
c. Top of footing shall be level for full bearing support of post.

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929m².

Note: Tributary area of shaded section on the free standing deck shown is 5’ x 6’ = 30 sq. ft. (2.79 m²) Code will require a minimum footing of 8” x 16” (203 mm x 406 mm) in accordance with Table AM102.1.

FIGURE AM102.1(2)
CALCULATED TRIBUTARY AREA

SECTION AM103
FLASHING

AM103.1 Flashing.
When attached to a structure, the structure to which attached shall have a treated wood band for the length of the deck, or corrosion-resistant flashing shall be used to prevent moisture from coming in contact with the untreated framing of the structure. Aluminum flashing shall not be used in conjunction with deck construction. The deck band and the structure band shall be constructed in contact with each other except on brick veneer structures and where plywood sheathing is required and properly flashed. Siding shall not be installed between the structure and the deck band. If attached to a brick structure, neither the flashing nor a treated band for brick structure is required. In addition, the treated deckband shall be constructed in contact with the brick veneer. Flashing shall be installed per Figure AM103.1.
AM104.1 Deck attachment.
When a deck is supported at the structure by attaching the deck to the structure, Tables AM104.1(1) and AM104.1(2) shall apply for attaching the deck band to the structure.

**TABLE AM104.1(1)**
DECK ATTACHMENT FOR ALL STRUCTURES EXCEPT BRICK VENEER

<table>
<thead>
<tr>
<th>FASTENERS</th>
<th>8' MAX JOIST SPAN&lt;sup&gt;a&lt;/sup&gt;</th>
<th>16' MAX JOIST SPAN&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8&quot; Hot dip galvanized bolts with nut and washer&lt;sup&gt;b&lt;/sup&gt; and 12d Common hot dip galvanized nails&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1 @ 3'-6&quot; o.c. and 2 @ 8&quot; o.c.</td>
<td>1 @ 1'-8&quot; o.c. and 3 @ 6&quot; o.c.</td>
</tr>
<tr>
<td>Self-Drilling Screw Fastener&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12&quot; o.c. staggered</td>
<td>6&quot; o.c. staggered</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm
a. Attachment interpolation between 8 foot and 16 foot joists span is allowed.
b. Minimum edge distance for bolts is 2 ½ inches.
c. Nails must penetrate the supporting structure band a minimum of 1 ½ inches.
d. Self-drilling screw fastener having a minimum shank diameter of 0.195 inches and a length long enough to penetrate through the supporting structure band. The structure band shall have a minimum depth of 1-1/8 inches. Screw shall be evaluated by an approved testing agency for allowable shear load for Southern Pine to Southern Pine lumber of 250 pounds and shall have a corrosion resistant finish equivalent to hot dip galvanized. Minimum edge distance for screws is 1-7/16 inches. A maximum of 1/2 inch thick wood structural panel is permitted to be located between the deck ledger and the structure band.

**TABLE AM104.1(2)**
DECK ATTACHMENT FOR BRICK VENEER STRUCTURES

<table>
<thead>
<tr>
<th>FASTENERS</th>
<th>8’ MAX JOIST SPANa</th>
<th>16’ MAX JOIST SPANa</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8” Hot dip galvanized bolts with nut and washerb</td>
<td>1 @ 2'-4” o.c.</td>
<td>1 @ 1'-4” o.c.</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4, 1 foot = 304.8 mm
a. Attachment interpolation between 8 foot and 16 foot joist span is allowed.
b. Minimum edge distance for bolts is 21/2 inches.

**AM104.1.1 Masonry ledge support.**
If the deck band is supported by a minimum of 1/2 inch (13 mm) masonry ledge along the foundation wall, 5/8 inch (16 mm) hot dip galvanized bolts with washers spaced at 48 inches (1219 mm) o.c. are permitted to be used for support.

**AM104.1.2 Other means of support.**
Joist hangers or other means of attachment are permitted to be connected to the house band and shall be properly flashed.

**SECTION AM105**
GIRDER SUPPORT AND SPAN

**AM105.1 General.**
Girders shall bear directly on the support post with the post attached at top to prevent lateral displacement or be connected to the side of the posts with two 5/8 inch (16 mm) hot dip galvanized bolts with nut and washer. Girder support is permitted to be installed in accordance with Figure AM105.1(1) for top mount; Figure AM105.1(2) for side mount and Figure AM105.1(3) for split girders. See Figure AM105.1(4) for cantilevered girders.
AM105.2 Girder span for uncovered porches and decks.

Maximum allowable spans for wood deck girders, as shown in Figure AM105.2, shall be in accordance with Table AM105.2. Girder plies shall be fastened with two rows of 10d (3-inch × 0.128-inch) nails minimum at 16 inches (406 mm) on center along each edge. Girders shall be
permitted to cantilever at each end up to one-fourth of the actual beam span. Splices of multispan beams shall be located at interior post locations.

**TABLE AM105.2**

**DECK GIRDER SPAN LENGTHS**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SIZE</th>
<th>DECK JOIST SPAN LESS THAN OR EQUAL TO:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(feet)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Southern pine</td>
<td>2 – 2 x 6</td>
<td>6-11</td>
</tr>
<tr>
<td></td>
<td>2 – 2 x 8</td>
<td>8-9</td>
</tr>
<tr>
<td></td>
<td>2 – 2 x 10</td>
<td>10-4</td>
</tr>
<tr>
<td></td>
<td>2 – 2 x 12</td>
<td>12-2</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 6</td>
<td>8-2</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 8</td>
<td>10-10</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 10</td>
<td>13-0</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 12</td>
<td>15-3</td>
</tr>
<tr>
<td>Douglas fir-larch, hem-fir, spruce-pine-fir, redwood, western cedars, ponderosa pine, red pine</td>
<td>3 x 6 or 2 – 2 x 6</td>
<td>5-5</td>
</tr>
<tr>
<td></td>
<td>3 x 8 or 2 – 2 x 8</td>
<td>6-10</td>
</tr>
<tr>
<td></td>
<td>3 x 10 or 2 – 2 x 10</td>
<td>8-4</td>
</tr>
<tr>
<td></td>
<td>3 x 12 or 2 – 2 x 12</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td>4 x 6</td>
<td>6-5</td>
</tr>
<tr>
<td></td>
<td>4 x 8</td>
<td>8-5</td>
</tr>
<tr>
<td></td>
<td>4 x 10</td>
<td>9-11</td>
</tr>
<tr>
<td></td>
<td>4 x 12</td>
<td>11-5</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 6</td>
<td>7-4</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 8</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 10</td>
<td>12-0</td>
</tr>
<tr>
<td></td>
<td>3 – 2 x 12</td>
<td>13-11</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound = 0.454 kg.

**FIGURE AM105.2**

**TYPICAL DECK GIRDER SPANS**
AM105.3 Girder span for roofed porches and decks.  
Girder spans for covered decks shall be in accordance with Tables R602.7(1) and (2).

SECTION AM106  
JOIST SPANS AND CANTILEVERS

AM106.1 Joist spans for uncovered porches and decks.  
Maximum allowable spans for wood deck joists, as shown in Figure AM106.1, shall be in accordance with Table AM106.1. Deck joists shall be permitted to cantilever not greater than one-fourth of the actual, adjacent joist span.

<table>
<thead>
<tr>
<th>TABLE AM106.1</th>
<th>DECK JOIST SPANS FOR COMMON LUMBER SPECIES&lt;sup&gt;f&lt;/sup&gt; (ft. - in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIES&lt;sup&gt;a&lt;/sup&gt;</td>
<td>SIZE</td>
</tr>
<tr>
<td>Southern pine</td>
<td>2 × 6</td>
</tr>
<tr>
<td></td>
<td>2 × 8</td>
</tr>
<tr>
<td></td>
<td>2 × 10</td>
</tr>
<tr>
<td></td>
<td>2 × 12</td>
</tr>
<tr>
<td>Douglas fir-larch</td>
<td>2 × 6</td>
</tr>
<tr>
<td></td>
<td>2 × 8</td>
</tr>
<tr>
<td></td>
<td>2 × 10</td>
</tr>
<tr>
<td></td>
<td>2 × 12</td>
</tr>
<tr>
<td>Redwood, western cedars, ponderosa pine&lt;sup&gt;d&lt;/sup&gt;, red pine</td>
<td>2 × 6</td>
</tr>
<tr>
<td></td>
<td>2 × 8</td>
</tr>
<tr>
<td></td>
<td>2 × 10</td>
</tr>
<tr>
<td></td>
<td>2 × 12</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound = 0.454 kg.

a. No. 2 grade with wet service factor.
b. Ground snow load, live load = 40 psf, dead load = 10 psf, L/D = 360.
c. Ground snow load, live load = 40 psf, dead load = 10 psf, L/D = 360 at main span, L/D = 180 at cantilever with a 220-pound point load applied to end.
d. Includes incising factor.
e. Northern species with no incising factor.
f. Cantilevered spans not exceeding the nominal depth of the joist are permitted.
AM106.1 Lateral restraint at supports.
Joist ends and bearing locations shall be provided with lateral restraint to prevent rotation. Where lateral restraint is provided by joist hangers or blocking between joists, their depth shall equal not less than 60 percent of the joist depth. Where lateral restraint is provided by rim joists, they shall be secured to the end of each joist with not less than (3) 10d (3-inch × 0.128-inch) nails or (3) No. 10 × 3-inch (76 mm) long wood screws.

AM106.2 Roofed porches and decks.
Joists spans shall be in accordance with Table R502.3.1(2) with 40 lbs per sq. ft. live load and 10 lbs per sq. ft. dead load. Cantilevered floor joists shall be in accordance with Table R502.3.3 (1).

SECTION AM107
FLOOR DECKING

AM107.1 Floor decking.
Floor decking shall be No. 2 grade treated Southern Pine or equivalent. The minimum floor decking thickness shall be in accordance with Table AM107.1.

<table>
<thead>
<tr>
<th>SPACING</th>
<th>DECKING (nominal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot; o.c.</td>
<td>1&quot; S4S</td>
</tr>
<tr>
<td>16&quot; o.c.</td>
<td>1&quot; T&amp;G</td>
</tr>
<tr>
<td>19.2&quot; o.c.</td>
<td>1 ¼&quot; S4S</td>
</tr>
<tr>
<td>24&quot;-36&quot; o.c.</td>
<td>2&quot; S4S</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4, 1 foot = 304.8 mm

SECTION AM108
POST HEIGHT

AM108.1 Post height.
Maximum height of deck support posts shall be in accordance with Table AM108.1.

<table>
<thead>
<tr>
<th>SPACING</th>
<th>DECK SUPPORT POST HEIGHT</th>
</tr>
</thead>
</table>

2018 North Carolina Residential Code
POST SIZE | MAXIMUM POST HEIGHT
---|---
4” x 4” | 8’-0”
6” x 6” | 20’-0”

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm

- This table is based on No. 2 Southern Pine posts.
- From top of footing to bottom of girder.
- Decks with post heights exceeding these requirements shall be designed by a registered design professional.

SECTION AM109 DECK BRACING

**AM109.1 Deck bracing.**

Decks shall be braced to provide lateral stability. Lateral stability shall be provided in accordance with one of the methods in Sections AM109.1.1 through AM109.1.5.

**AM109.1.1. Lateral bracing not required.**

When the deck floor height is less than 4 feet (1219 mm) above finished grade as shown in Figure AM109.1(1) and the deck is attached to the structure in accordance with Section AM104, lateral bracing is not required. Lateral bracing is not required for freestanding decks with a deck floor height 30 inches (762 mm) or less above finished grade.

**AM109.1.2. Knee bracing.**

4x4 wood knee braces are permitted to be provided on each column in both directions. The knee braces shall attach to each post at a point not less than 1/3 of the post length from the top of the post, and the braces shall be angled between 45 degrees (0.79 rad) and 60 degrees (1.05 rad) from the horizontal. Knee braces shall be bolted to the post and the girder/double band with one 5/8 inch (16 mm) hot dip galvanized bolt with nut and washer as shown in Figure AM109.1(2).

**AM109.1.3. Post embedment.**

For free standing decks without knee braces or diagonal bracing, lateral stability is permitted to be provided by embedding the post in accordance with Figure AM109.1(3) and Table AM109.1.

<table>
<thead>
<tr>
<th>POST SIZE</th>
<th>MAXIMUM TRIBUTARY AREA</th>
<th>MAXIMUM POST HEIGHT</th>
<th>EMBEDMENT DEPTH</th>
<th>CONCRETE DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>4” x 4”</td>
<td>48 SF</td>
<td>4’-0”</td>
<td>2’-6”</td>
<td>1’-0”</td>
</tr>
<tr>
<td>6” x 6”</td>
<td>120 SF</td>
<td>6’-0”</td>
<td>3’-6”</td>
<td>1’-8”</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929 m².

**AM109.1.4. Cross bracing.**

2x6 diagonal vertical cross bracing is permitted to be provided in two perpendicular directions for free standing decks or parallel to the structure at the exterior column line for attached decks. The 2x6 bracing shall be attached to the posts with one 5/8 inch (16 mm)
hot dip galvanized bolt with nut and washer at each end of each bracing member per Figure AM109.1(4).

**AM109.1.5. Piles in coastal regions.**
For embedment of piles in coastal regions, see Chapter 46.

![Diagram of pile embedment](image)

For SI: 1 inch = 25.4, 1 foot = 304.8 mm

**FIGURE AM109.1(1)**
NO LATERAL BRACING

**FIGURE AM109.1(2)**
KNEE BRACING

For SI: 1 inch = 25.4, 1 foot = 304.8 mm

**FIGURE AM109.1(3)**
POST EMBEDMENT

**FIGURE AM109.1(4)**
CROSS BRACING

For SI: 1 inch = 25.4, 1 foot = 304.8 mm.

**SECTION AM110 STAIRS**

**AM110.1 Stair construction.**

2018 North Carolina Residential Code
Stringer spans shall be no greater than 7 feet (2134 mm) between supports. Spacing between stringers shall be based upon decking material used in accordance with AM107.1. Each stringer shall have a minimum of 3 ½ inches (89 mm) between step cut and back of stringer. If used, suspended headers shall be attached with 3/8 inch (9.5 mm) galvanized bolts with nuts and washers to securely support stringers at the top. See Figure AM 110.1.

For SI: 1 inch = 25.4, 1 foot = 304.8 mm.

FIGURE AM110.1
STAIR STRINGER
SECTION AM111
HANDRAILS, GUARDS AND GENERAL

AM111.1 Handrails, guards and general.
Deck handrails, guards and general construction shall be as shown in Figure AM111.1.

For SI: 1 inch = 25.4, 1 foot = 304.8 mm.

FIGURE AM111.1
DECK CONSTRUCTION

SECTION AM112
WALKWAYS IN OCEAN HAZARD AREAS

AM112.1 Walkways over dunes.
Walkways over dunes in ocean hazard areas shall be constructed as shown in Figure AM112.1.
FIGURE AM112.1
WALKWAYS OVER DUNES OR BERRMS IN OCEAN HAZARD AREAS

For SI: 1 inch = 25.4, 1 foot = 304.8 mm.
* Posts for walkways over dunes or berms shall be embedded a minimum depth of 4’ - 0” and post heights shall be limited to 5’- 0” above grade for 4×4 and 10’ - 0” above grade for 6 × 6. Walkways or portions of walkways over 4’ 0” in width shall comply with the requirements of Chapters 45 and 46. Maximum walkway surface height is 30” above grade without guard rails.
**Walkway stair runs are permitted to be greater than 12’ without a landing.
***Open risers permitted on ocean shoreline stair.
****Horizontal guards permitted to have maximum 18 inch opening on cross-over walkway and ocean shoreline stair.
APPENDIX N

VENTING METHODS

(This appendix is informative and is not part of the code. This appendix provides examples of various venting methods.)

For SI: 1 inch = 25.4 mm.

FIGURE N1
TYPICAL SINGLE-BATH WET-VENT ARRANGEMENTS
FIGURE N2
TYPICAL DOUBLE-BATH WET-VENT ARRANGEMENTS

FIGURE N3
TYPICAL HORIZONTAL WET VENTING
FIGURE N4

For SI: 1 inch = 25.4 mm.
TYPICAL METHODS OF WET VENTING

For SI: 1 inch = 25.4 mm.

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FIGURE N5
SINGLE STACK SYSTEM FOR A TWO-STORY DWELLING

FIGURE N6
WASTE STACK VENTING

For SI: 1 inch = 25.4 mm.
FIGURE N7
CIRCUIT VENT WITH ADDITIONAL NONCIRCUIT-VENTED BRANCH
APPENDIX O

AUTOMATIC VEHICULAR GATES

FOAM PLASTIC DIAGRAMS

This appendix is a North Carolina addition and not part of the 2015 International Residential Code. There will be no underlined text.
(The provisions contained in this appendix are adopted as part of this code.)

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AO101
GENERAL

AO101.1 General.
The provisions of this appendix shall control the design and construction of automatic vehicular gates installed on the lot of a one- or two-family dwelling.

SECTION AO102
DEFINITION

AO102.1 General.
For the purposes of these requirements, the term used shall be defined as follows and as set forth in Chapter 2.

VEHICULAR GATE. A gate that is intended for use at a vehicular entrance or exit to the lot of a one- or two-family dwelling, and that is not intended for use by pedestrian traffic.

SECTION AO103
AUTOMATIC VEHICULAR GATES

AO103.1 Vehicular gates intended for automation.
Vehicular gates intended for automation shall be designed, constructed and installed to comply with the requirements of ASTM F-2200.

AO103.2 Vehicular gate openers.
Vehicular gate openers, where provided, shall be listed in accordance with UL 325.
FIGURE O-1
FOUNDATION WALL
N1102.2.9 Basement walls with exterior foam insulation. Insulation illustrations – Section view of exterior foam insulation location for basement walls (Includes detailing from N1102.2.11)
SECTION VIEW OF MONOLITHIC SLAB-ON-GRADE INSULATION

FIGURE O-3
FRAME WALL

N1102.2.10 Slab insulation details. Insulation illustrations
N1102.2.10 Slab insulation details. Insulation illustrations - Example for slab edge insulation location behind brick, stone, or masonry facing (Other options may also compliant)
N102.2.10 Slab insulation details. Insulation illustrations – Examples for slab insulation location for floating slab with stem wall.
APPENDIX P
SIZING OF WATER PIPING SYSTEM

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

(The provisions contained in this appendix are adopted as part of this code.)

SECTION AP101
GENERAL

AP101.1 Scope.

AP101.1.1
This appendix outlines two procedures for sizing a water piping system (see Sections AP103.3 and AP201.1). The design procedures are based on the minimum static pressure available from the supply source, the head changes in the system caused by friction and elevation, and the rates of flow necessary for operation of various fixtures.

AP101.1.2
Because of the variable conditions encountered in hydraulic design, it is impractical to specify definite and detailed rules for sizing of the water piping system. Accordingly, other sizing or design methods conforming to good engineering practice standards are acceptable alternatives to those presented herein.

SECTION AP102
INFORMATION REQUIRED

AP102.1 Preliminary.
Obtain the necessary information regarding the minimum daily static service pressure in the area where the building is to be located. If the building supply is to be metered, obtain information regarding friction loss relative to the rate of flow for meters in the range of sizes likely to be used. Friction loss data can be obtained from most manufacturers of water meters.

AP102.2 Demand load.

AP102.2.1
Estimate the supply demand of the building main and the principal branches and risers of the system by totaling the corresponding demand from the applicable part of Table AP103.3(3).

AP102.2.2
Estimate continuous supply demands, in gallons per minute (gpm) (L/m), for lawn sprinklers, air conditioners, etc., and add the sum to the total demand for fixtures. The result is the estimated supply demand for the building supply.
SECTION AP103
SELECTION OF PIPE SIZE

AP103.1 General.
Decide from Table P2903.1 what is the desirable minimum residual pressure that should be maintained at the highest fixture in the supply system. If the highest group of fixtures contains flushometer valves, the pressure for the group should be not less than 15 pounds per square inch (psi) (103.4 kPa) flowing. For flush tank supplies, the available pressure should be not less than 8 psi (55.2 kPa) flowing, except blowout action fixtures must not be less than 25 psi (172.4 kPa) flowing.

AP103.2 Pipe sizing.

AP103.2.1
Pipe sizes can be selected using the following procedure or by use of other design methods conforming to acceptable engineering practice that are approved by the building official. The sizes selected must not be less than the minimum required by this code.

AP103.2.2
Water pipe sizing procedures are based on a system of pressure requirements and losses, the sum of which must not exceed the minimum pressure available at the supply source. These pressures are as follows:

1. Pressure required at fixture to produce required flow. See Sections P2903.1 of this code and Section 604.3 of the International Plumbing Code.

2. Static pressure loss or gain (due to head) is computed at 0.433 psi per foot (9.8 kPa/m) of elevation change.

   Example: Assume that the highest fixture supply outlet is 20 feet (6096 mm) above or below the supply source. This produces a static pressure differential of 8.66 psi (59.8 kPa) loss [20 feet by 0.433 psi per foot (2096 mm by 9.8 kPa/m)].

3. Loss through water meter. The friction or pressure loss can be obtained from meter manufacturers.

4. Loss through taps in water main.

5. Loss through special devices, such as filters, softeners, backflow prevention devices and pressure regulators. These values must be obtained from the manufacturer.

6. Loss through valves and fittings. Losses for these items are calculated by converting to the equivalent length of piping and adding to the total pipe length.

7. Loss caused by pipe friction can be calculated where the pipe size, pipe length and flow through the pipe are known. With these three items, the friction loss can be determined. For piping flow charts not included, use manufacturers’ tables and velocity recommendations.
**Note:** For all examples, the following metric conversions are applicable.

1 cubic foot per minute = 0.4719 L/s.

1 square foot = 0.0929 m$^2$.

1 degree = 0.0175 rad.

1 pound per square inch = 6.895 kPa.

1 inch = 25.4 mm.

1 foot = 304.8 mm.

1 gallon per minute = 3.785 L/m.

**AP103.3 Segmented loss method.**

The size of water service mains, branch mains and risers by the segmented loss method, must be determined by knowing the water supply demand [gpm (L/m)], available water pressure [psi (kPa)] and friction loss caused by the water meter and *developed length* of pipe [feet (m)], including the *equivalent length* of fittings. This design procedure is based on the following parameters:

1. The calculated friction loss through each length of pipe.

2. A system of pressure losses, the sum of which must not exceed the minimum pressure available at the street main or other source of supply.

3. Pipe sizing based on estimated peak demand, total pressure losses caused by difference in elevation, equipment, *developed length* and pressure required at the most remote fixture; loss through taps in water main; losses through fittings, filters, backflow prevention devices, valves and pipe friction.

Because of the variable conditions encountered in hydraulic design, it is impractical to specify definite and detailed rules for the sizing of the water piping system. Current sizing methods do not address the differences in the probability of use and flow characteristics of fixtures between types of occupancies. Creating an exact model of predicting the demand for a building is impossible and final studies assessing the impact of water conservation on demand are not yet complete. The following steps are necessary for the segmented loss method.

1. **Preliminary.** Obtain the necessary information regarding the minimum daily static service pressure in the area where the building is to be located. If the building supply is to be metered, obtain information regarding friction loss relative to the rate of flow for meters in the range of sizes to be used. Friction loss data can be obtained from manufacturers of water meters. Enough pressure must be available to overcome all system losses caused by friction and elevation so that plumbing fixtures operate properly. Section 604.6 of the *International Plumbing Code* requires that the water distribution system be designed for the minimum pressure available taking into consideration pressure fluctuations. The lowest pressure must be selected to guarantee...
a continuous, adequate supply of water. The lowest pressure in the public main usually occurs in the summer because of lawn sprinkling and supplying water for air-conditioning cooling towers. Future demands placed on the public main as a result of large growth or expansion should be considered. The available pressure will decrease as additional loads are placed on the public system.

2. **Demand load.** Estimate the supply demand of the building main and the principal branches and risers of the system by totaling the corresponding demand from the applicable part of Table AP103.3(3). When estimating peak demand, sizing methods typically use water supply fixture units (w.s.f.u.) [see Table AP103.3(2)]. This numerical factor measures the load-producing effect of a single plumbing fixture of a given kind. The use of fixture units can be applied to a single basic probability curve (or table), found in the various sizing methods [see Table AP103.3(3)]. The fixture units are then converted into a gpm (L/m) flow rate for estimating demand.

2.1. Estimate continuous supply demand in gpm (L/m) for lawn sprinklers, air conditioners, etc., and add the sum to the total demand for fixtures. The result is the estimated supply demand for the building supply. Fixture units cannot be applied to constant-use fixtures, such as hose bibbs, lawn sprinklers and air conditioners. These types of fixtures must be assigned the gpm (L/m) value.

3. **Selection of pipe size.** This water pipe sizing procedure is based on a system of pressure requirements and losses, the sum of which must not exceed the minimum pressure available at the supply source. These pressures are as follows:

3.1. Pressure required at the fixture to produce required flow. See Section P2903.1 of this code and Section 604.3 of the *International Plumbing Code*.

3.2. Static pressure loss or gain (because of head) is computed at 0.433 psi per foot (9.8 kPa/m) of elevation change.

3.3. Loss through a water meter. The friction or pressure loss can be obtained from the manufacturer.

3.4. Loss through taps in water main [see Table AP103.3(4)].

3.5. Loss through special devices, such as filters, softeners, backflow prevention devices and pressure regulators. These values must be obtained from the manufacturers.

3.6. Loss through valves and fittings [see Tables AP103.3(5) and AP103.3(6)]. Losses for these items are calculated by converting to the *equivalent length* of piping and adding to the total pipe length.

3.7. Loss caused by pipe friction can be calculated where the pipe size, pipe length and flow through the pipe are known. With these three items, the friction loss can be determined using Figures AP103.3(2) through AP103.3(7). Where using charts, use pipe inside diameters. For piping flow charts not included, use manufacturers’ tables and velocity recommendations. Before attempting to size any water supply system, it is necessary to gather preliminary information.
including available pressure, piping material, select design velocity, elevation differences and developed length to the most remote fixture. The water supply system is divided into sections at major changes in elevation or where branches lead to fixture groups. The peak demand must be determined in each part of the hot and cold water supply system. The expected flow through each section is determined in w.s.f.u. and converted to gpm (L/m) flow rate. Sizing methods require determination of the "most hydraulically remote" fixture to compute the pressure loss caused by pipe and fittings. The hydraulically remote fixture represents the most downstream fixture along the circuit of piping requiring the most available pressure to operate properly. Consideration must be given to all pressure demands and losses, such as friction caused by pipe, fittings and equipment; elevation; and the residual pressure required by Table P2903.1. The two most common and frequent complaints about water supply system operation are lack of adequate pressure and noise.

**Problem:** What size Type L copper water pipe, service and distribution will be required to serve a two-story factory building having on each floor, back-to-back, two toilet rooms each equipped with hot and cold water? The highest fixture is 21 feet above the street main, which is tapped with a 2-inch corporation cock at which point the minimum pressure is 55 psi. In the building basement, a 2-inch meter with a maximum pressure drop of 11 psi and 3-inch reduced pressure principle backflow preventer with a maximum pressure drop of 9 psi are to be installed. The system is shown in Figure AP103.3(1). To be determined are the pipe sizes for the service main, and the cold and hot water distribution pipes.

**Solution:** A tabular arrangement such as shown in Table AP103.3(1) should first be constructed. The steps to be followed are indicated by the tabular arrangement itself as they are in sequence, Columns 1 through 10 and Lines A through L.

**Step 1**

**Columns 1 and 2:** Divide the system into sections breaking at major changes in elevation or where branches lead to fixture groups. After Point B [see Figure AP103.3(1)], separate consideration will be given to the hot and cold water piping. Enter the sections to be considered in the service and cold water piping in Column 1 of the tabular arrangement. Column 1 of Table AP103.3(1) provides a line-by-line, recommended tabular arrangement for use in solving pipe sizing.

The objective in designing the water supply system is to ensure an adequate water supply and pressure to all fixtures and equipment. Column 2 provides the psi (kPa) to be considered separately from the minimum pressure available at the main. Losses to take into consideration are the following: the differences in elevations between the water supply source and the highest water supply outlet; meter pressure losses; the tap in main loss; special fixture devices, such as water softeners and backflow prevention devices; and the pressure required at the most remote fixture outlet.

The difference in elevation can result in an increase or decrease in available pressure at the main. Where the water supply outlet is located above the source, this results in a loss in the available pressure and is subtracted from the pressure at the water source. Where the highest water supply outlet is located below the water supply source, there will be an increase in pressure that is added to the available pressure of the water source.
**Column 3:** Using Table AP103.3(3), determine the gpm (L/m) of flow to be expected in each section of the system. These flows range from 28.6 to 108 gpm. Load values for fixtures must be determined as w.s.f.u. and then converted to a gpm rating to determine peak demand. Where calculating peak demands, the w.s.f.u. are added and then converted to the gpm rating. For continuous flow fixtures, such as hose bibs and lawn sprinkler systems, add the gpm demand to the intermittent demand of fixtures. For example, a total of 120 w.s.f.u. is converted to a demand of 48 gpm. Two hose bibs × 5 gpm demand = 10 gpm. Total gpm rating = 48.0 gpm + 10 gpm = 58.0 gpm demand.

**Step 2**

**Line A:** Enter the minimum pressure available at the main source of supply in Column 2. This is 55 psi (379.2 kPa). The local water authorities generally keep records of pressures at different times of the day and year. The available pressure can also be checked from nearby buildings or from fire department hydrant checks.

**Line B:** Determine from Table P2903.1 the highest pressure required for the fixtures on the system, which is 15 psi (103.4 kPa), to operate a flushometer valve. The most remote fixture outlet is necessary to compute the pressure loss caused by pipe and fittings, and represents the most downstream fixture along the circuit of piping requiring the available pressure to operate properly as indicated by Table P2903.1.

**Line C:** Determine the pressure loss for the meter size given or assumed. The total water flow from the main through the service as determined in Step 1 will serve to aid in the meter selected. There are three common types of water meters; the pressure losses are determined by the American Water Works Association Standards for displacement type, compound type and turbine type. The maximum pressure loss of such devices takes into consideration the meter size, safe operating capacity [gpm (L/m)] and maximum rates for continuous operations [gpm (L/m)]. Typically, equipment imparts greater pressure losses than piping.

**Line D:** Select from Table AP103.3(4) and enter the pressure loss for the tap size given or assumed. The loss of pressure through taps and tees in psi (kPa) is based on the total gpm (L/m) flow rate and size of the tap.

**Line E:** Determine the difference in elevation between the main and source of supply and the highest fixture on the system. Multiply this figure, expressed in feet (mm), by 0.43 psi. Enter the resulting psi (kPa) loss on Line E. The difference in elevation between the water supply source and the highest water supply outlet has a significant impact on the sizing of the water supply system. The difference in elevation usually results in a loss in the available pressure because the water supply outlet is generally located above the water supply source. The loss is caused by the pressure required to lift the water to the outlet. The pressure loss is subtracted from the pressure at the water source. Where the highest water supply outlet is located below the water source, there will be an increase in pressure that is added to the available pressure of the water source.

**Lines F, G and H:** The pressure losses through filters, backflow prevention devices or other special fixtures must be obtained from the manufacturer or estimated and entered on these lines. Equipment, such as backflow prevention devices, check valves, water softeners,
instantaneous, or tankless water heaters, filters and strainers, can impart a much greater pressure loss than the piping. The pressure losses can range from 8 to 30 psi.

Step 3

**Line I**: The sum of the pressure requirements and losses that affect the overall system (Lines B through H) is entered on this line. Summarizing the steps, all of the system losses are subtracted from the minimum water pressure. The remainder is the pressure available for friction, defined as the energy available to push the water through the pipes to each fixture. This force can be used as an average pressure loss, as long as the pressure available for friction is not exceeded. Saving a certain amount for available water supply pressures as an area incurs growth, or because of the aging of the pipe or equipment added to the system is recommended.

Step 4

**Line J**: Subtract Line I from Line A. This gives the pressure that remains available from overcoming friction losses in the system. This figure is a guide to the pipe size that is chosen for each section, incorporating the total friction losses to the most remote outlet (measured length is called developed length).

**Exception**: Where the main is above the highest fixture, the resulting psi (kPa) must be considered a pressure gain (static head gain) and omitted from the sums of Lines B through H and added to Line J.

The maximum friction head loss that can be tolerated in the system during peak demand is the difference between the static pressure at the highest and most remote outlet at no-flow conditions and the minimum flow pressure required at that outlet. If the losses are within the required limits, every run of pipe will be within the required friction head loss. Static pressure loss is at the most remote outlet in feet × 0.433 = loss in psi caused by elevation differences.

Step 5

**Column 4**: Enter the length of each section from the main to the most remote outlet (at Point E). Divide the water supply system into sections breaking at major changes in elevation or where branches lead to fixture groups.

Step 6

**Column 5**: Where selecting a trial pipe size, the length from the water service or meter to the most remote fixture outlet must be measured to determine the developed length. However, in systems having a flushometer valve or temperature-controlled shower at the topmost floors, the developed length would be from the water meter to the most remote flushometer valve on the system. A rule of thumb is that size will become progressively smaller as the system extends farther from the main source of supply. A trial pipe size can be arrived at by the following formula:

**Line J**: \((\text{Pressure available to overcome pipe friction}) \times 100/\text{equivalent length of run total developed length} \times \text{most remote fixture} \times \text{percentage factor of 1.5} \) (Note: a percentage
factor is used only as an estimate for friction losses imposed for fittings for initial trial pipe size) = psi (average pressure drop per 100 feet of pipe).

For trial pipe size, see Figure AP103.3(3) (Type L copper) based on 2.77 psi and 108 gpm = 2\(\frac{1}{2}\) inches. To determine the equivalent length of run to the most remote outlet, the developed length is determined and added to the friction losses for fittings and valves. The developed lengths of the designated pipe sections are as follows:

- A-B = 54 feet
- B-C = 8 feet
- C-D = 13 feet
- D-E = 150 feet
- Total developed length = 225 feet

The equivalent length of the friction loss in fittings and valves must be added to the developed length (most remote outlet). Where the size of fittings and valves is not known, the added friction loss should be approximated. A general rule that has been used is to add 50 percent of the developed length to allow for fittings and valves. For example, the equivalent length of run equals the developed length of run (225 feet × 1.5 = 338 feet). The total equivalent length of run for determining a trial pipe size is 338 feet.

Example: 9.36 (pressure available to overcome pipe friction) × 100/338 (equivalent length of run = 225 × 1.5) = 2.77 psi (average pressure drop per 100 feet of pipe).

**Step 7**

**Column 6:** Select from Table AP103.3(6) the equivalent lengths for the trial pipe size of fittings and valves on each pipe section. Enter the sum for each section in Column 6. (The number of fittings to be used in this example must be an estimate). The equivalent length of piping is the developed length plus the equivalent lengths of pipe corresponding to the friction head losses for fittings and valves. Where the size of fittings and valves is not known, the added friction head losses must be approximated. An estimate for this example is found in Table AP.1.

**Step 8**

**Column 7:** Add the figures from Columns 4 and 6, and enter in Column 7. Express the sum in hundreds of feet.

**Step 9**

**Column 8:** Select from Figure AP103.3(3) the friction loss per 100 feet of pipe for the gpm flow in a section (Column 3) and trial pipe size (Column 5). Maximum friction head loss per 100 feet is determined on the basis of the total pressure available for friction head loss and the longest equivalent length of run. The selection is based on the gpm demand, uniform friction head loss and maximum design velocity. Where the size indicated by the hydraulic table indicates a velocity in excess of the selected velocity, a size must be selected that produces the required velocity.
Step 10

**Column 9:** Multiply the figures in Columns 7 and 8 for each section and enter in Column 9.

Total friction loss is determined by multiplying the friction loss per 100 feet for each pipe section in the total *developed length* by the pressure loss in fittings expressed as *equivalent length* in feet (mm). Note: Section C-F should be considered in the total pipe friction losses only if greater loss occurs in Section C-F than in pipe Section D-E. Section C-F is not considered in the total *developed length*. Total friction loss in *equivalent length* is determined in Table AP.2.

Step 11

**Line K:** Enter the sum of the values in Column 9. The value is the total friction loss in *equivalent length* for each designated pipe section.

Step 12

**Line L:** Subtract Line J from Line K and enter in Column 10.

The result should always be a positive or plus figure. If it is not, repeat the operation using Columns 5, 6, 8 and 9 until a balance or near balance is obtained. If the difference between Lines J and K is a high positive number, it is an indication that the pipe sizes are too large and should be reduced, thus saving materials. In such a case, the operations using Columns 5, 6, 8 and 9 should be repeated.

The total friction losses are determined and subtracted from the pressure available to overcome pipe friction for the trial pipe size. This number is critical because it provides a guide to whether the pipe size selected is too large and the process should be repeated to obtain an economically designed system.

**Answer:** The final figures entered in Column 5 become the design pipe size for the respective sections. Repeating this operation a second time using the same sketch but considering the demand for hot water, it is possible to size the hot water distribution piping. This has been worked up as a part of the overall problem in the tabular arrangement used for sizing the service and water distribution piping. Note that consideration must be given to the pressure losses from the street main to the water heater (Section A-B) in determining the hot water pipe sizes.

**TABLE AP.1**

<table>
<thead>
<tr>
<th>COLD WATER PIPE SECTION</th>
<th>FITTINGS/VALVES</th>
<th>PRESSURE LOSS EXPRESSED AS EQUIVALENT LENGTH OF TUBE (feet)</th>
<th>HOT WATER PIPE SECTION</th>
<th>FITTINGS/VALVES</th>
<th>PRESSURE LOSS EXPRESSED AS EQUIVALENT OF TUBE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B</td>
<td>3 – 2 1/2 ” Gate valves</td>
<td>3</td>
<td>A-B</td>
<td>3 – 2 1/2 ” Gate valves</td>
<td>3</td>
</tr>
</tbody>
</table>
### TABLE AP.2

<table>
<thead>
<tr>
<th>PIPE SECTIONS</th>
<th>FRICTION LOSS EQUIVALENT LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cold Water</td>
</tr>
<tr>
<td>A-B</td>
<td>0.69 x 3.2 = 2.21</td>
</tr>
<tr>
<td>B-C</td>
<td>0.085 x 3.1 = 0.26</td>
</tr>
<tr>
<td>C-D</td>
<td>0.20 x 1.9 = 0.38</td>
</tr>
<tr>
<td>D-E</td>
<td>1.62 x 1.9 = 3.08</td>
</tr>
<tr>
<td>Total pipe friction losses (Line K)</td>
<td>5.93</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.01745 rad.
For SI: 1 foot = 304.8 mm, 1 gallon per minute = 3.785 L/m.

**FIGURE AP103.3(1)**
**EXAMPLE—SIZING**

**TABLE AP103.3(1)**
**RECOMMENDED TABULAR ARRANGEMENT FOR USE IN SOLVING PIPE SIZING PROBLEMS**

<table>
<thead>
<tr>
<th>COLUMN</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td>Description</td>
<td>Pounds per square inch</td>
<td>Gallons per min through section</td>
<td>Length of section (feet)</td>
<td>Trial pipe size (inches)</td>
<td>Equivalent length of fittings and valves (feet)</td>
<td>Total equivalent length ([Col. 4 + Col. 6]/100 feet)</td>
<td>Friction loss per 100 feet of trial size</td>
<td>Friction loss in equivalent length Column 8 x Column 7 (psi)</td>
<td>Excess pressure over friction losses (psi)</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>Pipe section (from diagram)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Service and cold water distribution piping</td>
<td>Minimum pressure available at main</td>
<td>55.00</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Highest pressure required at a fixture (see Table P2903.1)</td>
<td>15.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Meter loss 2&quot; meter</td>
<td>11.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Tap in main loss 2&quot; tap [see Table AP103.3(4)]</td>
<td>1.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Static head loss 21 ft × 0.43 psi/ft</td>
<td>9.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Special fixture loss backflow preventer</td>
<td>9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Special fixture loss—Filter</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Special fixture loss—Other</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Total overall losses and requirements (Sum of Lines B through H)</td>
<td>45.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>Pressure available to overcome pipe friction (Line A minus Line I)</td>
<td>9.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipe section (from diagram)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-B</td>
<td>288</td>
<td>108.0</td>
<td>54</td>
<td>2^1/2</td>
</tr>
<tr>
<td>B-C</td>
<td>264</td>
<td>104.5</td>
<td>8</td>
<td>2^1/2</td>
</tr>
<tr>
<td>C-D</td>
<td>132</td>
<td>77.0</td>
<td>13</td>
<td>2^1/2</td>
</tr>
<tr>
<td>C-F</td>
<td>132</td>
<td>77.0</td>
<td>150</td>
<td>2^1/2</td>
</tr>
<tr>
<td>D-E</td>
<td>132</td>
<td>77.0</td>
<td>150</td>
<td>2^1/2</td>
</tr>
</tbody>
</table>
### TABLE AP103.3(2)
#### LOAD VALUES ASSIGNED TO FIXTURES

<table>
<thead>
<tr>
<th>FIXTURE</th>
<th>OCCUPANCY</th>
<th>TYPE OF SUPPLY CONTROL</th>
<th>LOAD VALUES, IN WATER SUPPLY FIXTURE UNITS (w.s.f.u.)</th>
<th>Cold</th>
<th>Hot</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathroom group</td>
<td>Private</td>
<td>Flush tank</td>
<td>2.7</td>
<td>1.5</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Bathroom group</td>
<td>Private</td>
<td>Flushometer valve</td>
<td>6.0</td>
<td>3.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Bathtub</td>
<td>Private</td>
<td>Faucet</td>
<td>1.0</td>
<td>1.0</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Bathtub</td>
<td>Public</td>
<td>Faucet</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Bidet</td>
<td>Private</td>
<td>Faucet</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Combination fixture</td>
<td>Private</td>
<td>Faucet</td>
<td>2.25</td>
<td>2.25</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Dishwashing machine</td>
<td>Private</td>
<td>Automatic</td>
<td>—</td>
<td>1.4</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Drinking fountain</td>
<td>Offices, etc.</td>
<td>3/8 valve</td>
<td>0.25</td>
<td>—</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>Private</td>
<td>Faucet</td>
<td>1.0</td>
<td>1.0</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
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<td>Hotel, restaurant</td>
<td>Faucet</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Laundry trays (1 to 3)</td>
<td>Private</td>
<td>Faucet</td>
<td>1.0</td>
<td>1.0</td>
<td>1.4</td>
<td></td>
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<td>Private</td>
<td>Faucet</td>
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<td>0.5</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Lavatory</td>
<td>Public</td>
<td>Faucet</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Service sink</td>
<td>Offices, etc.</td>
<td>Faucet</td>
<td>2.25</td>
<td>2.25</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Shower head</td>
<td>Public</td>
<td>Mixing valve</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Shower head</td>
<td>Private</td>
<td>Mixing valve</td>
<td>1.0</td>
<td>1.0</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Urinal</td>
<td>Public</td>
<td>1&quot; flushometer valve</td>
<td>10.0</td>
<td>—</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Urinal</td>
<td>Public</td>
<td>3/4&quot; flushometer valve</td>
<td>5.0</td>
<td>—</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Urinal</td>
<td>Public</td>
<td>Flush tank</td>
<td>3.0</td>
<td>—</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 3.785 L/m.

a. To be considered as pressure gain for fixtures below main (to consider separately, omit from “I” and add to “J”).

b. To consider separately, in Line K use Section C-F only if greater loss than the loss in Section D-E.
<table>
<thead>
<tr>
<th>Washing machine (8 lb)</th>
<th>Private</th>
<th>Automatic</th>
<th>1.0</th>
<th>1.0</th>
<th>1.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing machine (8 lb)</td>
<td>Public</td>
<td>Automatic</td>
<td>2.25</td>
<td>2.25</td>
<td>3.0</td>
</tr>
<tr>
<td>Washing machine (15 lb)</td>
<td>Public</td>
<td>Automatic</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Water closet</td>
<td>Private</td>
<td>Flushometer valve</td>
<td>6.0</td>
<td>—</td>
<td>6.0</td>
</tr>
<tr>
<td>Water closet</td>
<td>Private</td>
<td>Flush tank</td>
<td>2.2</td>
<td>—</td>
<td>2.2</td>
</tr>
<tr>
<td>Water closet</td>
<td>Public</td>
<td>Flushometer valve</td>
<td>10.0</td>
<td>—</td>
<td>10.0</td>
</tr>
<tr>
<td>Water closet</td>
<td>Public</td>
<td>Flush tank</td>
<td>5.0</td>
<td>—</td>
<td>5.0</td>
</tr>
<tr>
<td>Water closet</td>
<td>Public or private</td>
<td>Flushometer tank</td>
<td>2.0</td>
<td>—</td>
<td>2.0</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg.

a. For fixtures not listed, loads should be assumed by comparing the fixture to one listed using water in similar quantities and at similar rates. The assigned loads for fixtures with both hot and cold water supplies are given for separate hot and cold water loads, and for total load. The separate hot and cold water loads are three-fourths of the total load for the fixture in each case.

**TABLE AP103.3(3)**
**TABLE FOR ESTIMATING DEMAND**

<table>
<thead>
<tr>
<th>SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS</th>
<th>SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSHOMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load (w.s.f.u.)</td>
<td>Demand (gpm)</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>6.5</td>
</tr>
<tr>
<td>4</td>
<td>8.0</td>
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<tr>
<td>5</td>
<td>9.4</td>
</tr>
<tr>
<td>6</td>
<td>10.7</td>
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<tr>
<td>7</td>
<td>11.8</td>
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<tr>
<td>8</td>
<td>12.8</td>
</tr>
<tr>
<td>9</td>
<td>13.7</td>
</tr>
<tr>
<td>10</td>
<td>14.6</td>
</tr>
<tr>
<td>11</td>
<td>15.4</td>
</tr>
<tr>
<td>12</td>
<td>16.0</td>
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<tr>
<td>13</td>
<td>16.5</td>
</tr>
<tr>
<td>14</td>
<td>17.0</td>
</tr>
<tr>
<td>15</td>
<td>17.5</td>
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<tr>
<td>16</td>
<td>18.0</td>
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<td>17</td>
<td>18.4</td>
</tr>
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<td>18</td>
<td>18.8</td>
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<td>19</td>
<td>19.2</td>
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<tr>
<td>20</td>
<td>19.6</td>
</tr>
<tr>
<td>25</td>
<td>21.5</td>
</tr>
<tr>
<td>30</td>
<td>23.3</td>
</tr>
<tr>
<td>35</td>
<td>24.9</td>
</tr>
<tr>
<td>40</td>
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</tr>
<tr>
<td>45</td>
<td>27.7</td>
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<tr>
<td>50</td>
<td>29.1</td>
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</tbody>
</table>

2018 North Carolina Residential Code
### TABLE AP103.3(3)—continued

#### TABLE FOR ESTIMATING DEMAND

<table>
<thead>
<tr>
<th>Load (w.s.f.u.)</th>
<th>Demand (gpm)</th>
<th>Demand (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>75.0</td>
<td>10.026</td>
</tr>
<tr>
<td>275</td>
<td>80.0</td>
<td>10.6944</td>
</tr>
<tr>
<td>300</td>
<td>85.0</td>
<td>11.3628</td>
</tr>
<tr>
<td>400</td>
<td>105.0</td>
<td>14.0364</td>
</tr>
<tr>
<td>500</td>
<td>124.0</td>
<td>16.57632</td>
</tr>
<tr>
<td>750</td>
<td>170.0</td>
<td>22.7256</td>
</tr>
<tr>
<td>1,000</td>
<td>208.0</td>
<td>27.80544</td>
</tr>
<tr>
<td>1,250</td>
<td>239.0</td>
<td>31.94952</td>
</tr>
<tr>
<td>1,500</td>
<td>269.0</td>
<td>35.95992</td>
</tr>
<tr>
<td>1,750</td>
<td>297.0</td>
<td>39.70296</td>
</tr>
<tr>
<td>2,000</td>
<td>325.0</td>
<td>43.446</td>
</tr>
<tr>
<td>2,500</td>
<td>380.0</td>
<td>50.7984</td>
</tr>
<tr>
<td>3,000</td>
<td>433.0</td>
<td>57.88344</td>
</tr>
<tr>
<td>4,000</td>
<td>535.0</td>
<td>70.182</td>
</tr>
<tr>
<td>5,000</td>
<td>593.0</td>
<td>79.27224</td>
</tr>
</tbody>
</table>

#### SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS

<table>
<thead>
<tr>
<th>Load (w.s.f.u.)</th>
<th>Demand (gpm)</th>
<th>Demand (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>75.0</td>
<td>10.026</td>
</tr>
<tr>
<td>275</td>
<td>80.0</td>
<td>10.6944</td>
</tr>
<tr>
<td>300</td>
<td>85.0</td>
<td>11.3628</td>
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<tr>
<td>400</td>
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<td>14.0364</td>
</tr>
<tr>
<td>500</td>
<td>124.0</td>
<td>16.57632</td>
</tr>
<tr>
<td>750</td>
<td>170.0</td>
<td>22.7256</td>
</tr>
<tr>
<td>1,000</td>
<td>208.0</td>
<td>27.80544</td>
</tr>
<tr>
<td>1,250</td>
<td>239.0</td>
<td>31.94952</td>
</tr>
<tr>
<td>1,500</td>
<td>269.0</td>
<td>35.95992</td>
</tr>
<tr>
<td>1,750</td>
<td>297.0</td>
<td>39.70296</td>
</tr>
<tr>
<td>2,000</td>
<td>325.0</td>
<td>43.446</td>
</tr>
<tr>
<td>2,500</td>
<td>380.0</td>
<td>50.7984</td>
</tr>
<tr>
<td>3,000</td>
<td>433.0</td>
<td>57.88344</td>
</tr>
<tr>
<td>4,000</td>
<td>535.0</td>
<td>70.182</td>
</tr>
<tr>
<td>5,000</td>
<td>593.0</td>
<td>79.27224</td>
</tr>
</tbody>
</table>

#### SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSHOMETERS

For SI: 1 gallon per minute = 3.785 L/m, 1 cubic foot per minute = 0.000471 m³/s.

### TABLE AP103.3(4)

#### LOSS OF PRESSURE THROUGH TAPS AND TEES IN POUNDS PER SQUARE INCH (psi)

<table>
<thead>
<tr>
<th>Gallons Per Minute</th>
<th>(\frac{5}{8})</th>
<th>(\frac{3}{4})</th>
<th>1</th>
<th>(\frac{1}{4})</th>
<th>(\frac{1}{2})</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.35</td>
<td>0.64</td>
<td>0.18</td>
<td>0.08</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>20</td>
<td>5.38</td>
<td>2.54</td>
<td>0.77</td>
<td>0.31</td>
<td>0.14</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>30</td>
<td>12.10</td>
<td>5.72</td>
<td>1.62</td>
<td>0.69</td>
<td>0.33</td>
<td>0.10</td>
<td>—</td>
</tr>
<tr>
<td>40</td>
<td>—</td>
<td>10.20</td>
<td>3.07</td>
<td>1.23</td>
<td>0.58</td>
<td>0.18</td>
<td>—</td>
</tr>
<tr>
<td>50</td>
<td>—</td>
<td>15.90</td>
<td>4.49</td>
<td>1.92</td>
<td>0.91</td>
<td>0.28</td>
<td>—</td>
</tr>
<tr>
<td>60</td>
<td>—</td>
<td>—</td>
<td>6.46</td>
<td>2.76</td>
<td>1.31</td>
<td>0.40</td>
<td>—</td>
</tr>
<tr>
<td>PIPE SIZE (inches)</td>
<td>FITTING OR VALVE</td>
<td>1/2</td>
<td>3/4</td>
<td>1</td>
<td>1/4</td>
<td>1/2</td>
<td>2</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>70</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>8.79</td>
<td>3.76</td>
<td>1.78</td>
<td>0.55</td>
</tr>
<tr>
<td>80</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>11.50</td>
<td>4.90</td>
<td>2.32</td>
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<td>—</td>
<td>—</td>
<td>14.50</td>
<td>6.21</td>
<td>2.94</td>
<td>0.91</td>
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<td>17.94</td>
<td>7.67</td>
<td>3.63</td>
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<td>35.20</td>
<td>15.00</td>
<td>7.12</td>
<td>2.20</td>
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<td>—</td>
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<td>—</td>
<td>44.10</td>
<td>18.40</td>
<td>9.72</td>
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<td>—</td>
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<td>21.70</td>
<td>11.80</td>
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<td>19.90</td>
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<td>—</td>
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<td>44.80</td>
<td>24.90</td>
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<tr>
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<td>—</td>
<td>—</td>
<td>139.20</td>
<td>51.90</td>
<td>29.90</td>
<td>9.60</td>
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<tr>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>162.00</td>
<td>58.90</td>
<td>34.90</td>
<td>11.10</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 3.785 L/m.

**TABLE AP103.3(5)**
ALLOWANCE IN EQUIVALENT LENGTHS OF PIPE FOR FRICTION LOSS IN VALVES AND THREADED FITTINGS (feet)

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

**TABLE AP103.3(6)**
PRESSURE LOSS IN FITTINGS AND VALVES EXPRESSED AS EQUIVALENT LENGTH OF TUBE\(^a\) (feet)
<table>
<thead>
<tr>
<th>Fraction</th>
<th>1/8</th>
<th>3/8</th>
<th>1/4</th>
<th>11/8</th>
<th>23/8</th>
<th>35/8</th>
<th>47/8</th>
<th>59/8</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>1.5</td>
<td>0.5</td>
<td>2.0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2.5</td>
</tr>
<tr>
<td>3/4</td>
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<td>0.5</td>
<td>3.0</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3.0</td>
</tr>
<tr>
<td>1</td>
<td>2.5</td>
<td>1.0</td>
<td>4.5</td>
<td>—</td>
<td>—</td>
<td>0.5</td>
<td>—</td>
<td>—</td>
<td>4.5</td>
</tr>
<tr>
<td>1 1/4</td>
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<td>1.0</td>
<td>5.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>—</td>
<td>—</td>
<td>5.5</td>
</tr>
<tr>
<td>1 1/2</td>
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<td>7.0</td>
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<td>0.5</td>
<td>0.5</td>
<td>—</td>
<td>—</td>
<td>6.5</td>
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<tr>
<td>2</td>
<td>5.0</td>
<td>2.0</td>
<td>9.0</td>
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<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>7.5</td>
<td>9.0</td>
</tr>
<tr>
<td>2 1/2</td>
<td>7.0</td>
<td>2.5</td>
<td>12.0</td>
<td>0.5</td>
<td>0.5</td>
<td>—</td>
<td>1.0</td>
<td>10.0</td>
<td>11.5</td>
</tr>
<tr>
<td>3</td>
<td>9.0</td>
<td>3.5</td>
<td>15.0</td>
<td>1.0</td>
<td>1.0</td>
<td>—</td>
<td>1.5</td>
<td>15.5</td>
<td>14.5</td>
</tr>
<tr>
<td>3 1/2</td>
<td>9.0</td>
<td>3.5</td>
<td>14.0</td>
<td>1.0</td>
<td>1.0</td>
<td>—</td>
<td>2.0</td>
<td>—</td>
<td>12.5</td>
</tr>
<tr>
<td>4</td>
<td>12.0</td>
<td>5.0</td>
<td>21.0</td>
<td>1.0</td>
<td>1.0</td>
<td>—</td>
<td>2.0</td>
<td>16.0</td>
<td>18.5</td>
</tr>
<tr>
<td>5</td>
<td>16.0</td>
<td>6.0</td>
<td>27.0</td>
<td>1.5</td>
<td>1.5</td>
<td>—</td>
<td>3.0</td>
<td>11.5</td>
<td>23.5</td>
</tr>
<tr>
<td>6</td>
<td>19.0</td>
<td>7.0</td>
<td>34.0</td>
<td>2.0</td>
<td>2.0</td>
<td>—</td>
<td>3.5</td>
<td>13.5</td>
<td>26.5</td>
</tr>
<tr>
<td>8</td>
<td>29.0</td>
<td>11.0</td>
<td>50.0</td>
<td>3.0</td>
<td>3.0</td>
<td>—</td>
<td>5.0</td>
<td>12.5</td>
<td>39.0</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.01745 rad.

a. Allowances are for streamlined soldered fittings and recessed threaded fittings. For threaded fittings, double the allowances shown in the table. The equivalent lengths presented in the table are based on a C factor of 150 in the Hazen-Williams friction loss formula. The lengths shown are rounded to the nearest half-foot.
Note: Fluid velocities in excess of 5 to 8 feet per second are not usually recommended.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa,
1 foot per second = 0.305 m/s.
a. This figure applies to smooth new copper tubing with recessed (streamline) soldered joints and to the actual
sizes of types indicated on the diagram.

FIGURE AP103.3(2)
FRICITION LOSS IN SMOOTH PIPE
Note: Fluid velocities in excess of 5 to 8 feet per second are not usually recommended.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa,
1 foot per second = 0.305 m/s.

a. This figure applies to smooth new copper tubing with recessed (streamline) soldered joints and to the actual
sizes of types indicated on the diagram

FIGURE AP103.3(3)
FRICITION LOSS IN SMOOTH PIPE

2018 North Carolina Residential Code
Note: Fluid velocities in excess of 5 to 8 feet per second are not usually recommended.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa,
1 foot per second = 0.305 m/s.

a. This figure applies to smooth new copper tubing with recessed (streamline) soldered joints and to the actual
sizes of types indicated on the diagram.
FIGURE AP103.3(4)
FRICTION LOSS IN SMOOTH PIPE\textsuperscript{a}
(TYPE M, ASTM B 88 COPPER TUBING)
a. This figure applies to smooth new steel (fairly smooth) pipe and to actual diameters of standard-weight pipe.
a. This figure applies to fairly rough pipe and to actual diameters which, in general, will be less than the actual diameters of the new pipe of the same kind.

FIGURE AP103.3(6)
FRICITION LOSS IN FAIRLY ROUGH PIPE
a. This figure applies to very rough pipe and existing pipe, and to their actual diameters.

FIGURE AP103.3(7)
SECTION AP201
SELECTION OF PIPE SIZE

AP201.1 Size of water-service mains, branch mains and risers.
The minimum size water service pipe shall be \( \frac{3}{4} \) inch (19.1 mm). The size of water service mains, branch mains and risers shall be determined according to water supply demand [gpm (L/m)], available water pressure [psi (kPa)] and friction loss caused by the water meter and developed length of pipe [feet (m)], including the equivalent length of fittings. The size of each water distribution system shall be determined according to the procedure outlined in this section or by other design methods conforming to acceptable engineering practice and approved by the building official:

1. Supply load in the building water distribution system shall be determined by the total load on the pipe being sized, in terms of w.s.f.u., as shown in Table AP103.3(2). For fixtures not listed, choose a w.s.f.u. value of a fixture with similar flow characteristics.

2. Obtain the minimum daily static service pressure [psi (kPa)] available (as determined by the local water authority) at the water meter or other source of supply at the installation location. Adjust this minimum daily static pressure [psi (kPa)] for the following conditions:
   2.1. Determine the difference in elevation between the source of supply and the highest water supply outlet. Where the highest water supply outlet is located above the source of supply, deduct 0.5 psi (3.4 kPa) for each foot (0.3 m) of difference in elevation. Where the highest water supply outlet is located below the source of supply, add 0.5 psi (3.4 kPa) for each foot (0.3 m) of difference in elevation.
   2.2. Where a water pressure-reducing valve is installed in the water distribution system, the minimum daily static water pressure available is 80 percent of the minimum daily static water pressure at the source of supply or the set pressure downstream of the water pressure-reducing valve, whichever is smaller.
   2.3. Deduct all pressure losses caused by special equipment, such as a backflow preventer, water filter and water softener. Pressure loss data for each piece of equipment shall be obtained through the manufacturer of the device.
   2.4. Deduct the pressure in excess of 8 psi (55 kPa) resulting from the installation of the special plumbing fixture, such as temperature-controlled shower and flushometer tank water closet. Using the resulting minimum available pressure, find the corresponding pressure range in Table AP201.1.

3. The maximum developed length for water piping is the actual length of pipe between the source of supply and the most remote fixture, including either hot (through the water heater) or cold water branches multiplied by a factor of 1.2 to compensate for pressure loss through fittings. Select the appropriate column in Table AP201.1 equal to or greater than the calculated maximum developed length.
4. To determine the size of the water service pipe, meter and main distribution pipe to the building using the appropriate table, follow down the selected “maximum developed length” column to a fixture unit equal to or greater than the total installation demand calculated by using the “combined” w.s.f.u. column of Table AP201.1. Read the water service pipe and meter sizes in the first left-hand column and the main distribution pipe to the building in the second left-hand column on the same row.

5. To determine the size of each water distribution pipe, start at the most remote outlet on each branch (either hot or cold branch) and, working back toward the main distribution pipe to the building, add up the w.s.f.u. demand passing through each segment of the distribution system using the related hot or cold column of Table AP201.1. Knowing demand, the size of each segment shall be read from the second left-hand column of the same table and the maximum developed length column selected in Steps 1 and 2, under the same or next smaller size meter row. In no case does the size of any branch or main need to be larger than the size of the main distribution pipe to the building established in Step 4.

### TABLE AP201.1
MINIMUM SIZE OF WATER METERS, MAINS AND DISTRIBUTION PIPING BASED ON WATER SUPPLY FIXTURE UNIT VALUES (w.s.f.u.)

<table>
<thead>
<tr>
<th>METER AND SERVICE PIPE (inches)</th>
<th>DISTRIBUTION PIPE (inches)</th>
<th>MAXIMUM DEVELOPMENT LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Range 30 to 39 psi</td>
<td></td>
<td>40  60  80  100  150  200  250  300  400  500</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>$\frac{1}{2}$</td>
<td>2.5  2  1.5  1.5  1  1  0.5  0.5  0  0</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>$\frac{3}{4}$</td>
<td>9.5  7.5  6  5.5  4  3.5  3  2.5  2  1.5</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>1</td>
<td>32  25  20  16.5  11  9  7.8  6.5  5.5  4.5</td>
</tr>
<tr>
<td>$\frac{1}{4}$</td>
<td>1</td>
<td>32  32  27  21  13.5  10  8  7  5.5  5</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>32  32  32  32  30  24  20  17  13  10.5</td>
</tr>
<tr>
<td>1</td>
<td>$\frac{1}{4}$</td>
<td>80  80  70  61  45  34  27  22  16  12</td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>$\frac{1}{4}$</td>
<td>80  80  80  75  54  40  31  25  17.5  13</td>
</tr>
<tr>
<td>1</td>
<td>$\frac{1}{2}$</td>
<td>87  87  87  87  84  73  64  56  45  36</td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>$\frac{1}{2}$</td>
<td>151  151  151  151  117  92  79  69  54  43</td>
</tr>
<tr>
<td>2</td>
<td>$\frac{1}{2}$</td>
<td>151  151  151  151  128  99  83  72  56  45</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>87  87  87  87  87  87  87  87  87  86</td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>2</td>
<td>275  275  275  275  258  223  196  174  144  122</td>
</tr>
</tbody>
</table>
### TABLE AP201.1—continued

**MINIMUM SIZE OF WATER METERS, MAINS AND DISTRIBUTION PIPING BASED ON WATER SUPPLY FIXTURE UNIT VALUES (w.s.f.u.)**

<table>
<thead>
<tr>
<th>METER AND SERVICE PIPE (inches)</th>
<th>DISTRIBUTION PIPE (inches)</th>
<th>MAXIMUM DEVELOPMENT LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Pressure Range 50 to 60 psi</td>
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</tr>
<tr>
<td>3/4</td>
<td>1/2</td>
<td>3</td>
</tr>
<tr>
<td>3/4</td>
<td>3/4</td>
<td>9.5</td>
</tr>
<tr>
<td>3/4</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>3/4</td>
<td>1/4</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>1/4</td>
<td>80</td>
</tr>
<tr>
<td>1 1/2</td>
<td>1/4</td>
<td>80</td>
</tr>
<tr>
<td>1</td>
<td>1/2</td>
<td>87</td>
</tr>
<tr>
<td>1 1/2</td>
<td>1/2</td>
<td>151</td>
</tr>
<tr>
<td>2</td>
<td>1/2</td>
<td>151</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>87</td>
</tr>
<tr>
<td>1 1/2</td>
<td>2</td>
<td>275</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>365</td>
</tr>
<tr>
<td>2</td>
<td>2 1/2</td>
<td>533</td>
</tr>
</tbody>
</table>

* (continued)
<table>
<thead>
<tr>
<th>METER AND SERVICE PIPE (inches)</th>
<th>DISTRIBUTION PIPE (inches)</th>
<th>MAXIMUM DEVELOPMENT LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Range Over 60</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>3/4</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>3/4</td>
<td>3/4</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>1/4</td>
<td>80</td>
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<td>1/2</td>
<td>1/4</td>
<td>80</td>
</tr>
<tr>
<td>1</td>
<td>1/2</td>
<td>87</td>
</tr>
<tr>
<td>1/2</td>
<td>1/2</td>
<td>151</td>
</tr>
<tr>
<td>2</td>
<td>1/2</td>
<td>151</td>
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<tr>
<td>1</td>
<td>2</td>
<td>87</td>
</tr>
<tr>
<td>1/2</td>
<td>2</td>
<td>275</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>365</td>
</tr>
<tr>
<td>2</td>
<td>1/2</td>
<td>533</td>
</tr>
</tbody>
</table>
For SI: 1 inch = 25.4, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa.

a. Minimum size for building supply is a \( \frac{3}{4} \)-inch pipe.
APPENDIX Q

This appendix is a North Carolina addition to the 2015 International Residential Code. There will be no underlined text.
(The provisions contained in this appendix are adopted as part of this code.)
APPENDIX R
LIGHT STRAW-CLAY CONSTRUCTION

Deleted

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

SECTION AR101
GENERAL

AR101.1 Scope.
This appendix shall govern the use of light straw-clay as a nonbearing building material and wall infill system.

SECTION AR102
DEFINITIONS

AR102.1 General.
The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of the International Residential Code for general definitions.

CLAY. Inorganic soil with particle sizes of less than 0.00008 inch (0.002 mm) having the characteristics of high to very high dry strength and medium to high plasticity.

CLAY SLIP. A suspension of clay soil in water.

CLAY SOIL. Inorganic soil containing 50 percent or more clay by volume.

INFILL. Light straw-clay that is placed between the structural members of a building.

LIGHT STRAW-CLAY. A mixture of straw and clay compacted to form insulation and plaster substrate between or around structural and nonstructural members in a wall.

NONBEARING. Not bearing the weight of the building other than the weight of the light straw-clay itself and its finish.

STRAW. The dry stems of cereal grains after the seed heads have been removed.

VOID. Any space in a light straw-clay wall in which a 2-inch (51 mm) sphere can be inserted.

SECTION AR103
NONBEARING LIGHT STRAW-CLAY CONSTRUCTION
AR103.1 General.
Light straw-clay shall be limited to infill between or around structural and nonstructural wall framing members.

AR103.2 Structure.
The structure of buildings using light straw-clay shall be in accordance with the International Residential Code or shall be in accordance with an approved design by a registered design professional.

AR103.2.1 Number of stories.
Use of light straw-clay infill shall be limited to buildings that are not more than one story above grade plane.

Exception: Buildings using light straw-clay infill that are greater than one story above grade plane shall be in accordance with an approved design by a registered design professional.

AR103.2.2 Bracing.
Wind and seismic bracing shall be in accordance with Section R602.10 and shall use Method LIB. The required length of bracing shall comply with Section R602.10.3, with the additional requirements that Table 602.10.3(3) shall be applicable to buildings in Seismic Design Category C, and that the minimum total length of bracing in Table R602.10.3(3) shall be increased by 90 percent. In lieu of these prescriptive requirements, wind and seismic bracing shall be in accordance with an approved design by a registered design professional. Walls with light straw-clay infill shall not be sheathed with solid sheathing.

AR103.2.3 Weight of light straw-clay.
Light straw-clay shall be deemed to have a design dead load of 40 pounds per cubic foot (640 kg per cubic meter) unless otherwise demonstrated to the building official.

AR103.2.4 Reinforcement of light straw-clay.
Light straw-clay shall be reinforced as follows:

1. Vertical reinforcing shall be not less than nominal 2-inch by 6-inch (51 mm by 152 mm) wood members at not more than 32 inches (813 mm) on center where the vertical reinforcing is nonload bearing and at 24 inches (610 mm) on center where it is load bearing. The vertical reinforcing shall not exceed an unrestrained height of 10 feet (3048 mm) and shall be attached at top and bottom in accordance with Chapter 6 of this code. In lieu of these requirements, vertical reinforcing shall be in accordance with an approved design by a registered design professional.

2. Horizontal reinforcing shall be installed in the center of the wall at not more than 24 inches (610 mm) on center and shall be secured to vertical members. Horizontal reinforcing shall be of any of the following: 3/4-inch (19.1 mm) bamboo, 1/2-inch (12.7 mm) fiberglass rod, 1-inch (25 mm) wood dowel or nominal 1-inch by 2-inch (25 mm by 51 mm) wood.
AR103.3 Materials.
The materials used in light straw-clay construction shall be in accordance with Sections AR103.3.1 through AR103.3.4.

AR103.3.1 Straw.
Straw shall be wheat, rye, oats, rice or barley, and shall be free of visible decay and insects.

AR103.3.2 Clay soil.
Suitability of clay soil shall be determined in accordance with the Figure 2 Ribbon Test or the Figure 3 Ball Test of the Appendix to ASTM E 2392/E 2392M.

AR103.3.3 Clay slip.
Clay slip shall be of sufficient viscosity such that a finger dipped in the slip and withdrawn remains coated with an opaque coating.

AR103.3.4 Light straw-clay mixture.
Light straw-clay mixture shall contain not less than 65 percent and not more than 85 percent straw, by volume of bale-compacted straw to clay soil. Loose straw shall be mixed and coated with clay slip such that there is not more than 5 percent uncoated straw.

AR103.4 Wall construction.
Light straw-clay wall construction shall be in accordance with the requirements of Sections AR103.4.1 through AR103.4.7.

AR103.4.1 Light straw-clay maximum thickness.
Light straw-clay shall be not more than 12 inches (305 mm) thick, to allow adequate drying of the installed material.

AR103.4.2 Distance above grade.
Light straw-clay and its exterior finish shall be not less than 8 inches (203 mm) above exterior finished grade.

AR103.4.3 Moisture barrier.
An approved moisture barrier shall separate the bottom of light straw-clay walls from any masonry or concrete foundation or slab that directly supports the walls. Penetrations and joints in the barrier shall be sealed with an approved sealant.

AR103.4.4 Contact with wood members.
Light straw-clay shall be permitted to be in contact with untreated wood members.

AR103.4.5 Contact with nonwood structural members.
Nonwood structural members in contact with light straw-clay shall be resistant to corrosion or shall be coated to prevent corrosion with an approved coating.

AR103.4.6 Installation.
Light straw-clay shall be installed in accordance with the following:

1. Formwork shall be sufficiently strong to resist bowing where the light straw-clay is compacted into the forms.
2. Light straw-clay shall be uniformly placed into forms and evenly tamped to achieve stable walls free of voids. Light straw-clay shall be placed in lifts of not more than 6 inches (152 mm) and shall be thoroughly tamped before additional material is added.

3. Formwork shall be removed from walls within 24 hours after tamping, and walls shall remain exposed until moisture content is in accordance with Section AR103.5.1. Visible voids shall be patched with light straw-clay prior to plastering.

**AR103.4.7 Openings in walls.**

Openings in walls shall be in accordance with the following:

1. Rough framing for doors and windows shall be fastened to structural members in accordance with the *International Residential Code*. Windows and doors shall be flashed in accordance with the *International Residential Code*.

2. An approved moisture barrier shall be installed at window sills in light straw-clay walls prior to installation of windows.

**AR103.5 Wall finishes.**

The interior and exterior surfaces of light straw-clay walls shall be protected with a finish in accordance with Sections AR103.5.1 through AR103.5.5.

**AR103.5.1 Moisture content of light straw-clay prior to application of finish.**

Light straw-clay walls shall be dry to a moisture content of not more than 20 percent at a depth of 4 inches (102 mm), as measured from each side of the wall, prior to the application of finish on either side of the wall. Moisture content shall be measured with a moisture meter equipped with a probe that is designed for use with baled straw or hay.

**AR103.5.2 Plaster finish.**

Exterior plaster finishes shall be clay plaster or lime plaster. Interior plaster finishes shall be clay plaster, lime plaster or gypsum plaster. Plasters shall be permitted to be applied directly to the surface of the light straw-clay walls without reinforcement, except that the juncture of dissimilar substrates shall be in accordance with Section AR103.5.3. Plasters shall have a thickness of not less than \(\frac{1}{2}\) inch (12.7 mm) and not more than 1 inch (25 mm) and shall be installed in not less than two coats. Exterior clay plaster shall be finished with a lime-based or silicate-mineral coating.

**AR103.5.3 Separation of wood and plaster.**

Where wood framing occurs in light straw-clay walls, such wood surfaces shall be separated from exterior plaster with No.15 asphalt felt, Grade D paper or other approved material except where the wood is preservative treated or naturally durable.

**Exception:** Exterior clay plasters shall not be required to be separated from wood.

**AR103.5.4 Bridging across dissimilar substrates.**

Bridging shall be installed across dissimilar substrates prior to the application of plaster. Acceptable bridging materials include: expanded metal lath, woven wire mesh, welded wire mesh, fiberglass mesh, reed matting or burlap. Bridging shall extend not less than 4 inches (102 mm), on both sides of the juncture.
AR103.5.5 Exterior siding.

Exterior wood, metal or composite material siding shall be spaced not less than $\frac{3}{4}$ inch (19.1 mm) from the light straw clay such that a ventilation space is created to allow for moisture diffusion. The siding shall be fastened to wood furring strips in accordance with the manufacturer’s instructions. Furring strips shall be spaced not more than 32 inches (813 mm) on center, and shall be securely fastened to the vertical wall reinforcing or structural framing. Insect screening shall be provided at the top and bottom of the ventilation space.

An air barrier consisting of not more than $\frac{3}{8}$-inch-thick (9.5 mm) clay plaster or lime plaster shall be applied to the light straw-clay prior to the application of siding.

SECTION AR104
THERMAL INSULATION

AR104.1 R-value.

Light straw-clay, where installed in accordance with this appendix, shall be deemed to have an R-value of 1.6 per inch.

SECTION AR105
REFERENCED STANDARD

ASTM E 2392/ E 2392M—10 Standard Guide for Design of Earthen Wall Building Systems AR103.3.2
APPENDIX S
STRAWBALE CONSTRUCTION

Deleted

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

SECTION AS101
GENERAL

AS101.1 Scope.
This appendix provides prescriptive and performance-based requirements for the use of baled straw as a building material. Other methods of strawbale construction shall be subject to approval in accordance with Section 104.11 of this code. Buildings using strawbale walls shall comply with the this code except as otherwise stated in this appendix.

SECTION AS102
DEFINITIONS

AS102.1 Definitions.
The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of the International Residential Code for general definitions.

BALE. Equivalent to straw bale.

CLAY. Inorganic soil with particle sizes less than 0.00008 inch (0.002 mm) having the characteristics of high to very high dry strength and medium to high plasticity.

CLAY SLIP. A suspension of clay particles in water.

FINISH. Completed compilation of materials on the interior or exterior faces of stacked bales.

FLAKE. An intact section of compressed straw removed from an untied bale.

LAID FLAT. The orientation of a bale with its largest faces horizontal, its longest dimension parallel with the wall plane, its ties concealed in the unfinished wall and its straw lengths oriented across the thickness of the wall.

LOAD-BEARING WALL. A strawbale wall that supports more than 100 pounds per linear foot (1459 N/m) of vertical load in addition its own weight.

MESH. An openwork fabric of linked strands of metal, plastic, or natural or synthetic fiber, embedded in plaster.

NONSTRUCTURAL WALL. Walls other than load-bearing walls or shear walls.
ON-EDGE. The orientation of a bale with its largest faces vertical, its longest dimension parallel with the wall plane, its ties on the face of the wall and its straw lengths oriented vertically.

PIN. A vertical metal rod, wood dowel or bamboo, driven into the center of stacked bales, or placed on opposite surfaces of stacked bales and through tied.

PLASTER. Gypsum or cement plaster, as defined in Sections R702 and AS104, or clay plaster, soil-cement plaster, lime plaster or cement-lime plaster as defined in Section AS104.

PRECOMPRESSION. Vertical compression of stacked bales before the application of finish.

REINFORCED PLASTER. A plaster containing mesh reinforcement.

RUNNING BOND. The placement of straw bales such that the head joints in successive courses are offset not less than one-quarter the bale length.

SHEAR WALL. A strawbale wall designed and constructed to resist lateral seismic and wind forces parallel to the plane of the wall in accordance with Section AS106.13.

SKIN. The compilation of plaster and reinforcing, if any, applied to the surface of stacked bales.

STRUCTURAL WALL. A wall that meets the definition for a load-bearing wall or shear wall.

STACK BOND. The placement of straw bales such that head joints in successive courses are vertically aligned.

STRAW. The dry stems of cereal grains after the seed heads have been removed.

STRAW BALE. A rectangular compressed block of straw, bound by ties.

STRAWBALE. The adjective form of straw bale.

STRAW-CLAY. Loose straw mixed and coated with clay slip.

TIE. A synthetic fiber, natural fiber or metal wire used to confine a straw bale.

TRUTH WINDOW. An area of a strawbale wall left without its finish, to allow view of the straw otherwise concealed by its finish.

SECTION AS103

BALES

AS103.1 Shape.
Bales shall be rectangular in shape.

AS103.2 Size.
Bales shall have a height and thickness of not less than 12 inches (305 mm), except as otherwise permitted or required in this appendix. Bales used within a continuous wall shall be of consistent height and thickness to ensure even distribution of loads within the wall system.
AS103.3 Ties.
Bales shall be confined by synthetic fiber, natural fiber or metal ties sufficient to maintain required bale density. Ties shall be not less than 3 inches (76 mm) and not more than 6 inches (152 mm) from the two faces without ties and shall be spaced not more than 12 inches (305 mm) apart. Bales with broken ties shall be retied with sufficient tension to maintain required bale density.

AS103.4 Moisture content.
The moisture content of bales at the time of application of the first coat of plaster or the installation of another finish shall not exceed 20 percent of the weight of the bale. The moisture content of bales shall be determined by use of a moisture meter designed for use with baled straw or hay, equipped with a probe of sufficient length to reach the center of the bale. Not less than 5 percent and not less than 10 bales used shall be randomly selected and tested.

AS103.5 Density.
Bales shall have a dry density of not less than 6.5 pounds per cubic foot (104 kg/cubic meter). The dry density shall be calculated by subtracting the weight of the moisture in pounds (kg) from the actual bale weight and dividing by the volume of the bale in cubic feet (cubic meters). Not less than 2 percent and not less than five bales to be used shall be randomly selected and tested on site.

AS103.6 Partial bales.
Partial bales made after original fabrication shall be retied with ties complying with Section AR103.3.

AS103.7 Types of straw.
Bales shall be composed of straw from wheat, rice, rye, barley or oat.

AS103.8 Other baled material.
The dry stems of other cereal grains shall be acceptable where approved by the building official.

SECTION AS104
FINISHES

AS104.1 General.
Finishes applied to strawbale walls shall be any type permitted by this code, and shall comply with this section and with Chapters 3 and 7 of this code unless stated otherwise in this section.

AS104.2 Purpose, and where required.
Strawbale walls shall be finished so as to provide mechanical protection, fire resistance and protection from weather and to restrict the passage of air through the bales, in accordance with this appendix and this code. Vertical strawbale wall surfaces shall receive a coat of plaster not less than $\frac{3}{8}$ inch (10 mm) thick, or greater where required elsewhere in this appendix, or shall fit tightly against a solid wall panel. The tops of strawbale walls shall receive a coat of plaster not less than $\frac{3}{8}$ inch (10 mm) thick where straw would otherwise be exposed.
**Exception:** Truth windows shall be permitted where a fire-resistance rating is not required. Weather-exposed truth windows shall be fitted with a weather-tight cover. Interior truth windows in Climate Zones 5, 6, 7, 8 and Marine 4 shall be fitted with an air-tight cover.

AS104.3 Vapor retarders.
Class I and II vapor retarders shall not be used on a strawbale wall, nor shall any other material be used that has a vapor permeance rating of less than 3 perms, except as permitted or required elsewhere in this appendix.

AS104.4 Plaster.
Plaster applied to bales shall be any type described in this section, and as required or limited in this appendix. Plaster thickness shall not exceed 2 inches (51 mm).

**AS104.4.1 Plaster and membranes.**
Plaster shall be applied directly to strawbale walls to facilitate transpiration of moisture from the bales, and to secure a mechanical bond between the skin and the bales, except where a membrane is allowed or required elsewhere in this appendix.

**AS104.4.2 Lath and mesh for plaster.**
The surface of the straw bales functions as lath, and other lath or mesh shall not be required, except as required for out-of-plane resistance by Table AS105.4 or for structural walls by Tables AS106.12 and AS106.13(1).

**AS104.4.3 Clay plaster.**
Clay plaster shall comply with Sections AS104.4.3.1 through AS104.4.3.6.

**AS104.4.3.1 General.**
Clay plaster shall be any plaster having a clay or clay-soil binder. Such plaster shall contain sufficient clay to fully bind the plaster, sand or other inert granular material, and shall be permitted to contain reinforcing fibers. Acceptable reinforcing fibers include chopped straw, sisal, and animal hair.

**AS104.4.3.2 Lath and mesh.**
Clay plaster shall not be required to contain reinforcing lath or mesh except as required in Tables AS105.4 and AS106.13(1). Where provided, mesh shall be natural fiber, corrosion-resistant metal, nylon, high-density polypropylene or other approved material.

**AS104.4.3.3 Thickness and coats.**
Clay plaster shall be not less than 1 inch (25 mm) thick, except where required to be thicker for structural walls as described elsewhere in this appendix, and shall be applied in not less than two coats.

**AS104.4.3.4 Rain-exposed.**
Clay plaster, where exposed to rain, shall be finished with lime wash, lime plaster, linseed oil or other approved erosion-resistant finish.

**AS104.4.3.5 Prohibited finish coat.**
Plaster containing Portland cement shall not be permitted as a finish coat over clay plasters.
AS104.4.3.6 Plaster additives.
Additives shall be permitted to increase plaster workability, durability, strength or water resistance.

AS104.4.4 Soil-cement plaster.
Soil-cement plaster shall comply with Sections AS104.4.4.1 through AS104.4.4.3.

AS104.4.4.1 General.
Soil-cement plaster shall be composed of soil (free of organic matter), sand and not less than 10 percent and not more than 20 percent Portland cement by volume, and shall be permitted to contain reinforcing fibers.

AS104.4.4.2 Lath and mesh.
Soil-cement plaster shall use any corrosion-resistant lath or mesh permitted by this code, or as required in Section AS106 where used on structural walls.

AS104.4.4.3 Thickness.
Soil-cement plaster shall be not less than 1 inch (25 mm) thick.

AS104.4.5 Gypsum plaster.
Gypsum plaster shall comply with Section R702. Gypsum plaster shall be limited to use on interior surfaces of nonstructural walls, and as an interior finish coat over a structural plaster that complies with this appendix.

AS104.4.6 Lime plaster.
Lime plaster shall comply with Sections AS104.4.6.1 and AS104.4.6.3.

AS104.4.6.1 General.
Lime plaster is any plaster with a binder that is composed of calcium hydroxide (CaOH) including Type N or S hydrated lime, hydraulic lime, natural hydraulic lime or quicklime. Hydrated lime shall comply with ASTM C 206. Hydraulic lime shall comply with ASTM C 1707. Natural hydraulic lime shall comply with ASTM C 141 and EN 459. Quicklime shall comply with ASTM C 5.

AS104.4.6.2 Thickness and coats.
Lime plaster shall be not less than \( \frac{7}{8} \) inch (22 mm) thick, and shall be applied in not less than three coats.

AS104.4.6.3 On structural walls.
Lime plaster on strawbale structural walls in accordance with Table AS106.12 or Table AS106.13(1) shall use a binder of hydraulic or natural hydraulic lime.

AS104.4.7 Cement-lime plaster.
Cement-lime plaster shall be plaster mixes CL, F or FL, as described in ASTM C 926.

AS104.4.8 Cement plaster.
Cement plaster shall conform to ASTM C 926 and shall comply with Sections R703.6.2, R703.6.4 and R703.6.5, except that the amount of lime in plaster coats shall be not less
than 1 part lime to 6 parts cement to allow a minimum acceptable vapor permeability. The combined thickness of plaster coats shall be not more than $1 \frac{1}{2}$ inches (38 mm) thick.

SECTION AS105
STRAWBALE WALLS—GENERAL

AS105.1 General.
Strawbale walls shall be designed and constructed in accordance with this section. Strawbale structural walls shall be in accordance with the additional requirements of Section AS106.

AS105.2 Building requirements for use of strawbale nonstructural walls.
Buildings using strawbale nonstructural walls shall be subject to the following limitations and requirements:

1. Number of stories: not more than one, except that two stories shall be allowed with an approved engineered design.

2. Building height: not more than 25 feet (7620 mm).

3. Wall height: in accordance with Table AS105.4.

4. Braced wall panel length, and increase in Seismic Design Categories C, D, D1, and D2: the required length of bracing for buildings using strawbale nonstructural walls shall comply with Section R602.10.3 of this code, with the additional requirements that Table 602.10.3(3) shall be applicable to buildings in Seismic Design Category C, and that the minimum total length of braced wall panels in Table R602.10.3(3) shall be increased by 60 percent.

AS105.3 Sill plates.
Sill plates shall support and be flush with each face of the straw bales above and shall be of naturally durable or preservative-treated wood where required by this code. Sill plates shall be not less than nominal 2 inches by 4 inches (51 mm by 102 mm) with anchoring complying with Section R403.1.6 and the additional requirements of Tables AS105.4 and AS106.6(1), where applicable.

AS105.4 Out-of-plane resistance and unrestrained wall dimensions.
Strawbale walls shall employ a method of out-of-plane resistance in accordance with Table AS105.4, and comply with its associated limits and requirements.

<table>
<thead>
<tr>
<th>METHOD OF OUT-OF-PLANE RESISTANCE</th>
<th>FOR WIND DESIGN SPEEDS (mph)</th>
<th>FOR SEISMIC DESIGN CATEGORIES</th>
<th>UNRESTRAINED WALL DIMENSIONS, H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute limit in feet</td>
<td>Limit based on bale thickness T in feet (mm)</td>
<td>MESH STAPLE SPACING AT BOUNDARY RESTRAINTS</td>
<td></td>
</tr>
</tbody>
</table>

TABLE AS105.4
OUT-OF-PLANE RESISTANCE AND UNRESTRAINED WALL DIMENSIONS
## Nonplaster finish or unreinforced plaster

<table>
<thead>
<tr>
<th>Nonplaster finish or unreinforced plaster</th>
<th>≤100</th>
<th>A, B, C, D₀</th>
<th>H ≤ 8</th>
<th>H ≤ 5T</th>
<th>None required</th>
</tr>
</thead>
</table>

## Pins per Section AS105.4.2

<table>
<thead>
<tr>
<th>Pins per Section AS105.4.2</th>
<th>≤100</th>
<th>A, B, C, D₀</th>
<th>H ≤ 12</th>
<th>H ≤ 8T</th>
<th>None required</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Pins per Section AS105.4.2</th>
<th>≤110</th>
<th>A, B, C, D₀, D₁, D₂</th>
<th>H ≤ 10</th>
<th>H ≤ 7T</th>
<th>None required</th>
</tr>
</thead>
</table>

## Reinforced cement-clay plaster

<table>
<thead>
<tr>
<th>Reinforced cement-clay plaster</th>
<th>≤110</th>
<th>A, B, C, D₀, D₁, D₂</th>
<th>H ≤ 10</th>
<th>H ≤ 8T ( \frac{0.5}{(H ≤ 140T)} )</th>
<th>≤ 6 inches</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Reinforced cement-clay plaster</th>
<th>≤110</th>
<th>A, B, C, D₀, D₁, D₂</th>
<th>10 &lt; H ≤ 12</th>
<th>H ≤ 8T ( \frac{0.5}{(H ≤ 140T)} )</th>
<th>≤ 4 inches</th>
</tr>
</thead>
</table>

## Reinforced cement-lime, lime or soil-cement plaster

<table>
<thead>
<tr>
<th>Reinforced cement-lime, lime or soil-cement plaster</th>
<th>≤110</th>
<th>A, B, C, D₀, D₁, D₂</th>
<th>H ≤ 10</th>
<th>H ≤ 9T ( \frac{0.5}{(H ≤ 157T)} )</th>
<th>≤ 6 inches</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Reinforced cement-lime, lime or soil-cement plaster</th>
<th>≤120</th>
<th>A, B, C, D₀, D₁, D₂</th>
<th>H ≤ 12</th>
<th>H ≤ 9T ( \frac{0.5}{(H ≤ 157T)} )</th>
<th>≤ 4 inches</th>
</tr>
</thead>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Finishes applied to both sides of stacked bales. Where different finishes are used on opposite sides of a wall, the more restrictive requirements shall apply.

b. \( H \) = Stacked bale height in feet (mm) between sill plate and top plate or other approved horizontal restraint, or the horizontal distance in feet (m) between approved vertical restraints. For load-bearing walls, \( H \) refers to vertical height only.

c. \( T \) = Bale thickness in feet (mm).

d. Plaster reinforcement shall be any mesh allowed in Table AS106.16 for the matching plaster type, and with staple spacing in accordance with this table. Mesh shall be installed in accordance with Section AS106.9.

e. Sill plate attachment shall be with \( \frac{5}{8} \)-inch anchor bolts or approved equivalent at not more than 48 inches on center where staple spacing is required to be ≤ 4 inches.

### AS105.4.1 Determination of out-of-plane loading.

Out-of-plane loading for the use of Table AS105.4 shall be in terms of the design wind speed and seismic design category as determined in accordance with Sections R301.2.1 and R301.2.2 of this code.

### AS105.4.2 Pins.

Pins used for out-of-plane resistance shall comply with the following or shall be in accordance with an approved engineered design. Pins shall be external, internal or a combination of the two.

1. Pins shall be \( \frac{1}{2} \)-inch-diameter (12.7 mm) steel, \( \frac{3}{4} \)-inch-diameter (19.1 mm) wood or \( \frac{1}{2} \)-inch-diameter (12.7 mm) bamboo.

2. External pins shall be installed vertically on both sides of the wall at a spacing of not more than 24 inches (610 mm) on center. External pins shall have full lateral bearing on the sill plate and the top plate or roof-bearing element, and shall be tightly tied through the wall to an opposing pin with ties spaced not more than 32 inches (813 mm) apart and not more than 8 inches (203 mm) from each end of the pins.
3. Internal pins shall be installed vertically within the center third of the bales, at spacing of not more than 24 inches (610 mm) and shall extend from top course to bottom course. The bottom course shall be similarly connected to its support and the top course shall be similarly connected to the roof- or floor-bearing member above with pins or other approved means. Internal pins shall be continuous or shall overlap through not less than one bale course.

AS105.5 Connection of light-framed walls to strawbale walls.
Light-framed walls perpendicular to, or at an angle to a straw bale wall assembly, shall be fastened to the bottom and top wood members of the strawbale wall in accordance with requirements for wood or cold-formed steel light-framed walls in this code, or the abutting stud shall be connected to alternating straw bale courses with a $\frac{1}{2}$-inch-diameter (12.7 mm) steel, $\frac{3}{4}$-inch-diameter (19.1 mm) wood or $\frac{5}{8}$-inch-diameter (15.9 mm) bamboo dowel, with not less than 8-inch (203 mm) penetration.

AS105.6 Moisture control.
Strawbale walls shall be protected from moisture intrusion and damage in accordance with Sections AS105.6.1 through AS105.6.8.

AS105.6.1 Water-resistant barriers and vapor permeance ratings.
Plastered bale-walls shall be constructed without any membrane barrier between straw and plaster to facilitate transpiration of moisture from the bales, and to secure a structural bond between straw and plaster, except as permitted or required elsewhere in this appendix. Where a water-resistant barrier is placed behind an exterior finish, it shall have a vapor permeance rating of not less than 5 perms, except as permitted or required elsewhere in this appendix.

AS105.6.2 Vapor retarders.
Wall finishes shall have an equivalent vapor permeance rating of a Class III vapor retarder on the interior side of exterior strawbale walls in Climate Zones 5, 6, 7, 8 and Marine 4, as defined in Chapter 11. Bales in walls enclosing showers or steam rooms shall be protected on the interior side by a Class I or Class II vapor retarder.

AS105.6.3 Penetrations in exterior strawbale walls.
Penetrations in exterior strawbale walls shall be sealed with an approved sealant or gasket on the exterior side of the wall in all climate zones, and on the interior side of the wall in Climate Zones 5, 6, 7, 8 and Marine 4, as defined in Chapter 11.

AS105.6.4 Horizontal surfaces.
Bale walls and other bale elements shall be provided with a water-resistant barrier at weather-exposed horizontal surfaces. The water-resistant barrier shall be of a material and installation that will prevent water from entering the wall system. Horizontal surfaces shall include exterior window sills, sills at exterior niches and buttresses. The finish material at such surfaces shall be sloped not less than 1 unit vertical in 12 units horizontal (8-percent slope) and shall drain away from bale walls and elements. Where the water-resistant barrier is below the finish material, it shall be sloped not less than 1 unit vertical in 12 units.
horizontal (8-percent slope) and shall drain to the outside surface of the bales wall’s vertical finish.

**AS105.6.5 Separation of bales and concrete.**
A sheet or liquid-applied Class II vapor retarder shall be installed between bales and supporting concrete or masonry. The bales shall be separated from the vapor retarder by not less than \( \frac{3}{4} \) inch (19.1 mm), and that space shall be filled with an insulating material such as wood or rigid insulation, or a material that allows vapor dispersion such as gravel, or other approved insulating or vapor dispersion material. Sill plates shall be installed at this interface in accordance with Section AS105.3. Where bales abut a concrete or masonry wall that retains earth, a Class II vapor retarder shall be provided between such wall and the bales.

**AS105.6.6 Separation of bales and earth.**
Bales shall be separated from earth by not less than 8 inches (203 mm).

**AS105.6.7 Separation of exterior plaster and earth.**
Exterior plaster applied to straw bales shall be located not less than 6 inches (102 mm) above earth or 3 inches (51 mm) above paved areas.

**AS105.6.8 Separation of wood and plaster.**
Where wood framing or wood sheathing occurs on the exterior face of strawbale walls, such wood surfaces shall be separated from exterior plaster with two layers of Grade D paper, No. 15 asphalt felt or other approved material in accordance with Section R703.6.3.

**Exceptions:**

1. Where the wood is preservative treated or naturally durable and is not greater than \( 1 \frac{1}{2} \) inches (38 mm) in width.

2. Clay plaster shall not be required to be separated from untreated wood that is not greater than \( 1 \frac{1}{2} \) inches (38 mm) in width.

**AS105.7 Inspections.**
The building official shall inspect the following aspects of strawbale construction in accordance with Section R109.1:

1. Sill plate anchors, as part of and in accordance with Section R109.1.1.

2. Mesh placement and attachment, where mesh is required by this appendix.

3. Pins, where required by and in accordance with Section AS105.4.

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**SECTION AS106**
**STRAWBALE WALLS—STRUCTURAL**
AS106.1 General.
Plastered strawbale walls shall be permitted to be used as structural walls in one-story buildings in accordance with the prescriptive provisions of this section.

AS106.2 Loads and other limitations.
Live and dead loads and other limitations shall be in accordance with Section R301 of the International Residential Code. Strawbale wall dead loads shall not exceed 60 psf (2872 N/m²) per-face area of wall.

AS106.3 Foundations.
Foundations for plastered strawbale walls shall be in accordance with Chapter 4.

AS106.4 Configuration of bales.
Bales in strawbale structural walls shall be laid flat or on edge and in a running bond or stack bond, except that bales in structural walls with unreinforced plasters shall be laid in a running bond only.

AS106.5 Voids and stuffing.
Voids between bales in strawbale structural walls shall not exceed 4 inches (102 mm) in width, and such voids shall be stuffed with flakes of straw or straw-clay, before application of finish.

AS106.6 Plaster on structural walls.
Plaster on load-bearing walls shall be in accordance with Table AS106.12. Plaster on shear walls shall be in accordance with Table AS106.13(1).

AS106.6.1 Compressive strength.
For plaster on strawbale structural walls, the building official is authorized to require a 2-inch (51mm) cube test conforming to ASTM C 109 to demonstrate a minimum compressive strength in accordance with Table AS106.6.1.

**TABLE AS106.6.1
MINIMUM COMPRESSIVE STRENGTH FOR PLASTERS ON STRUCTURAL WALLS**

<table>
<thead>
<tr>
<th>PLASTER TYPE</th>
<th>MINIMUM COMPRESSIVE STRENGTH (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>100</td>
</tr>
<tr>
<td>Soil-cement</td>
<td>1000</td>
</tr>
<tr>
<td>Lime</td>
<td>600</td>
</tr>
<tr>
<td>Cement-lime</td>
<td>1000</td>
</tr>
<tr>
<td>Cement</td>
<td>1400</td>
</tr>
</tbody>
</table>

For SI: 1 pound per square inch = 6894.76 N/m².

AS106.7 Straightness of plaster.
Plaster on strawbale structural walls shall be straight, as a function of the bale wall surfaces they are applied to, in accordance with all of the following:
1. As measured across the face of a bale, straw bulges shall not protrude more than $\frac{3}{4}$ inch (19.1 mm) across 2 feet (610 mm) of its height or length.

2. As measured across the face of a bale wall, straw bulges shall not protrude from the vertical plane of a bale wall more than 2 inches (51 mm) over 8 feet (2438 mm).

3. The vertical faces of adjacent bales shall not be offset more than $\frac{3}{8}$ inch (9.5 mm).

**AS106.8 Plaster and membranes.**
Strawbale structural walls shall not have a membrane between straw and plaster, or shall have attachment through the bale wall from one plaster skin to the other in accordance with an approved engineered design.

**AS106.9 Mesh.**
Mesh in plasters on strawbale structural walls, and where required by Table AS105.4, shall be installed in accordance with Sections AS106.9.1 through AS106.9.4.

**AS106.9.1 Mesh laps.**
Mesh required by Table AS105.4 or AS106.12 shall be installed with not less than 4-inch (102 mm) laps. Mesh required by Table AS106.13(1) or in walls designed to resist wind uplift of more than 100 plf (1459 N/m), shall run continuous vertically from sill plate to the top plate or roof-bearing element, or shall lap not less than 8 inches (203 mm). Horizontal laps in such mesh shall be not less than 4 inches (102 mm).

**AS106.9.2 Mesh attachment.**
Mesh shall be attached with staples to top plates or roof-bearing elements and to sill plates in accordance with all of the following:

1. **Staples.** Staples shall be pneumatically driven, stainless steel or electro-galvanized, 16 gage with $\frac{1}{2}$-inch (38 mm) legs, $\frac{1}{2}$-inch (11.1 mm) crown; or manually driven, galvanized, 15 gage with 1-inch (25 mm) legs. Other staples shall be permitted to be used as designed by a registered design professional. Staples into preservative-treated wood shall be stainless steel.

2. **Staple orientation.** Staples shall be firmly driven diagonally across mesh intersections at the required spacing.

3. **Staple spacing.** Staples shall be spaced not more than 4 inches (102 mm) on center, except where a lesser spacing is required by Table AS106.13(1) or Section AS106.14, as applicable.

**AS106.9.3 Steel mesh.**
Steel mesh shall be galvanized, and shall be separated from preservative-treated wood by Grade D paper, No. 15 roofing felt or other approved barrier.
AS106.9.4 Mesh in plaster.
Required mesh shall be embedded in the plaster except where staples fasten the mesh to horizontal boundary elements.

AS106.10 Support of plaster skins.
Plaster skins on strawbale structural walls shall be continuously supported along their bottom edge. Acceptable supports include: a concrete or masonry stem wall, a concrete slab on grade, a wood-framed floor blocked with an approved engineered design or a steel angle anchored with an approved engineered design. A weep screed as described in Section R702.8.2.1 is not an acceptable support.

AS106.11 Transfer of loads to and from plaster skins.
Where plastered strawbale walls are used to support superimposed vertical loads, such loads shall be transferred to the plaster skins by continuous direct bearing or by an approved engineered design. Where plastered strawbale walls are used to resist in-plane lateral loads, such loads shall be transferred to the reinforcing mesh from the structural member or assembly above and to the sill plate in accordance with Table AS106.13(3).

AS106.12 Load-bearing walls.
Plastered strawbale walls shall be permitted to be used as load-bearing walls in one-story buildings to support vertical loads imposed in accordance with Section R301, in accordance with and not more than the allowable bearing capacities indicated in Table AS106.12.

**TABLE AS106.12**
ALLOWABLE SUPERIMPOSED VERTICAL LOADS (LBS/FOOT) FOR PLASTERED LOAD-BEARING STRAWBALE WALLS

<table>
<thead>
<tr>
<th>WALL DESIGNATION</th>
<th>PLASTER&lt;sup&gt;a&lt;/sup&gt; (both sides) Minimum thickness in inches each side</th>
<th>MESH&lt;sup&gt;b&lt;/sup&gt;</th>
<th>STAPLES&lt;sup&gt;c&lt;/sup&gt;</th>
<th>ALLOWABLE BEARING CAPACITY&lt;sup&gt;d&lt;/sup&gt; (plf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Clay-1&lt;sup&gt;7/8&lt;/sup&gt;</td>
<td>None required</td>
<td>None required</td>
<td>400</td>
</tr>
<tr>
<td>B</td>
<td>Soil-cement-1</td>
<td>Required</td>
<td>Required</td>
<td>800</td>
</tr>
<tr>
<td>C</td>
<td>Lime-1&lt;sup&gt;7/8&lt;/sup&gt;</td>
<td>Required</td>
<td>Required</td>
<td>500</td>
</tr>
<tr>
<td>D</td>
<td>Cement-lime-1</td>
<td>Required</td>
<td>Required</td>
<td>800</td>
</tr>
<tr>
<td>E</td>
<td>Cement-1&lt;sup&gt;7/8&lt;/sup&gt;</td>
<td>Required</td>
<td>Required</td>
<td>800</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4mm, 1 pound per foot = 14.5939 N/m.
<sup>a</sup> Plasters shall conform to Sections AS104.4.3 through AS104.4.8, AS106.7 and AS106.10.
<sup>b</sup> Any metal mesh allowed by this appendix and installed in accordance with Section AS106.9.
<sup>c</sup> In accordance with Section AS106.9.2, except as required to transfer roof loads to the plaster skins in accordance with Section AS106.11.
<sup>d</sup> For walls with a different plaster on each side, the lower value shall be used.
**AS106.12.1 Precompression of load-bearing strawbale walls.**
Prior to application of plaster, walls designed to be load bearing shall be precompressed by a uniform load of not less than 100 plf (1459 N/m).

**AS106.12.2 Concentrated loads.**
Concentrated loads shall be distributed by structural elements capable of distributing the loads to the bearing wall within the allowable bearing capacity listed in Table AS106.12 for the plaster type used.

**AS106.13 Braced panels.**
Plastered strawbale walls shall be permitted to be used as braced wall panels for one-story buildings in accordance with Section R602.10 of the *International Residential Code*, and with Tables AS106.13(1), AS106.13(2) and AS106.13(3). Wind design criteria shall be in accordance with Section R301.2.1. Seismic design criteria shall be in accordance with Section R301.2.2.

### TABLE AS106.13(1)
**PLASTERED STRAWBALE BRACED WALL PANEL TYPES**

<table>
<thead>
<tr>
<th>WALL DESIGNATION</th>
<th>PLASTER Type</th>
<th>PLASTER Thickness (minimum in inches each side)</th>
<th>SILL PLATES Type</th>
<th>SILL PLATES Size (nominal in inches)</th>
<th>ANCHOR BOLT SPACING (inches on center)</th>
<th>MESH (inches)</th>
<th>STAPLE SPACING (inches on center)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Clay</td>
<td>1.5</td>
<td>2 × 4</td>
<td>32</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>A2</td>
<td>Clay</td>
<td>1.5</td>
<td>2 × 4</td>
<td>32</td>
<td>2 × 2 high-density polypropylene</td>
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<tr>
<td>A3</td>
<td>Clay</td>
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<td>2 × 4</td>
<td>32</td>
<td>2 × 2 × 14 gage</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Soil-cement</td>
<td>1</td>
<td>4 × 4</td>
<td>24</td>
<td>2 × 2 × 14 gage</td>
<td>2</td>
<td></td>
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<tr>
<td>C1</td>
<td>Lime</td>
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<td>2 × 4</td>
<td>32</td>
<td>17-gage woven wire</td>
<td>3</td>
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<tr>
<td>C2</td>
<td>Lime</td>
<td>7/8</td>
<td>4 × 4</td>
<td>24</td>
<td>2 × 2 × 14 gage</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>Cement-lime</td>
<td>7/8</td>
<td>4 × 4</td>
<td>32</td>
<td>17-gage woven wire</td>
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<tr>
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<td>24</td>
<td>2 × 2 × 14 gage</td>
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</table>

SI: 1 inch = 25.4 mm  
a. Plasters shall conform with Sections AS104.4.3 through AS104.4.8, AS106.7, AS106.8 and AS106.12.  
b. Sill plates shall be Douglas fir-larch or southern pine and shall be preservative treated where required by the *International Residential Code*.  
c. Anchor bolts shall be in accordance with Section AS106.13.3 at the spacing shown in this table.  
d. Installed in accordance with Section AS106.9.  
e. Staples shall be in accordance with Section AS106.9.2 at the spacing shown in this table.
### TABLE AS106.13(2)
**BRACING REQUIREMENTS FOR STRAWBALE BRACED WALL PANELS BASED ON WIND SPEED**

- **EXPOSURE CATEGORY B**
- **25-FOOT MEAN ROOF HEIGHT**
- **10-FOOT EAVE-TO-RIDGE HEIGHT**
- **10-FOOT WALL HEIGHT**
- **2 BRACED WALL LINES**

<table>
<thead>
<tr>
<th>Basic wind speed (mph)</th>
<th>Story location</th>
<th>Braced wall line spacing (feet)</th>
<th>Strawbale-braced wall panel a,A2,A3</th>
<th>Strawbale-braced wall panel e,C1,C2,D1</th>
<th>Strawbale-braced wall panel e,D2,E1,E2</th>
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<td>≤85</td>
<td>One-story building</td>
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<td>6.4</td>
<td>3.8</td>
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<td>16.3</td>
<td>7.7</td>
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<td>60</td>
<td>31.6</td>
<td>11.4</td>
<td>8.5</td>
</tr>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 mile per hour = 0.447 m/s.

- **a.** Linear interpolation shall be permitted.
- **b.** All braced wall panels shall be without openings and shall have an aspect ratio \((H:L) \leq 2:1\).
- **c.** Tabulated minimum total lengths are for braced wall lines using single braced wall panels with an aspect ratio \((H:L) \leq 2:1\), or using multiple braced wall panels with aspect ratios \((H:L) < 1:1\). For braced wall lines using two or more braced wall panels with an aspect ratio \((H:L) > 1:1\), the minimum total length shall be multiplied by the largest aspect ratio \((H:L)\) of braced wall panels in that line.
- **d.** Subject to applicable wind adjustment factors associated with “All methods” in Table R602.10.3(2).
- **e.** Strawbale braced panel types indicated shall comply with Sections AS106.13.1 through AS106.13.3 and with Table AS106.13(1).
### Seismic Design Category

<table>
<thead>
<tr>
<th>Seismic Design Category</th>
<th>Story Location</th>
<th>Braced-wall line length (feet)</th>
<th>Strawbale Braced Wall Panels A2, C1, C2, D1</th>
<th>Strawbale Braced Wall Panels B, D2, E1, E2</th>
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<td>5.7</td>
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<td>16.3</td>
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</table>

For SI: 1 inch = 25.4 mm, 1 foot = 305 mm, 1 pound per square foot = 0.0479 kPa.

a. Linear interpolation shall be permitted.
b. Braced wall panels shall be without openings and shall have an aspect ratio \( (H:L) \leq 2:1 \).
c. Tabulated minimum total lengths are for braced wall lines using single braced wall panels with an aspect ratio \( (H:L) \leq 2:1 \), or using multiple braced wall panels with aspect ratios \( (H:L) > 1:1 \). For braced wall lines using two or more braced wall panels with an aspect ratio \( (H:L) > 1:1 \), the minimum total length shall be multiplied by the largest aspect ratio \( (H:L) \) of braced wall panels in that line.
d. Subject to applicable seismic adjustment factors associated with “All methods” in Table R602.10.3(4), except “Wall dead load.”
e. Strawbale braced wall panel types indicated shall comply with Sections AS106.13.1 through AS106.13.3 and Table AS106.13(1).

#### AS106.13.1 Bale wall thickness.
The thickness of the stacked bale wall without its plaster shall be not less than 15 inches (381 mm).

#### AS106.13.2 Sill plates.
Sill plates shall be in accordance with Table AS106.13(1).

#### AS106.13.3 Sill-plate fasteners.
Sill plates shall be fastened with not less than \( \frac{5}{8} \)-inch-diameter (15.9 mm) steel anchor bolts.
with 3-inch by 3-inch by \( \frac{3}{16} \)-inch (76.2 mm by 76.2 mm by 4.8 mm) steel washers, with not less than 7-inch (177.8 mm) embedment in a concrete or masonry foundation, or shall be an approved equivalent, with the spacing shown in Table AS106.13(1). Anchor bolts or other fasteners into framed floors shall be of an approved engineered design.

**AS106.14 Resistance to wind uplift forces.**

Plaster mesh in skins of strawbale walls that resist uplift forces from the roof assembly, as determined in accordance with Section R802.11, shall be in accordance with all of the following:

1. Plaster shall be any type and thickness allowed in Section AS104.
2. Mesh shall be any type allowed in Table AS106.13(1), and shall be attached to top plates or roof-bearing elements and to sill plates in accordance with Section AS106.9.2.
3. Sill plates shall be not less than nominal 2-inch by 4-inch (51 mm by 102 mm) with anchoring complying with Section R403.1.6.
4. Mesh attached with staples at 4 inches (51 mm) on center shall be considered to be capable of resisting uplift forces of 100 plf (1459 N/m) for each plaster skin.
5. Mesh attached with staples at 2 inches (51 mm) on center shall be considered to be capable of resisting uplift forces of 200 plf (2918 N/m) for each plaster skin.

**SECTION AS107**  
**FIRE RESISTANCE**

**AS107.1 Fire-resistance rating.**

Strawbale walls shall be considered to be nonrated, except for walls constructed in accordance with Section AS107.1.1 or AS107.1.2. Alternately, fire-resistance ratings of strawbale walls shall be determined in accordance with Section R302 of the *International Residential Code*.

**AS107.1.1 One-hour rated clay plastered wall.**

One-hour fire-resistance rated nonload-bearing clay plastered strawbale walls shall comply with all of the following:

1. Bales shall be laid flat or on-edge in a running bond.
2. Bales shall maintain thickness of not less than 18 inches (457 mm).
3. Gaps shall be stuffed with straw-clay.
4. Clay plaster on each side of the wall shall be not less than 1 inch (25 mm) thick and shall be composed of a mixture of 3 parts clay, 2 parts chopped straw and 6 parts sand, or an alternative approved clay plaster.
5. Plaster application shall be in accordance with Section AS104.4.3.3 for the number and thickness of coats.
AS107.1.2 Two-hour rated cement plastered wall.  
Two-hour fire-resistance-rated nonload-bearing cement plastered strawbale walls shall comply with all of the following:

1. Bales shall be laid flat or on-edge in a running bond.

2. Bales shall maintain a thickness of not less than 14 inches (356 mm).

3. Gaps shall be stuffed with straw-clay.

4. 1 1/2-inch (38 mm) by 17-gage galvanized woven wire mesh shall be attached to wood members with 1 1/2-inch (38 mm) staples at 6 inches (152 mm) on center. 9 gage U-pins with not less than 8-inch (203 mm) legs shall be installed at 18 inches (457 mm) on center to fasten the mesh to the bales.

5. Cement plaster on each side of the wall shall be not less than 1 inch (25 mm) thick.

6. Plaster application shall be in accordance with Section AS104.4.8 for the number and thickness of coats.

AS107.2 Openings in rated walls.  
Openings and penetrations in bale walls required to have a fire-resistance rating shall satisfy the same requirements for openings and penetrations as prescribed in the International Residential Code.

AS107.3 Clearance to fireplaces and chimneys.  
Strawbale surfaces adjacent to fireplaces or chimneys shall be finished with not less than 3/8-inch (10 mm) thick plaster of any type permitted by this appendix. Clearance from the face of such plaster to fireplaces and chimneys shall be maintained as required from fireplaces and chimneys to combustibles in Chapter 10, or as required by manufacturer’s instructions, whichever is more restrictive.

SECTION AS108  
THERMAL INSULATION

AS108.1 R-value.  
The unit R-value of a strawbale wall with bales laid flat is R-1.3 per inch of bale thickness. The unit R-value of a strawbale wall with bales on-edge is R-2 per inch of bale thickness.

SECTION AS109  
REFERENCED STANDARDS

ASTM  
C.5—10 Standard Specification for Quicklime for Structural Purposes

AS104.4.6.1
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<th>Code</th>
<th>Description</th>
<th>Standard</th>
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<td>Standard Specification for Hydrated Hydraulic Lime for Structural Purposes</td>
<td>C 141/C 141M—09</td>
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<td>C-206—03</td>
<td>Standard Specification for Finishing Hydrated Lime</td>
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<td>Standard Specification for Application of Portland Cement Based Plaster</td>
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AS106.6.1

AS104.4.6.1

AS104.4.7, AS104.4.8

AS104.4.6.1

AS104.4.6.1
APPENDIX T
RECOMMENDED PROCEDURE FOR WORST-CASE TESTING OF ATMOSPHERIC VENTING SYSTEMS UNDER N1102.4 OR N1105 CONDITIONS ≤ 5ACH₅₀

Deleted
(This appendix is informative and is not part of the code.)

SECTION T101
SCOPE

T101.1 General.
This appendix is intended to provide guidelines for worst-case testing of atmospheric venting systems. Worst-case testing is recommended to identify problems that weaken draft and restrict combustion air.

SECTION T202
GENERAL DEFINITIONS

COMBUSTION APPLIANCE ZONE (CAZ). A contiguous air volume within a building that contains a Category I or II atmospherically vented appliance or a Category III or IV direct-vent or integral vent appliance drawing combustion air from inside the building or dwelling unit. The CAZ includes, but is not limited to, a mechanical closet, a mechanical room or the main body of a house or dwelling unit.

DRAFT. The pressure difference existing between the appliance or any component part and the atmosphere that causes a continuous flow of air and products of combustion through the gas passages of the appliance to the atmosphere.

Mechanical or induced draft. The pressure difference created by the action of a fan, blower or ejector that is located between the appliance and the chimney or vent termination.

Natural draft. The pressure difference created by a vent or chimney because of its height and the temperature difference between the flue gases and the atmosphere.

SPILLAGE. Combustion gases emerging from an appliance or venting system into the combustion appliance zone during burner operation.

SECTION T301
TESTING PROCEDURE
T301.1 Worst-case testing of atmospheric venting systems.
Buildings or dwelling units containing a Category I or II atmospherically vented appliance, or a Category III or IV direct-vent or integral vent appliance drawing combustion air from inside of the building or dwelling unit, shall have the Combustion Appliance Zone (CAZ) tested for spillage, acceptable draft and carbon monoxide (CO) in accordance with this Section. Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope and prior to final inspection.

Exception: Buildings or dwelling units containing only Category III or IV direct-vent or integral vent appliances that do not draw combustion air from inside of the building or dwelling unit.

The enumerated test procedure as follows shall be complied with during testing:

1. Set combustion appliances to the pilot setting or turn off the service disconnects for combustion appliances. Close exterior doors and windows and the fireplace damper. With the building or dwelling unit in this configuration, measure and record the baseline ambient pressure inside the building or dwelling unit CAZ. Compare the baseline ambient pressure of the CAZ to that of the outside ambient pressure and record the difference (Pa).

2. Establish worst case by turning on the clothes dryer and all exhaust fans. Close interior doors that make the CAZ pressure more negative. Turn on the air handler, where present, and leave on if, as a result, the pressure in the CAZ becomes more negative. Check interior door positions again, closing only the interior doors that make the CAZ pressure more negative. Measure net change in pressure from the CAZ to outdoor ambient pressure, correcting for the base ambient pressure inside the home. Record “worst case depressurization” pressure and compare to Table T301.1(1). Where CAZ depressurization limits are exceeded under worst-case conditions in accordance with Table T301.1(1), additional combustion air shall be provided or other modifications to building air leakage performance or exhaust appliances such that depressurization is brought within the limits prescribed in Table T301.1(1).

3. Measure worst-case spillage, acceptable draft and carbon monoxide (CO) by firing the fuel-fired appliance with the smallest Btu capacity first.

   a. Test for spillage at the draft diverter with a mirror or smoke puffer. An appliance that continues to spill flue gases for more than 60 seconds fails the spillage test.

   b. Test for CO measuring undiluted flue gases in the throat or flue of the appliance using a digital gauge in parts per million (ppm) at the 10-minute mark. Record CO ppm readings to be compared with Table T301.1(3) upon completion of Step 4. Where the spillage test fails under worst case, go to Step 4.
c. Where spillage ends within 60 seconds, test for acceptable draft in the connector not less than 1 foot (305 mm), but not more than 2 feet (610 mm) downstream of the draft diverter. Record draft pressure and compare to Table T301.1(2).

d. Fire all other CONNECTED appliances simultaneously and test again at the draft diverter of each appliance for spillage, CO and acceptable draft using procedures 3a through 3c.

4. Measure spillage, acceptable draft, and carbon monoxide (CO) under natural conditions—without clothes dryer and exhaust fans on—in accordance with the procedure outlined in Step 3, measuring the net change in pressure from worst case condition in Step 3 to natural in the CAZ to confirm the worst case depressurization taken in Step 2. Repeat the process for each appliance, allowing each vent system to cool between tests.

5. Monitor indoor ambient CO in the breathing zone continuously during testing, and abort the test where indoor ambient CO exceeds 35 ppm by turning off the appliance, ventilating the space, and evacuating the building. The CO problem shall be corrected prior to completing combustion safety diagnostics.

6. Make recommendations based on test results and the retrofit action prescribed in Table T301.1(3).

TABLE T301.1(1)
CAZ DEPRESSURIZATION LIMITS

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<thead>
<tr>
<th>VENTING CONDITION</th>
<th>LIMIT (Pa)</th>
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<tbody>
<tr>
<td>Category I, atmospherically-vented water heater</td>
<td>−2.0</td>
</tr>
<tr>
<td>Category I or II atmospherically vented boiler or furnace common vented with a</td>
<td>−3.0</td>
</tr>
<tr>
<td>Category I atmospherically-vented water heater</td>
<td></td>
</tr>
<tr>
<td>Category I or II atmospherically vented boiler or furnace, equipped with a flue</td>
<td>−5.0</td>
</tr>
<tr>
<td>damper, and common vented with a Category I atmospherically vented water heater</td>
<td></td>
</tr>
<tr>
<td>Category I or II atmospherically vented boiler or furnace alone</td>
<td></td>
</tr>
<tr>
<td>Category I or II atmospherically vented, fan-assisted boiler or furnace common</td>
<td></td>
</tr>
<tr>
<td>vented with a Category I atmospherically-vented water heater</td>
<td></td>
</tr>
<tr>
<td>Decorative vented, gas appliance</td>
<td></td>
</tr>
<tr>
<td>Power vented or induced-draft boiler or furnace alone, or fan-assisted water heater</td>
<td>−15.0</td>
</tr>
<tr>
<td>Category IV direct-vented appliances and sealed combustion appliances</td>
<td>−50.0</td>
</tr>
</tbody>
</table>

For SI: 6894.76 Pa = 1.0 psi.

TABLE T301.1(2)
ACCEPTABLE DRAFT TEST CORRECTION

<table>
<thead>
<tr>
<th>OUTSIDE TEMPERATURE (°F)</th>
<th>MINIMUM DRAFT PRESSURE REQUIRED (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10</td>
<td>−2.5</td>
</tr>
<tr>
<td>10 – 90</td>
<td>(Outside Temperature ÷ 40) − 2.75</td>
</tr>
</tbody>
</table>
For SI: 6894.76 Pa = 1.0 psi.

### TABLE T301.1(3)
**ACCEPTABLE DRAFT TEST CORRECTION**

<table>
<thead>
<tr>
<th>CARBON DIOXIDE LEVEL (ppm)</th>
<th>AND/ OR</th>
<th>SPILLAGE AND ACCEPTABLE DRAFT TEST RESULTS</th>
<th>RETROFIT ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0—25</td>
<td>and</td>
<td>Passes</td>
<td>Proceed with work</td>
</tr>
<tr>
<td>25 ≤ ≤ 100</td>
<td>and</td>
<td>Passes</td>
<td>Recommend that CO problem be resolved</td>
</tr>
<tr>
<td>25 ≤ ≤ 100</td>
<td>and</td>
<td>Fails in worst case only</td>
<td>Recommend an appliance service call and repairs to resolve the problem</td>
</tr>
<tr>
<td>100 ≤ ≤ 400</td>
<td>or</td>
<td>Fails under natural conditions</td>
<td><strong>Stop!</strong> Work shall not proceed until appliance is serviced and problem resolved</td>
</tr>
<tr>
<td>&gt; 400</td>
<td>and</td>
<td>Passes</td>
<td><strong>Stop!</strong> Work shall not proceed until appliance is serviced and problem resolved</td>
</tr>
<tr>
<td>&gt; 400</td>
<td>and</td>
<td>Fails under any condition</td>
<td><strong>Emergency!</strong> Shut off fuel to appliance and call for service immediately</td>
</tr>
</tbody>
</table>
APPENDIX U
SOLAR-READY PROVISIONS—DETACHED ONE- AND TWO-FAMILY DWELLINGS, MULTIPLE SINGLE-FAMILY DWELLINGS (TOWNHOUSES)

Deleted

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION U101
SCOPE

U101.1 General.
These provisions shall be applicable for new construction where solar-ready provisions are required.

SECTION U102
GENERAL DEFINITIONS

SOLAR-READY ZONE. A section or sections of the roof or building overhang designated and reserved for the future installation of a solar photovoltaic or solar thermal system.

SECTION U103
SOLAR-READY ZONE

U103.1 General.
New detached one- and two-family dwellings, and multiple single-family dwellings (townhouses) with not less than 600 square feet (55.74 m²) of roof area oriented between 110 degrees and 270 degrees of true north shall comply with sections U103.2 through U103.8.

Exceptions:

1. New residential buildings with a permanently installed on-site renewable energy system.

2. A building with a solar-ready zone that is shaded for more than 70 percent of daylight hours annually.

U103.2 Construction document requirements for solar ready zone.
Construction documents shall indicate the solar-ready zone.
U103.3 Solar-ready zone area.
The total solar-ready zone area shall be not less than 300 square feet (27.87 m²) exclusive of mandatory access or set back areas as required by the International Fire Code. New multiple single-family dwellings (townhouses) three stories or less in height above grade plane and with a total floor area less than or equal to 2,000 square feet (185.8 m²) per dwelling shall have a solar-ready zone area of not less than 150 square feet (13.94 m²). The solar-ready zone shall be composed of areas not less than 5 feet (1.52 m) in width and not less than 80 square feet (7.44 m²) exclusive of access or set back areas as required by the International Fire Code.

U103.4 Obstructions.
Solar-ready zones shall be free from obstructions, including but not limited to vents, chimneys, and roof-mounted equipment.

U103.5 Roof load documentation.
The structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents.

U103.6 Interconnection pathway.
Construction documents shall indicate pathways for routing of conduit or plumbing from the solar-ready zone to the electrical service panel or service hot water system.

U103.7 Electrical service reserved space.
The main electrical service panel shall have a reserved space to allow installation of a dual-pole circuit breaker for future solar electric installation and shall be labeled “For Future Solar Electric.” The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.

U103.8 Construction documentation certificate.
A permanent certificate, indicating the solar-ready zone and other requirements of this section, shall be posted near the electrical distribution panel, water heater or other conspicuous location by the builder or registered design professional.
APPENDIX V
SWIMMING POOLS, SPAS AND HOT TUBS

This appendix is a North Carolina addition and not part of the 2015 International Residential Code. There will be no underlined text.

(The provisions contained in this appendix are adopted as part of this code.)

SECTION AV101
GENERAL

AV101.1 General.
The provisions of this appendix shall control the design and construction of swimming pools, spas and hot tubs installed in or on the lot of a one- or two-family dwelling.

AV101.2 Pools in flood hazard areas.
Pools that are located in flood hazard areas established by Table R301.2(1), including above-ground pools, on-ground pools and in-ground pools that involve placement of fill, shall comply with Sections AV101.2.1 or AV101.2.2.

Exception: Pools located in riverine flood hazard areas which are outside of designated floodways.

AV101.2.1 Pools located in designated floodways.
Where pools are located in designated floodways, documentation shall be submitted to the building official, which demonstrates that the construction of the pool will not increase the design flood elevation at any point within the jurisdiction.

AV101.2.2 Pools located where floodways have not been designated.
Where pools are located where design flood elevations are specified but floodways have not been designated, the applicant shall provide a floodway analysis that demonstrates that the proposed pool will not increase the design flood elevation more than 1 foot (305 mm) at any point within the jurisdiction.

SECTION AV102
DEFINITIONS

AV102.1 General.
For the purposes of these requirements, the terms used shall be defined as follows and as set forth in Chapter 2.

ABOVE-GROUND/ON-GROUND POOL. See “Swimming pool.”

BARRIER. A fence, wall, building wall or combination thereof which completely surrounds the swimming pool and obstructs access to the swimming pool.

HOT TUB. See “Swimming pool.”

2018 North Carolina Residential Code
IN-GROUND POOL. See “Swimming pool.”

RESIDENTIAL. That which is situated on the premises of a detached one- or two-family dwelling or a one-family townhouse not more than three stories in height.

SPA, NONPORTABLE. See “Swimming pool.”

SPA, PORTABLE. A nonpermanent structure intended for recreational bathing, in which all controls, water-heating and water-circulating equipment are an integral part of the product.

SWIMMING POOL. Any structure intended for swimming or recreational bathing that contains water over 24 inches (610 mm) deep. This includes in-ground, above-ground and on-ground swimming pools, hot tubs and spas.

SWIMMING POOL, INDOOR. A swimming pool which is totally contained within a structure and surrounded on all four sides by the walls of the enclosing structure.

SWIMMING POOL, OUTDOOR. Any swimming pool which is not an indoor pool.

SECTION AV103
SWIMMING POOLS

AV103.1 In-ground pools. In-ground pools shall be designed and constructed in conformance with ANSI/NSPI-5 as listed in Section AV108.

AV103.2 Above-ground and on-ground pools. Above-ground and on-ground pools shall be designed and constructed in conformance with ANSI/NSPI-4 as listed in Section AV108.

AV103.3 Pools in flood hazard areas. In flood hazard areas established by Table R301.2(1), pools in coastal high hazard areas shall be designed and constructed in conformance with ASCE 24.

SECTION AV104
SPAS AND HOT TUBS

AV104.1 Permanently installed spas and hot tubs. Permanently installed spas and hot tubs shall be designed and constructed in conformance with ANSI/NSPI-3 as listed in Section AV108.

AV104.2 Portable spas and hot tubs. Portable spas and hot tubs shall be designed and constructed in conformance with ANSI/NSPI-6 as listed in Section AV108.

SECTION AV105
BARRIER REQUIREMENTS

AV105.1 Application.
The provisions of this chapter shall control the design of barriers for residential swimming pools, spas and hot tubs. These design controls are intended to provide protection against potential drownings and near drownings by restricting access to swimming pools, spas and hot tubs.

**AV105.2 Outdoor swimming pool.**
An outdoor swimming pool, including an in-ground, above-ground or on-ground pool, hot tub or spa shall be surrounded by a barrier which shall comply with the following:

1. The top of the barrier shall be at least 48 inches (1219 mm) above grade measured on the side of the barrier which faces away from the swimming pool. The maximum vertical clearance between grade and the bottom of the barrier shall be 2 inches (51 mm) or 4 inches (102 mm) where concrete or fixed solid material is used measured on the side of the barrier which faces away from the swimming pool. Where the top of the pool structure is above grade, such as an above-ground pool, the barrier may be at ground level, such as the pool structure, or mounted on top of the pool structure. Where the barrier is mounted on top of the pool structure, the maximum vertical clearance between the top of the pool structure and the bottom of the barrier shall be 4 inches (102 mm).

2. Openings in the barrier shall not allow passage of a 4-inch-diameter (102 mm) sphere.

3. Solid barriers which do not have openings, such as a masonry or stone wall, shall not contain indentations or protrusions except for normal construction tolerances and tooled masonry joints.

4. Where the barrier is composed of horizontal and vertical members and the distance between the tops of the horizontal members is less than 45 inches (1143 mm), the horizontal members shall be located on the swimming pool side of the fence. Spacing between vertical members shall not exceed 13/4 inches (44 mm) in width. Where there are decorative cutouts within vertical members, spacing within the cutouts shall not exceed 13/4 inches (44 mm) in width.

5. Where the barrier is composed of horizontal and vertical members and the distance between the tops of the horizontal members is 45 inches (1143 mm) or more, spacing between vertical members shall not exceed 4 inches (102 mm). Where there are decorative cutouts within vertical members, spacing within the cutouts shall not exceed 13/4 inches (44 mm) in width.

6. Maximum mesh size for chain link fences shall be a 21/4-inch (57 mm) square unless the fence has slats fastened at the top or the bottom which reduce the openings to not more than 13/4 inches (44 mm).

7. Where the barrier is composed of diagonal members, such as a lattice fence, the maximum opening formed by the diagonal members shall not be more than 13/4 inches (44 mm).

8. Access gates shall comply with the requirements of Section AV105.2, Items 1 through 7, and shall be equipped to accommodate a locking device. Pedestrian access gates shall open outward away from the pool and shall be self-closing and have a self-latching
device. Gates other than pedestrian access gates shall have a self-latching device. Where the release mechanism of the self-latching device is located less than 54 inches (1372 mm) from the bottom of the gate, the release mechanism and openings shall comply with the following:

8.1. The release mechanism shall be located on the pool side of the gate at least 3 inches (76 mm) below the top of the gate; and

8.2. The gate and barrier shall have no opening larger than 1/2 inch (12.7 mm) within 18 inches (457 mm) of the release mechanism.

9. Where a wall of a dwelling serves as part of the barrier, one of the following conditions shall be met:

9.1. The pool shall be equipped with a powered safety cover in compliance with ASTM F 1346; or

9.2. Doors with direct access to the pool through that wall shall be equipped with an alarm which produces an audible warning when the door and/or its screen, if present, are opened. The alarm shall be listed and labeled in accordance with UL 2017. The deactivation switch(es) shall be located at least 54 inches (1372 mm) above the threshold of the door; or

9.3. Other means of protection, such as self-closing doors with self-latching devices, which are approved by the governing body, shall be acceptable as long as the degree of protection afforded is not less than the protection afforded by Item 9.1 or 9.2 described above.

10. Where an above-ground pool structure is used as a barrier or where the barrier is mounted on top of the pool structure, and the means of access is a ladder or steps:

10.1. The ladder or steps shall be capable of being secured, locked or removed to prevent access; or

10.2. The ladder or steps shall be surrounded by a barrier which meets the requirements of Section AV105.2, Items 1 through 9. When the ladder or steps are secured, locked or removed, any opening created shall not allow the passage of a 4-inch-diameter (102 mm) sphere.

AV105.3 Indoor swimming pool.
Walls surrounding an indoor swimming pool shall comply with Section AV105.2, Item 9.

AV105.4 Prohibited locations.
Barriers shall be located to prohibit permanent structures, equipment or similar objects from being used to climb them.

AV105.5 Barrier exceptions.
Spas or hot tubs with a safety cover which complies with ASTM F 1346, as listed in Section AV107, shall be exempt from the provisions of this appendix.
SECTION AV106
ENTRAPMENT PROTECTION FOR SWIMMING POOL AND SPA SUCTION OUTLETS

AV106.1 General.
Suction outlets shall be designed and installed in accordance with ANSI/APSP-7.

SECTION AV107
ABBREVIATIONS

AV107.1 General.
ANSI—American National Standards Institute
11 West 42nd Street
New York, NY 10036

APSP—Association of Pool and Spa Professionals
NSPI—National Spa and Pool Institute
2111 Eisenhower Avenue
Alexandria, VA 22314

ASCE—American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, VA 98411-0700

ASTM—ASTM International
100 Barr Harbor Drive,
West Conshohocken, PA 19428

UL—Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062-2096

SECTION AV108
STANDARDS

AV108.1 General.

ANSI/NSPI

ANSI/NSPI-3-99 Standard for Permanently Installed Residential Spas . . . . . . . . AV104.1

ANSI/NSPI-4-07 Standard for Above-ground/On-ground Residential Swimming Pools . . . . . . . AV103.2

ANSI/NSPI-5-2003 Standard for Residential In-ground Swimming Pools. . . . . . . . AV103.1

ANSI/NSPI-6-99 Standard for Residential Portable Spas . . . . . . . . . . . . . . . . . . . AV104.2

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ANSI/APSP

ANSI/APSP-7-06 Standard for Suction Entrapment avoidance in Swimming Pools, Wading Pools, Spas, Hot Tubs and Catch Basins. ................. AV106.1

ASCE

ASCE/SEI-24-05 Flood Resistant Design and Construction ...................... AV103.3

ASTM


UL

APPENDIX W

BASIC LOAD ESTIMATING

This appendix is a North Carolina addition and not part of the 2015 International Residential Code. There will be no underlined text.
(The provisions contained in this appendix are adopted as part of this code.)

For SI: 1 inch = 25.4, 1 foot = 304.8 mm, 1 square foot = 0.0929m².

ASSUMPTIONS (sleeping area live load; roof or stick frame rafters with no interior bearing):

2018 North Carolina Residential Code
Loads
Secondary floor level is 30# L.L. + 10# D.L. = 40#/sq. ft.
Attic level is 20# live load + 10# dead load = 30#/sq. ft.
Nook ceiling is 10# dead load (No attic storage) = 10#/sq. ft.
Wall load
Studs @ 16", 1/2" gypsum = 8#/sq. ft.
Roof load
20# live load + 10# dead load = 30#/sq. ft.

EXAMPLE OF LOAD ESTIMATING
LOAD ON BEAM IN FAMILY ROOM

Loads in Section A - A as follows:

Total Loads

2nd floor load = \( \frac{\text{front joist span + rear joist span}}{2} \times \text{2nd floor (dead load + live load)} = \text{LOAD/linear ft} \)

\[ = \frac{(10 + 12)}{2} \times (10 + 30) = \frac{(22)}{2} \times (40) = 11 \times 40 = 440 \text{ pounds/linear ft} \]

Interior wall load = Wall Weight per Square foot x Wall Height = \text{LOAD/linear foot}

\[ = 8 \text{ pounds/sq. ft.} \times 8\text{ ft.} = 64 \text{ pounds/linear ft} \]

(Wall weight can vary. Verify actual weight of materials used)

Attic load = \( \frac{\text{front joist span + rear joist span}}{2} \times \text{attic (dead load + live load)} = \text{LOAD/linear ft} \)

\[ = \frac{(10 + 12)}{2} \times (10 + 20) = \frac{(22)}{2} \times (30) = 11 \times 30 = 330 \text{ pounds/linear ft} \]

Roof load: No roof load is transmitted to the beam in the family room. Roof Load = 0

Total Load on Beam in Family Room = 834 pounds/1ft.

Beam span in family room is 9 feet and total estimated load is 834#/linear foot:

By using Table W-1, the required beam is 4 @ 2 x 12 SPF

OR

By using Table W-2, the required minimum flitch beam is 2@2 x 8 with 5/8"x7" steel plate bolted with 1/2" bolts spaced at 2’ o.c.
EXAMPLE OF LOAD ESTIMATING
LOAD ON BEAM IN NOOK AREA

Loads in Section B - B as follows:

Total Loads

(in pounds/linear foot)

2nd floor load = \( \frac{(\text{front joist span} + \text{rear joist span})}{2} \times 2\text{nd floor (dead load + live load)} = \text{LOAD/linear ft} \)

\[
= \frac{(0 + 12)}{2} \times (10 + 30) = \frac{12}{2} \times 40 = 240 \text{ pounds/linear ft}
\]

Exterior wall load = Wall Weight per Square foot \( \times \) Wall Height = LOAD/linear foot

\[
= 8 \text{ pounds/sq. ft.} \times 8\text{ft.} = 64 \text{ pounds/linear ft}
\]

(Wall weight can vary. Verify actual weight of materials used)

Attic load = \( \frac{(\text{front joist span} + \text{rear joist span})}{2} \times \text{attic (dead load + live load)} = \text{LOAD/linear ft} \)

\[
= \frac{(0 + 12)}{2} \times (10 + 20) = \frac{12}{2} \times 30 = 180 \text{ pounds/linear ft}
\]

Roof load = \( \frac{\text{(rafter span} + \text{rafter span})}{2} \times \text{roof(dead load+live load)=LOAD/linear ft} \)

\[
= \frac{(11+11)+1}{2} \times (10 + 20) = \frac{22}{2} \times 30 = 360 \text{ pounds/linear ft}
\]

Nook Ceiling load = \( \frac{(\text{joist span} + \text{joist span})}{2} \times \text{ceiling(dead load+live load)=LOAD/linear ft} \)

\[
= \frac{(0+2)}{2} \times (10+0) = \frac{2}{2} \times 10 = 10 \text{ pounds/linear ft}
\]

Nook Roof load = \( \frac{(\text{rafter span} + \text{rafter span})}{2} \times \text{roof(dead load+live load)=LOAD/linear ft} \)

\[
= \frac{(0+2)}{2} \times (10 + 20) = \frac{2}{2} \times 30 = 30 \text{ pounds/linear ft}
\]

Total Load on Beam in Nook = \( 884 \text{ pounds/1ft.} \)

Beam span in nook is 8 feet and total estimated load is \( 884\#/\text{linear foot} \):

By using Table W-1, the required beam is \( 4 \times 2 \times 12 \) Southern pine or \( 4 \times 2 \times 12 \) Spruce-pine-fir

OR

By using Table W-2, the required minimum flitch beam is \( 2@2 \times 8 \) with \( 1/2" \times 7" \) steel plate bolted with \( 1/2" \) bolts spaced at 2’ o.c.

2018 North Carolina Residential Code
### Table W-1

**WOOD BEAMS AND GIRDERS ALLOWABLE LOADS**

**IN POUNDS PER LINEAR FOOT** 1, 2, 3, 4

<table>
<thead>
<tr>
<th>Span L (feet)</th>
<th>2X8 (1 ½” X 7 ¼”)</th>
<th>2X10 (1 ½” X 9 ¼”)</th>
<th>2X12 (1 ½” X 11 ¼”)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spruce-Pine-Fir 5</td>
<td>Southern Pine</td>
<td>Spruce-Pine-Fir 5</td>
</tr>
<tr>
<td></td>
<td>2 ply</td>
<td>3 ply</td>
<td>4 ply</td>
</tr>
<tr>
<td>3</td>
<td>1305</td>
<td>1956</td>
<td>2610</td>
</tr>
<tr>
<td>4</td>
<td>979</td>
<td>1468</td>
<td>1958</td>
</tr>
<tr>
<td>5</td>
<td>736</td>
<td>1104</td>
<td>1472</td>
</tr>
<tr>
<td>6</td>
<td>511</td>
<td>767</td>
<td>1022</td>
</tr>
<tr>
<td>7</td>
<td>375</td>
<td>563</td>
<td>751</td>
</tr>
<tr>
<td>8</td>
<td>287</td>
<td>431</td>
<td>575</td>
</tr>
<tr>
<td>9</td>
<td>227</td>
<td>341</td>
<td>454</td>
</tr>
<tr>
<td>10</td>
<td>184</td>
<td>276</td>
<td>368</td>
</tr>
<tr>
<td>12</td>
<td>114</td>
<td>172</td>
<td>228</td>
</tr>
<tr>
<td>14</td>
<td>72</td>
<td>108</td>
<td>144</td>
</tr>
</tbody>
</table>

**Table W-1 Notes:**

1. Lumber grade is #2 intended for an in-service moisture content of 19% or less.
2. Deflection is limited to L/360.
3. Load duration factor used in calculations is 1.0.
4. Adequate bearing and lateral support for the member must be provided. Support for the member ends must provide a continuous load path from the bearing to the foundation.
5. Values tabulated are for Spruce-Pine-Fir, not Spruce-Pine-Fir (South). Values tabulated for Southern Pine are based on design values published by the American Wood Council in an addendum to NDS dated March 2013.

6. Span, L, is clear span. Effective span for bending and deflection is clear span plus 3 inches.

### Table W-2
**Flitch Plate Beam Allowable Loads**
IN POUNDS PER LINEAR FOOT \(^{1,2,3,4,5}\)

#### (2) 2x6 with Plate Indicated

<table>
<thead>
<tr>
<th>Span (ft.)</th>
<th>Plate Size / (Beam Weight per Foot)</th>
<th>(\frac{1}{4}''\times5'') Plate (8 lb./ft.)</th>
<th>(\frac{3}{8}''\times5'') Plate (10 lb./ft.)</th>
<th>(\frac{1}{2}''\times5'') Plate (13 lb./ft.)</th>
<th>(\frac{5}{8}''\times5'') Plate (15 lb./ft.)</th>
<th>(\frac{3}{4}''\times5'') Plate (17 lb./ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6'0&quot;</td>
<td>643</td>
<td>825</td>
<td>1006</td>
<td>1188</td>
<td>1370</td>
<td></td>
</tr>
<tr>
<td>7'0&quot;</td>
<td>473</td>
<td>606</td>
<td>739</td>
<td>873</td>
<td>1006</td>
<td></td>
</tr>
<tr>
<td>8'0&quot;</td>
<td>362</td>
<td>464</td>
<td>566</td>
<td>668</td>
<td>771</td>
<td></td>
</tr>
<tr>
<td>9'0&quot;</td>
<td>272</td>
<td>348</td>
<td>425</td>
<td>502</td>
<td>579</td>
<td></td>
</tr>
<tr>
<td>10'0&quot;</td>
<td>198</td>
<td>254</td>
<td>310</td>
<td>366</td>
<td>422</td>
<td></td>
</tr>
<tr>
<td>11'0&quot;</td>
<td>149</td>
<td>191</td>
<td>233</td>
<td>275</td>
<td>317</td>
<td></td>
</tr>
<tr>
<td>12'0&quot;</td>
<td>115</td>
<td>147</td>
<td>179</td>
<td>212</td>
<td>244</td>
<td></td>
</tr>
</tbody>
</table>

#### (2) 2x8 with Plate Indicated

<table>
<thead>
<tr>
<th>Span (ft.)</th>
<th>Plate Size / (Beam Weight per Foot)</th>
<th>(\frac{1}{4}''\times7'') Plate (11 lb./ft.)</th>
<th>(\frac{3}{8}''\times7'') Plate (14 lb./ft.)</th>
<th>(\frac{1}{2}''\times7'') Plate (17 lb./ft.)</th>
<th>(\frac{5}{8}''\times7'') Plate (20 lb./ft.)</th>
<th>(\frac{3}{4}''\times7'') Plate (23 lb./ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6'0&quot;</td>
<td>1150</td>
<td>1499</td>
<td>1849</td>
<td>2199</td>
<td>2549</td>
<td></td>
</tr>
<tr>
<td>7'0&quot;</td>
<td>845</td>
<td>1102</td>
<td>1359</td>
<td>1615</td>
<td>1872</td>
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#### (2) 2x10 with Plate Indicated

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<th>Span (ft.)</th>
<th>Plate Size / (Beam Weight per Foot)</th>
<th>(\frac{1}{4}''\times9'') Plate (14 lb./ft.)</th>
<th>(\frac{3}{8}''\times9'') Plate (18 lb./ft.)</th>
<th>(\frac{1}{2}''\times9'') Plate (22 lb./ft.)</th>
<th>(\frac{5}{8}''\times9'') Plate (26 lb./ft.)</th>
<th>(\frac{3}{4}''\times9'') Plate (30 lb./ft.)</th>
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Table W-2 Notes

1. Lumber species and grade is #2 Southern Pine intended for an in-service moisture content of 19% or less. Design values used were published by the American Wood Council in an addendum to NDS dated March 2013. For Spruce-Pine-Fir lumber using the tabulated flitch plate allowable loads will be slightly conservative.

2. Tabulated values are based on ASTM A36 structural steel plate.

3. Deflection is limited to L/360.

4. Load duration factor used in calculations is 1.0.

5. Adequate bearing and lateral support for the member must be provided. Support for the member ends must provide a continuous load path from the bearing to the foundation.

Span, L, is center to center of supports. Wood side plates and steel flitch plates shall be continuous throughout the span.