CHAPTER 1

ADMINISTRATION AND ENFORCEMENT

COMM 63 SUBCHAPTER I PURPOSE, SCOPE, APPLICATION AND COMPLIANCE

Comm 63.0001 Purpose. The purpose of ch. Comm 63 is to regulate the design of building envelopes for adequate thermal resistance and low air leakage and the design and selection of mechanical, electrical, service water-heating and illumination systems and equipment which will enable effective use of energy in new building construction.

Comm 63.0002 Scope.

(1) General. The scope of ch. Comm 63 is as specified in s. Comm 61.02, except as exempted in sub. (2).

(2) Exempt buildings and structures. The following buildings or portions of buildings shall be exempt from ch. Comm 63.

(a) Buildings, or portions thereof, without space heating or cooling, service water heating, or illumination are exempt from the requirements of ch. Comm 63 that apply to those systems.

(b) Buildings and structures, or portions thereof separated by building envelope assemblies from the remainder of the building, that have a peak design rate of energy usage less than 3.4 Btu/h·ft^2 of floor area for all purposes are exempt.

Comm 63.0003 Application.

(1) General. Chapter Comm 63 shall be applied as specified in s. Comm 61.03 and as modified in subs. (2) to (5).

(2) Additions.

(a) Building envelope. Additions to existing buildings or structures may be made without the existing building or structure having to comply with the building envelope requirements of ch. Comm 63, but the addition envelope shall comply with ch. Comm 63.

(b) HVAC systems. Where an existing HVAC system serves both an existing building and a proposed addition, any portion of the HVAC system or equipment that is altered shall comply with ch. Comm 63.

(c) Lighting systems. Lighting systems installed in a new addition or in conjunction with an increase of floor area, such as the addition of a mezzanine, shall comply with ch. Comm 63.

(3) Alterations.

(a) Building envelope. Alterations to the building envelope shall comply with one of the following:

1. The alteration shall not increase the rate of heat loss through the portion of the building envelope containing the alteration.
2. The alteration shall not increase the annual energy use from heat gain or loss through the entire building envelope.
3. The building envelope shall be brought into compliance with the requirements of ch. Comm 63.

(b) HVAC systems. Rooftop fan systems that replace existing fan systems shall be provided with economizers that comply with ch. Comm 63 requirements for new construction.

(c) Lighting systems.

1. When alterations to an existing lighting system increase the connected interior lighting load of the building or replace more than 50 percent of the lighting fixtures, the interior lighting system shall comply with ss. Comm 63.1044 to 63.1049.
2. When alterations to an existing lighting system increase the connected exterior lighting load or replace more than 50 percent of the lighting fixtures, the entire exterior lighting system shall comply with ss. Comm 63.1041 to 63.1043.
3. a. Except as specified in subpar. b., alterations to controls shall comply with ss. Comm 63.1050 and 63.1051.

   b. Shutoff lighting controls in s. Comm 63.1050 (4) are not required in contiguous altered spaces of less than 5,000 square feet (464 m^2) unless shutoff controls were required by the building code at the time of the original lighting design or if an exception to s. Comm 63.1050 (4) (b) is no longer applicable.

(4) Change in occupancy.

(a) Any change in the occupancy classification of a building or structure that would increase the required minimum inside temperature as specified in Table 64.0403 shall comply with the requirements of ch. Comm 63.

(b) Any change in a building or structure that would result in an increase in demand for either fossil fuel

or electrical energy supply shall comply with ch. Comm 63.

(5) Mixed residential and commercial occupancy.

(a) General. Except as specified in par. (b), when a building houses both a residential and a commercial occupancy, each portion of the building shall conform to the requirements for the occupancy, residential or commercial, housed therein. Where minor accessory uses do not occupy more than 10 percent of the area of any floor of a building, the major use shall determine whether the building is a residential or commercial building.

(b) Exception. All buildings with a height of four or more stories above grade shall be considered a commercial building for purposes of ch. Comm 63.

Comm 63.0004 Compliance.

(1) General. All buildings shall comply with the *International Energy Conservation Code* (IECC), with the changes, additions or omissions specified in subch. II, and with the compliance approaches specified in sub. (2) for residential buildings and sub. (3) for commercial buildings.

(2) Residential buildings.

(a) Except as specified in par. (b), for residential buildings one of the following approaches for compliance shall be used:

1. A systems approach for the entire building and its energy-using subsystems, which uses renewable sources as specified in IECC chapter 4.
2. An approach based on performance of individual components of the building envelope as specified in IECC chapter 5.
3. An approach based on performance of the total building envelope specified in IECC chapter 5.
4. An approach based on acceptable practice for each envelope component specified in IECC chapter 5.
5. An approach by prescriptive specification for individual components of the building envelope specified in IECC chapter 5.
6. An approach based on simplified, prescriptive specification specified in IECC chapter 6 when the glazing areas do not exceed 25 percent of the gross areas of exterior walls.

(b) Chapter Comm 63 does not apply to Type A-1 residential buildings as defined in IECC section 202 as one- and two-family dwellings.

(3) Commercial buildings. For commercial buildings one of the following approaches for compliance shall be used:

(a) A prescriptive, system, or energy cost budget approach specified in subch. III.

(b) A prescriptive or performance option specified in IECC chapter 8.

COMM 63 SUBCHAPTER II CHANGES, ADDITIONS OR OMISSIONS TO THE *INTERNATIONAL ENERGY CONSERVATION CODE* (IECC)

Comm 63.0100 Changes, additions or omissions to IECC. Changes, additions or omissions to the IECC are specified in this subchapter and are rules of the department and are not requirements of the IECC.

Note: This subchapter is numbered to correspond to the numbering used within the model code; i.e. s. Comm 63.0101 refers to section IECC 101. With a few exceptions, subchapter III of this chapter is numbered to correspond to the numbering in the previous energy requirements of Comm 63; i.e., s. Comm 63.1005 was previously Comm 63.05.

Note: Copies of the *International Energy Conservation Code* can be obtained from organizations as specified in s. Comm 61.05.

Note: Copies of department forms are available from the Safety and Buildings Division, P.O. Box 7162, Madison, WI 53707-7162; telephone (608) 266-3151 or TTY (608) 264-877; or on the Commerce webpage at: www.commerce.state.wi.us

SECTION 101 SCOPE AND GENERAL REQUIREMENTS

Comm 63.0101. Requirements relating to purpose, scope and application are contained in subch. I.

SECTION 102 MATERIALS, SYSTEMS AND EQUIPMENT

102.1 General. Materials, equipment and systems shall be identified in a manner that will allow a determination of their compliance with the applicable provisions of this code.

102.2 Materials, equipment and systems installation. All insulation materials, caulking and weatherstripping, fenestration assemblies, mechanical equipment and systems components, and water-heating equipment and system components shall be installed in accordance with the manufacturer's installation instructions.

102.3 Maintenance information. Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. Such label shall include the title or publication number, the operation and maintenance manual for that particular model and type of product. Maintenance instructions shall be furnished for equipment that requires preventive maintenance for efficient operation.

102.4 Insulation installation. Roof/ceiling, floor, wall cavity and duct distribution systems insulation shall be installed in a manner that permits inspection of the manufacturer's *R*-value identification mark.

102.4.1 Protection of exposed foundation insulation. Insulation applied to the exterior of foundation walls and around 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 area of the exterior insulation and extend a minimum of 6 inches (153 mm) below grade.

102.5 Identification. Materials, equipment and systems shall be identified in accordance with Sections 102.5.1, 102.5.2 and 102.5.3.

102.5.1 Building envelope insulation. A thermal resistance (*R*) identification mark shall be applied by the manufacturer to each piece of building envelope insulation 12 inches (305 mm) or greater in width.

Alternatively, the insulation installer shall provide a signed and dated certification for the insulation installed in each element of the building envelope, listing the type of insulation installations in roof/ceilings, the manufacturer and the *R*-value. For blown-in or sprayed insulation, the installer shall also provide the initial installed thickness, the settled thickness, the coverage area and the number of bags installed. Where blown-in or sprayed insulation is installed in walls, floors and cathedral ceilings, the installer shall provide a certification of the installed density and *R*-value. The installer shall post the certification in a conspicuous place on the job site.

102.5.1.1 Roof/ceiling insulation. The thickness of roof/ceiling insulation that is either blown in or sprayed shall be identified by thickness markers that are labeled in inches or millimeters 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 and minimum settled thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access. The thickness of installed insulation shall meet or exceed the minimum initial installed thickness shown by the marker.

102.5.2 Fenestration product rating, certification and labeling. *U*-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100 by an accredited, independent laboratory, and labeled and certified by the manufacturer. The solar heat gain coefficient (SHGC) 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. Where a shading coefficient for a fenestration product is used, it shall be determined by converting the product's SHGC, as determined in accordance with NFRC 200, to a shading coefficient, by dividing the SHGC by 0.87. Such certified and labeled *U*-factors and SHGCs shall be accepted for purposes of determining compliance with the building envelope requirements of this code.

When a manufacturer has not determined product *U*-factor in accordance with NFRC 100 for a particular product line, compliance with the building envelope requirements of this code shall be determined by assigning such products a default *U*-factor in accordance with Tables 102.5.2(1) and 102.5.2(2). When a SHGC or shading coefficient is used for code compliance and a manufacturer has not determined product SHGC in accordance with NFRC 200 for a particular product line, compliance with the building envelope requirements of this code shall be determined by assigning such products a default SHGC in accordance with Table 102.5.2(3). Product features must be verifiable for the product to qualify for the default value associated with those features. Where the existence of a particular feature cannot be determined with reasonable certainty, the product shall not receive credit for that feature. Where a composite of materials from two different product types is used, the product shall be assigned the higher *U*-factor.

102.5.3 Duct distribution systems insulation. A thermal resistance (*R*) identification mark shall be applied by the manufacturer in maximum intervals of no greater than 10 feet (3048 mm) to insulated flexible duct products showing the thermal performance *R*-value for the duct insulation itself (excluding air films, vapor retarders, or other duct components).

TABLE 102.5.2(1)
***U*-FACTOR DEFAULT TABLE FOR WINDOWS, GLAZED DOORS AND SKYLIGHTS**

FRAME MATERIAL AND PRODUCT TYPE[a]	SINGLE GLAZED	DOUBLE GLAZED
Metal without thermal break		
Operable (including sliding and swinging glass doors)	1.27	0.87
Fixed	1.13	0.69
Garden window	2.60	1.81
Curtain wall	1.22	0.79
Skylight	1.98	1.31
Site-assembled sloped/overhead glazing	1.36	0.82
Metal with thermal break		
Operable (including sliding and swinging glass doors)	1.08	0.65
Fixed	1.07	0.63
Curtain wall	1.11	0.68
Skylight	1.89	1.11
Site-assembled sloped/overhead glazing	1.25	0.70
Reinforced vinyl/metal clad wood		
Operable (including sliding and swinging glass doors)	0.90	0.57
Fixed	0.98	0.56
Skylight	1.75	1.05
Wood/vinyl/fiberglass		
Operable (including sliding and swinging glass doors)	0.89	0.55
Fixed	0.98	0.56
Garden window	2.31	1.61
Skylight	1.47	0.84

a. Glass block assemblies with mortar but without reinforcing or framing shall have a *U*-factor of 0.60.

TABLE 102.5.2(2)
***U*-FACTOR DEFAULT TABLE FOR NONGLAZED DOORS**

DOOR TYPE	WITH FOAM CORE	WITHOUT FOAM CORE
Steel doors (1.75 inches thick)	0.35	0.60
	WITHOUT STORM DOOR	**WITH STORM DOOR**
Wood doors (1.75 inches thick)		
Panel with 0.438-inch panels	0.54	0.36
Hollow core flush	0.46	0.32
Panel with 1.125-inch panels	0.39	0.28
Solid core flush	0.40	0.26

For SI: 1 inch = 25.4 mm.

TABLE 102.5.2(3)
SHGC DEFAULT TABLE FOR FENESTRATION

PRODUCT DESCRIPTION	SINGLE GLAZED				DOUBLE GLAZED			
	Clear	Bronze	Green	Gray	Clear + Clear	Bronze + Clear	Green + Clear	Gray + Clear
Metal frames								
Operable	0.75	0.64	0.62	0.61	0.66	0.55	0.53	0.52
Fixed	0.78	0.67	0.65	0.64	0.68	0.57	0.55	0.54
Nonmetal frames								
Operable	0.63	0.54	0.53	0.52	0.55	0.46	0.45	0.44
Fixed	0.75	0.64	0.62	0.61	0.66	0.54	0.53	0.52

Comm 63.0102

(1) **Prohibition of heated sidewalks.** The installation or use of heated sidewalks is prohibited as specified in s. 101.124, Stats.

Note: Section 101.124, Wisconsin Stats., reads as follows: "Heated Sidewalks Prohibited. In this section 'exterior pedestrian traffic surface' means any sidewalk, ramp, stair, stoop, step, entrance way, plaza or pedestrian bridge not fully enclosed within a building and 'heated' means heated by electricity or energy derived from the combustion of fossil fuels, but not including the use of waste thermal energy. 'Exterior pedestrian traffic surface' does not include any means of ingress or egress by the physically disabled required under s. 101.13 (2). No person may construct a heated exterior pedestrian traffic surface. The department or any city, village, town or county is prohibited from approving any plan under s. 101.12 which includes such heated surface. The department shall order any existing heated exterior pedestrian traffic surface in operation to be shut off. This section does not apply to any inpatient health care facility as defined in s. 50.135 (1), or community-based residential facility, as defined in s. 50.01 (1g)."

(2) **Material properties.** Thermal properties, performance of building envelope sections and components and heat transfer properties shall be determined in accordance with s. Comm 63.1018.

SECTION 103
ALTERNATE MATERIALS—METHODS OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS
Deleted

SECTION 104
CONSTRUCTION DOCUMENTS

Comm 63.0104 Construction documents. Construction documents and other supporting documents shall be submitted in accordance with ch. Comm 61.

SECTION 105
INSPECTIONS

Comm 63.0105 Inspections. Inspections shall be performed in accordance with ch. Comm 61.

SECTION 106
VALIDITY

106.1 General. If a 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.

SECTION 107
REFERENCED STANDARDS

107.1 General. The standards, and portions thereof, which are referred to in this code and listed in Chapter 9, shall be considered part of the requirements of this code to the extent of such reference.

107.2 [Comm 63.0107] Conflicting requirements. The process for dealing with conflicting rules shall be as specified in ch. Comm 61.

CHAPTER 2

DEFINITIONS

SECTION 201
GENERAL

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

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.

201.3 Terms defined in other codes. Where terms are not defined in this code and are defined in the *International Building Code*, ICC *Electrical Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code* or the *International Plumbing Code*, such terms shall have meanings ascribed to them as in those codes.

201.4 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 202
GENERAL DEFINITIONS

ACCESSIBLE (AS APPLIED TO EQUIPMENT). Admitting close approach because not guarded by locked doors, elevation or other effective means (see "Readily accessible").

ADDITION. An extension or increase in the height, conditioned floor area or conditioned volume of a building or structure.

ALTERATION. Any construction, renovation or change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

AIR TRANSPORT FACTOR. The ratio of the rate of useful sensible heat removal from the conditioned space to the energy input to the supply and return fan motor(s), expressed in consistent units and under the designated operating conditions.

ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE). The ratio of annual output energy to annual input energy which includes any nonheating season pilot input loss, and for gas or oil-fired furnaces or boilers, does not include electrical energy.

APPROVED. Has the meaning given in ch. Comm 62.0202 (2) (a). [Comm 63.0201 (2)]

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. The opaque portion of a wall which encloses one side of a basement and having an average below-grade area greater than or equal to 50 percent of its total wall area, including openings (see "Gross area of exterior walls").

BTU. Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound (0.454 kg) of water 1°F (0.56°C), (1 Btu = 1,055 J).

BUILDING. Any structure occupied or intended for supporting or sheltering any use or occupancy.

BUILDING ENVELOPE. The elements of a building which enclose conditioned spaces through which thermal energy is capable of being transferred to or from the exterior or to or from spaces exempted by the provisions of Section 101.4.1

CIRCULATING SYSTEM. A service water heating system without a heat trap, or systems with circulating pump. [Comm 63.0202 (1)]

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

COEFFICIENT OF PERFORMANCE (COP)—COOLING. The ratio of the rate of heat removal to the rate of energy input in consistent units, for a complete cooling system or factory-assembled equipment, as tested under a nationally recognized standard or designated operating conditions.

COEFFICIENT OF PERFORMANCE (COP)—HEAT PUMP—HEATING. The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system under designated operating conditions. Supplemental heat shall not be considered when checking compliance with the heat pump equipment (COPs listed in the tables in Sections 503 and 803).

COMFORT ENVELOPE. The area on a psychrometric chart enclosing all those conditions described in Figure 2 in ASHRAE 55 as being comfortable.

COMMERCIAL BUILDING. All buildings over three stories in height above grade or buildings, other than residential buildings, that are three stories or less in height above grade.

CONDENSER. A heat exchanger designed to liquefy refrigerant vapor by removal of heat.

CONDENSING UNIT. A specific refrigerating machine combination for a given refrigerant, consisting of one or more power-driven compressors, condensers, liquid receivers (when required), and the regularly furnished accessories.

CONDITIONED FLOOR AREA. The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

CONDITIONED SPACE. A heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.

COOLED SPACE. Space within a building which is provided with a positive cooling supply (see "Positive cooling supply").

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

DEADBAND. The temperature range in which no heating or cooling is used.

DEGREE DAY, COOLING. A unit, based on temperature difference and time, used in estimating cooling energy consumption and specifying nominal cooling load of a building in summer. For any one day, when the mean temperature is more than 65°F (18°C), there are as many degree days as there are degrees Fahrenheit (Celsius) difference in temperature between the mean temperature for the day and 65°F (18°C). Annual cooling degree days (CDD) are the sum of the degree days over a calendar year.

DEGREE DAY, HEATING. A unit, based upon temperature difference and time, used in estimating heating energy consumption and specifying nominal heating load of a building in winter. For any one day, when the mean temperature is less than 65°F (18°C), there are as many degree days as there are degrees Fahrenheit (Celsius) difference in temperature between the mean temperature for the day and 65°F (18°C). Annual heating degree days (HDD) are the sum of the degree days over a calendar year.

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.

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

ECONOMIZER. A ducting arrangement and automatic control system that allows a cooling supply fan system to supply outdoor air to reduce or eliminate the need for mechanical refrigeration during mild or cold weather.

ENERGY. The capacity for doing work taking a number of forms which is capable of being transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical in customary units, measured in joules (J) kilowatt-hours (kW × h) or British thermal units (Btu).

ENERGY ANALYSIS. A method for determining the annual (8,760 hours) energy use of the Proposed design and Standard design based on hour-by-hour estimates of energy use.

ENERGY COST. The total estimated annual cost for purchased energy for the building, including any demand charges, fuel adjustment factors and delivery charges applicable to the building.

ENERGY EFFICIENCY RATIO (EER). The ratio of net equipment cooling capacity in Btu/h (W) to total rate of electric input in watts under designated operating conditions. When consistent units are used, this ratio becomes equal to COP (see also "Coefficient of performance").

EVAPORATOR. That part of the system in which liquid refrigerant is vaporized to produce refrigeration.

EXTERIOR ENVELOPE. See "Building envelope."

EXTERIOR WALL. An above-grade wall enclosing conditioned space. 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 which is less than 50 percent of the total opaque and nonopaque area of that enclosing side.

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

FURNACE, DUCT. A furnace normally installed in distribution ducts of air-conditioning systems to supply warm air for heating and which depends on a blower not furnished as part of the duct furnace for air circulation.

FURNACE, WARM AIR. A self-contained, indirect-fired or electrically heated furnace that supplies heated air through ducts to spaces that require it.

GLAZING AREA. Total area of the glazed fenestration measured using the rough opening and including sash, curbing or other framing elements that enclose conditioned space. Glazing area includes the area of glazed fenestration assemblies in walls bounding conditioned basements. For doors where the daylight opening area is less than 50 percent of the door area, the glazing area is the daylight opening area. For all other doors, the glazing area is the rough opening area for the door including the door and the frame.

GROSS AREA OF EXTERIOR WALLS. The normal projection of all exterior walls, including the area of all windows and doors installed therein (see "Exterior wall").

GROSS FLOOR AREA. The sum of the areas of several floors of the building, including basements, cellars, mezzanine and intermediate floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding:

1. Covered walkways, open roofed-over areas, porches and similar spaces.
2. Pipe trenches, exterior terraces or steps, chimneys, roof overhangs and similar features.

HEAT. The form of energy that is transferred by virtue of a temperature difference or a change in state of a material.

HEAT CAPACITY (HC). The amount of heat necessary to raise the temperature of a given mass by one degree. The heat capacity of a building element is the sum of the heat capacities of each of its components.

HEAT PUMP. A refrigeration system that extracts heat from one substance and transfers it to another portion of the same substance or to a second substance at a higher temperature for a beneficial purpose.

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 or hot air distribution system is in contact with or placed within the slab or the subgrade.

HEATED SPACE. Space within a building which is provided with a positive heat supply (see "Positive heating supply"). Finished living space within a basement with registers or heating devices designed to supply heat to a basement space shall automatically define that space as heated space.

HEATING SEASONAL PERFORMANCE FACTOR (HSPF). The total heating output of a heat pump during its normal annual usage period for heating, in Btu, divided by the total electric energy input during the same period, in watt hours, as determined by DOE 10 CFR Part 430, Subpart B, Test Procedures and based on Region 4.

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

HVAC. Heating, ventilating and air conditioning.

HVAC SYSTEM. The equipment, distribution network, and terminals that provide either collectively or individually the processes of heating, ventilating, or air conditioning to a building.

HVAC SYSTEM COMPONENTS. HVAC system components provide, in one or more factory-assembled packages, means for chilling or heating water, or both, with controlled temperature for delivery to terminal units serving the conditioned spaces of the building. Types of HVAC system components include, but are not limited to, water chiller packages, reciprocating condensing units and water source (hydronic) heat pumps (see "HVAC system equipment").

HVAC SYSTEM EQUIPMENT. HVAC system equipment provides, in one (single package) or more (split system) factory-assembled packages, means for air circulation, air cleaning, air cooling with controlled temperature and dehumidification and, optionally, either alone or in combination with a heating plant, the functions of heating and humidifying. The cooling function is either electrically or heat operated and the refrigerant condenser is air, water or evaporatively cooled. Where the equipment is provided in more than one package, the separate packages shall be designed by the manufacturer to be used together. The equipment shall be permitted to provide the heating function as a heat pump or by the use of electric or fossil-fuel-fired elements. (The word "equipment" used without a modifying adjective, in accordance with common industry usage, applies either to HVAC system equipment or HVAC system components.)

INFILTRATION. The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INSULATING SHEATHING. An insulating board having a minimum thermal resistance of R-2 of the core material.

INTEGRATED PART-LOAD VALUE (IPLV). A single number of merit based on part-load EER or COP expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

LABELED. Devices, equipment, appliances, assemblies or materials 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 by whose label the manufacturer attests to compliance with applicable nationally recognized standards.

LISTED. Equipment, appliances, assemblies or materials included in a list published by a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment, appliances, assemblies or material, and whose listing states either that the equipment, appliances, assemblies, or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

LOW-VOLTAGE LIGHTING. Lighting equipment that is powered through a transformer such as cable conductor, rail conductor, and track lighting.

MANUAL. Capable of being operated by personal intervention (see "Automatic").

MULTIFAMILY DWELLING. A building containing three or more dwelling units.

OCCUPANCY. The purpose for which a building, or portion thereof, is utilized or occupied.

OPAQUE AREAS. All exposed areas of a building envelope which enclose conditioned space, except openings for windows, skylights, doors and building service systems.

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

OZONE DEPLETION FACTOR. A relative measure of the potency of chemicals in depleting stratospheric ozone. The ozone depletion factor potential depends upon the chlorine and the bromine content and atmospheric lifetime of the chemical. The depletion factor potential is normalized such that the factor for CFC-11 is set equal to unity and the factors for the other chemicals indicate their potential relative to CFC-11.

PACKAGED TERMINAL AIR CONDITIONER (PTAC). A factory-selected wall sleeve and separate unencased combination of heating and cooling components, assemblies or sections (intended for mounting through the wall to serve a single room or zone). It includes heating capability by hot water, steam, or electricity. (For the complete technical definition, see ARI 310/380.)

PACKAGED TERMINAL HEAT PUMP. A PTAC capable of using the refrigeration system in a reverse cycle or heat pump mode to provide heat. (For the complete technical definition, see ARI 310/380.)

POSITIVE COOLING SUPPLY. Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space-cooling components, such as evaporator coil cases and cooling distribution systems which continually maintain air temperatures within the space of 85°F (29°C) or lower during normal operation. To be consid-

ered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

POSITIVE HEAT SUPPLY. Heat deliberately supplied to a space by design, such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space-heating components, such as furnaces, boilers and heating and cooling distribution systems which continually maintain air temperature within the space of 50°F (10°C) or higher during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this code.

PROPOSED DESIGN. A description of the proposed building design used to estimate annual energy costs for determining compliance based on total building performance.

READILY ACCESSIBLE. Capable of being reached quickly for operation, renewal or inspections, 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").

REFRIGERANT. A substance utilized to produce refrigeration by its expansion or vaporization or absorption.

RENEWABLE ENERGY SOURCES. Sources of energy (excluding minerals) derived from incoming solar radiation, including natural daylighting and photosynthetic processes; from phenomena resulting therefrom, including wind, waves and tides, lake or pond thermal differences; and from the internal heat of the earth, including nocturnal thermal exchanges.

REPAIR. The reconstruction or renewal of any part of an existing building for the purpose of its maintenance.

RESIDENTIAL BUILDING, TYPE A-1. Detached one- and two-family dwellings.

RESIDENTIAL BUILDING, TYPE A-2. A building containing multiple (i.e., three or more) dwelling units where the occupants are primarily permanent in nature, such as townhouses, row houses, apartment houses, convents, monasteries, rectories, fraternities and sororities, dormitories, and rooming houses, all of which are three stories or less in height above grade.

ROOF ASSEMBLY. A roof assembly shall be considered as all roof/ceiling components of the building envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses conditioned space.

The gross area of a roof assembly consists of the total interior surface of all roof/ceiling components, including opaque surfaces, dormer and bay window roofs, treyed ceilings, overhead portions of an interior stairway to an unconditioned attic, doors and hatches, glazing and skylights exposed to conditioned space, that are horizontal or sloped at an angle less than sixty (60) degrees (1.1 rad) from the horizontal (see "Exterior wall"). A roof assembly, or portions thereof, having a slope of 60 degrees (1.1 rad) or greater from horizontal shall be considered in the gross area of exterior walls and thereby excluded from consideration in the roof assembly. Skylight shaft walls 12 inches (305 mm) in depth or greater (as measured from the ceiling plane to the roof deck) shall be considered in the gross area of exterior walls and are thereby excluded from consideration in the roof assembly.

ROOM AIR CONDITIONER. An encased assembly designed as a unit for mounting in a window or through a wall, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulating and cleaning air, and shall be permitted to also include means for ventilating and heating.

SASH CRACK. The sum of all perimeters of all window sashes, based on overall dimensions of such parts, expressed in feet. If a portion of one sash perimeter overlaps a portion of another sash perimeter, only count the length of the overlapping portions once.

SCREW LAMP HOLDERS. A lamp base that requires a screw-in-type lamp such as an incandescent or tungsten-halogen bulb.

SEASONAL ENERGY EFFICIENCY RATIO (SEER). The total cooling output of an air conditioner during its normal annual usage period for cooling, in Btu/h (W), divided by the total electric energy input during the same period, in watt-hours, as determined by DOE 10 CFR Part 430, Subpart B, Test Procedures.

SERVICE SYSTEMS. All energy-using systems in a building that are operated to provide services for the occupants or processes housed therein, including HVAC, service water heating, illumination, transportation, cooking or food preparation, laundering and similar functions.

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

SIMULATION TOOL. An approved software program or calculation-based methodology that projects the hour-by-hour loads and annual energy use of a building.

STANDARD DESIGN. A version of the Proposed design that meets the minimum requirements of this code and is used to determine the maximum annual energy cost 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.

SKYLIGHT. Glazing that is horizontal or sloped at an angle less than sixty (60) degrees (1.1 rad) from the horizontal (see "Glazing area").

SLAB-ON-GRADE FLOOR INSULATION. Insulation around the perimeter of the floor slab or its supporting foundation when the top edge of the floor perimeter slab is above the finished grade or 12 inches (305 mm) or less below the finished grade.

SOLAR ENERGY SOURCE. Source of natural daylighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation.

SYSTEM. A combination of central or terminal equipment or components or controls, accessories, interconnecting means, and terminal devices by which energy is transformed so as to perform a specific function, such as HVAC, service water heating or illumination.

THERMAL CONDUCTANCE. Time rate of heat flow through a body (frequently per unit area) from one of its bounding surfaces to the other for a unit temperature difference between the two surfaces, under steady conditions (Btu/h · ft^2 · °F) [W/(m^2 · K)].

THERMAL RESISTANCE (*R*). The reciprocal of thermal conductance (h · ft^2 · °F/Btu) [(m^2 · K)/W].

THERMAL RESISTANCE, OVERALL(R_o). The reciprocal of overall thermal conductance (h · ft^2 · °F/Btu) [(m^2 · K)/W]. The overall thermal resistance of the gross area or individual component of the exterior building envelope (such as roof/ceiling, exterior wall, floor, crawl space wall, foundation, window, skylight, door, opaque wall, etc.), which includes the area weighted *R*-values of the specific component assemblies (such as air film, insulation, drywall, framing, glazing, etc.).

THERMAL TRANSMITTANCE (*U*). The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm-side and cold-side air films (Btu/h · ft^2 · °F) [W/(m^2 · K)]. The *U*-factor applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity airspaces and surface air films on both sides of a building element.

THERMAL TRANSMITTANCE, OVERALL (U_o). The overall (average) heat transmission of a gross area of the exterior building envelope (Btu/h · ft^2 · °F) [W/(m^2 · K)]. The U_o-factor applies to the combined effect of the time rate of heat flow through the various parallel paths, such as windows, doors and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors or roof/ceilings.

THERMOSTAT. An automatic control device actuated by temperature and designed to be responsive to temperature.

UNITARY COOLING AND HEATING EQUIPMENT. One or more factory-made assemblies which include an evaporator or cooling coil, a compressor and condenser combination, and which shall be permitted to include a heating function as well. When heating and cooling equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

UNITARY HEAT PUMP. One or more factory-made assemblies which include an indoor conditioning coil, compressor(s) and outdoor coil or refrigerant-to-water heat exchanger, including means to provide both heating and cooling functions. When heat pump equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

VENTILATION. The process of supplying or removing air by natural or mechanical means to or from any space. Such air shall be permitted to be conditioned or unconditioned.

VENTILATION AIR. That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space (see ASHRAE 62 and definition of "Outdoor air").

WATER HEATER, INSTANTANEOUS. A water heater with an input rating of at least 4,000 Btu/h per gallon (310 W/L) stored water and a storage capacity of less than 10 gallons (38 L).

WATER HEATER, STORAGE. A water heater with an input rating less than 4,000 Btu/h per gallon (310 W/L) of stored water or storage capacity of at least 10 gallons (38 L).

WINDOW PROJECTION FACTOR. A measure of the portion of glazing that is shaded by an eave or overhang.

ZONE. A space or group of spaces within a building with heating or cooling requirements, or both, sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

CHAPTER 3

DESIGN CONDITIONS

SECTION 301
DESIGN CRITERIA

301.1 General. The criteria of this chapter establish the design conditions for use with Chapters 4, 5, 6 and 8.

SECTION 302
THERMAL DESIGN PARAMETERS

302.1 Exterior design conditions. The following design parameters in Table 302.1 shall be used for calculations required under this code.

TABLE 302.1
EXTERIOR DESIGN CONDITIONS

CONDITION	VALUE
Winter[a], Design Dry-bulb (°F)	
Summer[a], Design Dry-bulb (°F)	
Summer[a], Design Wet-bulb (°F)	
Degree days heating[b]	
Degree days cooling[b]	
Climate zone[c]	

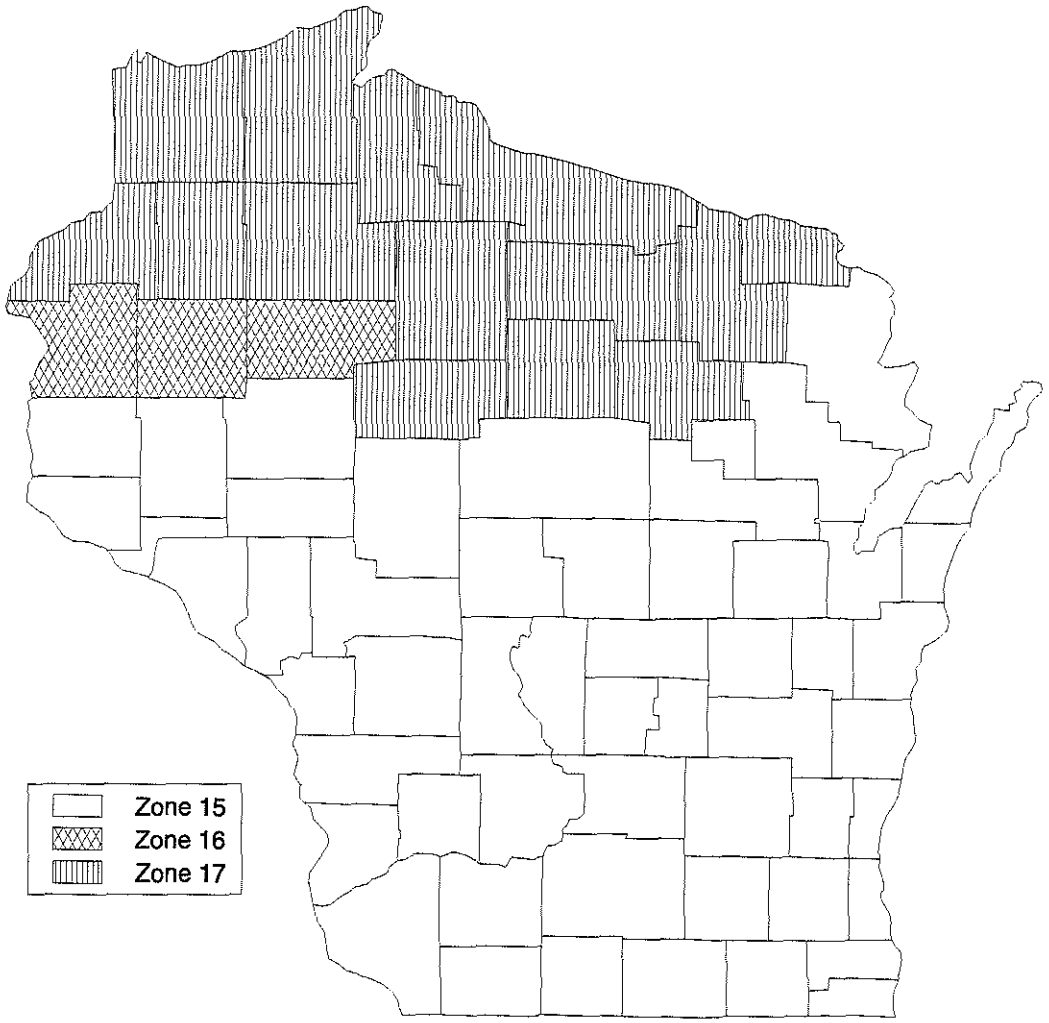
For SI: °C = [(°F)-32]/1.8.

a. **[Comm 63.0302 (1)]** The outdoor design temperature shall be selected from the columns of $97^1/_2$ percent values for winter and $2^1/_2$ percent values for summer from tables in the ASHRAE *Handbook of Fundamentals*. Adjustments shall be permitted to reflect local climates, which differ from the tabulated temperatures, or local weather experience as determined by other weather resources.

b. **[Comm 63.0302 (2)]** The degree days heating (base 65°F) and cooling (base 65°F) shall be selected from National Oceanic and Atmospheric Administration "Annual Degree Days to Selected Bases Derived from the 1961-1990 Normals," the ASHRAE *Handbook of Fundamentals*, data available from adjacent military installations, or other sources of local weather data.

c. The climate zone shall be selected from the map provided in Figure 302.1(50) on the following page.

Figures 302.1(1) - 302.1(49) Deleted.



Zone	County	Zone	County
15	Adams	15	Marathon
17	Ashland	15	Marinette
16	Barron	15	Marquette
17	Bayfield	15	Menominee
15	Brown	15	Milwaukee
15	Buffalo	15	Monroe
17	Burnett	15	Oconto
15	Calumet	17	Oneida
15	Chippewa	15	Outagamie
15	Clark	15	Ozaukee
15	Columbia	15	Pepin
15	Crawford	15	Pierce
15	Dane	16	Polk
15	Dodge	15	Portage
15	Door	17	Price
17	Douglas	15	Racine
15	Dunn	15	Richland
15	Eau Claire	15	Rock
17	Florence	16	Rusk
15	Fond Du Lac	15	Sauk
17	Forest	17	Sawyer
15	Grant	15	Shawano
15	Green	15	Sheboygan
15	Green Lake	15	St Croix
15	Iowa	17	Taylor
17	Iron	15	Trempealeau
15	Jackson	15	Vernon
15	Jefferson	17	Vilas
15	Juneau	15	Walworth
15	Kenosha	17	Washburn
15	Kewaunee	15	Washington
15	La Crosse	15	Waukesha
15	Lafayette	15	Waupaca
17	Langlade	15	Waushara
17	Lincoln	15	Winnebago
15	Manitowoc	15	Wood

FIGURE 302.1(50)
WISCONSIN

CHAPTER 4

RESIDENTIAL BUILDING DESIGN BY SYSTEMS ANALYSIS AND DESIGN OF BUILDINGS UTILIZING RENEWABLE ENERGY SOURCES

SECTION 401
SCOPE

401.1 General. This chapter establishes design criteria in terms of total energy use by a residential building, including all of its systems.

SECTION 402
SYSTEMS ANALYSIS

402.1 Energy analysis. Compliance with this chapter will require an analysis of the annual energy usage, hereinafter called an "annual energy analysis."

Exception: Chapters 5 and 6 establishes criteria for different energy-consuming and enclosure elements of the building which, if followed, will eliminate the requirement for an annual energy analysis while meeting the intent of this code.

402.1.1 Standard design. A building designed in accordance with this chapter will be deemed as complying with this code if the calculated annual energy consumption is not greater than a similar building (defined as a "Standard design") whose enclosure elements and energy-consuming systems are designed in accordance with Chapter 5.

Exceptions:

1. The exterior wall assembly *U*-factors for the Standard design shall be selected by climate in accordance with Table 402.1.1(1).
2. The fenestration system *U*-factor used in the Standard design shall be selected by climate in accordance with Table 402.1.1(2).
3. The window area of the Standard design, inclusive of the framed sash and glazing area, shall be equal to 18 percent of the conditioned floor area of the Proposed design.
4. Skylights and other nonvertical roof glazing elements shall not be included in the Standard design, and ceiling *U*-factors used in the Standard design shall not include such elements in their computation.

402.1.2 Proposed design. For a proposed alternate building design (defined as a "Proposed design") to be considered similar to a "Standard design," it shall utilize the same energy source(s) for the same functions and have equal conditioned floor area and the same ratio of thermal envelope area to floor area (i.e., the same geometry), exterior design conditions, occupancy, climate data, and usage operational schedule as the Standard design.

TABLE 402.1.1(1)
STANDARD DESIGN WALL ASSEMBLY *U*-FACTORS (U_w)

HEATING DEGREE DAYS[a]	U_w (air to air)[b]
> 13,000	0.038
9,000-12,999	0.046
6,500-8,999	0.052
4,500-6,499	0.058
3,500-4,499	0.064
2,600-3,499	0.076
< 2,600	0.085

a. From Table 302.1.
b. Including framing effects.

TABLE 402.1.1(2)
STANDARD DESIGN FENESTRATION SYSTEM *U*-FACTORS (U_g or U_f)

HEATING DEGREE DAYS[a]	U_g FOR SECTION 502.2.1.1 AND U_f FOR SECTION 502.2.3.1 (air to air)[b]
> 13,000	0.25
9,000-12,999	0.26
6,500-8,999	0.28
4,500-6,499	0.30
3,500-4,499	0.41
2,600-3,499	0.44
700-2,599	0.47
< 700	0.74

a. From Table 302.1.
b. Entire assembly, including sash.

402.1.3 Input values for residential buildings. The input values in Sections 402.1.3.1 through 402.1.3.10 shall be used in calculating annual energy performance. The requirements of this section specifically indicate which variables shall remain constant between the Standard design and Proposed design calculations. The Standard design shall be a base version of the design that directly complies with the provisions of this code. The proposed building shall be permitted to utilize a design methodology that is demonstrated, through calculations satisfactory to the code official, to have equal or lower annual energy use than the Standard design.

402.1.3.1 Glazing systems. The input values in Sections 402.1.3.1.1 through 402.1.3.1.5, specific to glazing systems, shall be used in calculating annual energy performance.

402.1.3.1.1 Orientation, Standard design. Equal areas on north, northeast, east, southeast, south, southwest, west, and northwest exposures shall be assumed.

402.1.3.1.2 Shading calculations, Proposed design. Results from shading calculations on a Proposed design shall not be used for groups of buildings, unless those results constitute the worst possible building orientation in terms of annual energy use, considering all eight of the above orientations for a group of otherwise identical Proposed designs.

402.1.3.1.3 Exterior shading, Standard design. Glazing areas in the Standard design shall not be provided with exterior shading such as roof overhangs. Energy performance impacts of added exterior shading for glazing areas which are accounted for in the Proposed design for a specific building shall be permitted, provided that the code official approves the actual installation of such systems.

402.1.3.1.4 Fenestration system solar heat gain coefficient, Standard design. The fenestration system solar heat gain coefficient (SHGC), inclusive of framed sash and glazing area, of the glazing systems in the Standard design shall be 0.40 for HDD < 3,500 and 0.68 for HDD ≥ 3,500 during periods of mechanical heating and cooling operation. These fenestration system SHGC values shall be multiplied together with (added in series to) the interior shading values as specified in Section 402.1.3.1.5 to arrive at an overall solar heat gain coefficient for the installed glazing system.

Where the SHGC characteristics of the proposed fenestration products are not known, the default SHGC values given in Table 102.5.2(3) shall be used for the Proposed design.

402.1.3.1.5 Interior shading, Standard design and Proposed design. The same schedule of interior shading values, expressed as the fraction of the solar heat gain admitted by the fenestration system that is also admitted by the interior shading, shall be assumed for the Standard and Proposed designs.

The values used for interior shading shall be 0.70 in summer, and 0.90 in winter.

Exception: South-facing solar gain apertures on passive heating Proposed designs analyzed using interior shading values for interior shading specific to those shading measures specified in the Proposed design, with values above used in the Standard design.

402.1.3.2 Passive solar. Passive solar building designs shall provide documentation, acceptable to the code official, that fixed external or other acceptable shading is provided to limit excessive summer cooling energy gains to the building interior.

402.1.3.3 Heat storage (thermal mass). The following input values, specific to heat storage (thermal mass), shall be used in calculating annual energy performance:

Internal mass	8 pounds per square foot (39 kg/m^2)
Structural mass	3.5 pounds per square foot (17 kg/m^2)

Passive solar buildings shall utilize at least 45 Btu/°F (7.92 kJ/K) of additional thermal mass, per square foot (m^2) of added glass area, when added south-facing glass area exceeds 33 percent of the total glass area in walls.

402.1.3.4 Building thermal envelope — surface areas and volume. The input values in Sections 402.1.3.4.1 through 402.1.3.4.4, specific to building thermal envelope surface areas, shall be used in calculating annual energy performance.

402.1.3.4.1 Floors, walls, ceiling. The Standard and Proposed designs shall have equal areas.

402.1.3.4.2 Foundation and floor type. The foundation and floor type for both the Standard and Proposed designs shall be equal.

402.1.3.4.3 Doors. The exterior door area of the Standard design shall have an equal exterior door area as that of the Proposed design with a U-factor of 0.2 Btu/h · ft^2 · °F [1.14 W/(m^2 · K)]. The U_d of the Standard design shall be selected to permit calculated U_o wall compliance of the Standard design.

402.1.3.4.4 Building volume. The volume of both the Standard and Proposed designs shall be equal.

402.1.3.5 Heating and cooling controls. Unless otherwise specified by local codes, heating and cooling thermostats shall be set to the default settings in Table 402.1.3.5 for the Standard and Proposed designs. The input values, specific to heating and cooling controls, shall be used in calculating annual energy performance.

TABLE 402.1.3.5
HEATING AND COOLING CONTROLS

PARAMETER	VALUE
Heating	68°F
Cooling	78°F
Set back/set up	5°F
Set-back/set-up duration	6 hours per day
Number of set-back/set-up periods per unit[a]	1
Maximum number of zones per unit[a]	2
Number of thermostats per zone	1

For SI: °C = [(°F)-32]/1.8.

a. Units = Number of living units in Standard and Proposed designs.

402.1.3.6 Internal heat gains (constants). The following input values, specific to internal heat gains, shall be used in calculating annual energy performance:

Type A-1 Residential building	3,000 Btu/hr (879 W) per dwelling unit
Type A-2 Residential building	1,500 Btu/hr (440 W) per dwelling unit

402.1.3.7 Domestic hot water (calculate, then constants). The following input values, specific to domestic hot water, shall be used in calculating annual energy performance.

Temperature set point	120°F (49°C)
Daily hot water consumption	Gallons = $(30 \times a) + (10 \times b)$

where:

a = Number of living units in Standard and Proposed designs.

b = Number of bedrooms in each living unit.

402.1.3.8 Site weather data (constants). The typical meteorological year (TMY), or its "Ersatz" equivalent, from the National Oceanic and Atmospheric Administration (NOAA), or an approved equivalent, for the closest available location shall be used.

402.1.3.9 Forced-air distribution system loss factors (DLF). The heating and cooling system efficiency shall be proportionately adjusted for those portions of the ductwork located outside or inside the conditioned space using the values shown below:

System Operating Mode	Duct Location	
	Outside	Inside
Heating	0.80	1.00
Cooling	0.80	1.00

Note: Ducts located in a space that contains a positive heating supply or cooling supply, or both, shall be considered inside the building envelope.

Impacts from improved distribution loss factors (DLF) shall be accounted for in the Proposed design only if the entire air distribution system is specified on the construction documents to be substantially leak free, and is tested after installation to ensure that the installation is substantially leak free."Substantially leak free" shall be defined as the condition under which the entire air distribution system (including the air handler cabinet) is capable of maintaining a 0.1-inch w.g. (25 Pa) internal pressure at 5 percent or less of the air handler's rated airflow when the return grilles and supply registers are sealed off. This test shall be conducted using methods and procedures as specified in Section 3 of the SMACNA *HVAC Air Duct Leakage Test Manual*, or by using other, similar pressurization test methods and as approved by the code official. Where test results show that the entire distribution system is substantially leak free, then seasonal DLFs shall be calculated separately for heating and cooling modes using engineering methods capable of considering the net seasonal cooling energy heat gain impacts and the net seasonal heating energy heat loss impacts that result from the portion of the thermal air distribution system that is located outside the conditioned space. Once these heating and cooling season "distribution system energy impacts" are known, then heating and cooling mode DLFs for the Proposed design shall be calculated using the following two equations:

Total Seasonal Energy = Seasonal Building Energy + Distribution System Energy Impacts

DLF = Seasonal Building Energy/ Total Seasonal Energy

Once the DLFs for the heating and cooling seasons are known, the total "adjusted system efficiency" is calculated using the following equation:

Adjusted System Efficiency = (Equipment Efficiency × DLF × Percent of Duct Outside) + (Equipment Efficiency × DLF × Percent of Duct Inside)

This equation shall be used to develop adjusted system efficiency for each heating and cooling system included in the Standard design. Where a single system provides both heating and cooling, efficiencies shall be calculated separately for heating and cooling modes.

402.1.3.10 Air infiltration. Annual average air changes per hour (ACH) for the Standard design shall be determined using the following equation:

ACH = Normalized Leakage × Weather Factor

where:	Normalized leakage = 0.57
and	Weather factor is determined in accordance with the weather factors (W) given by ASHRAE 136, as taken from the weather station nearest the building site.

Where the Proposed design takes credit for reduced ACH levels, documentation of measures providing such reductions, and results of a post-construction blower-door test shall be provided to the code official using ASTM E 779. No energy credit shall be granted for ACH levels below 0.35.

402.1.3.11 Foundation walls. When performing annual energy analyses for buildings with insulated basement or crawl space walls, the design U-factors taken from Table 502.2 for these walls of the standard building shall be permitted to be decreased by accounting for the R-values of the adjacent soil, provided that the foundation wall U-factor of the proposed building also accounts for the R-value of the adjacent soil.

402.2 Design. The Standard design, conforming to the criteria of Chapter 5 and the proposed alternative design, shall be de-

signed on a common basis as specified in Sections 402.2.1 through 402.2.3.

402.2.1 Units of energy. The comparison shall be expressed as Btu input per square foot of gross floor area per year at building site (W/m²).

402.2.2 Equivalent energy units. If the proposed alternative design results in an increase in consumption of one energy source and a decrease in another energy source, even though similar sources are used for similar purposes, the difference in each energy source shall be converted to equivalent energy units for purposes of comparing the total energy used.

402.2.3 Site energy. The different energy sources shall be compared on the basis of energy use at the site where: 1 kWh = 3,413 Btu.

402.3 Analysis procedure. The analysis of the annual energy usage of the standard and the proposed alternative building and system design shall meet the criteria specified in Sections 402.3.1 and 402.3.2.

402.3.1 Load calculations. The building heating and cooling load calculation procedures used for annual energy consumption analysis shall be detailed to permit the evaluation of effect of factors specified in Section 402.4.

402.3.2 Simulation details. The calculation procedure used to simulate the operation of the building and its service systems through a full-year operating period shall be detailed to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of systems and equipment. The calculation procedure shall be based upon 8,760 hours of operation of the building and its service systems and shall utilize the design methods specified in the ASHRAE *Handbook of Fundamentals*.

402.4 Calculation procedure. The calculation procedure shall include the items specified in Sections 402.4.1 through 402.4.7.

402.4.1 Design requirements. Environmental requirements as required in Chapter 3.

402.4.2 Climatic data. Coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.

402.4.3 Building data. Orientation, size, shape, mass, air, moisture and heat transfer characteristics.

402.4.4 Operational characteristics. Temperature, humidity, ventilation, illumination, and control mode for occupied and unoccupied hours.

402.4.5 Mechanical equipment. Design capacity, and part-load profile.

402.4.6 Building loads. Internal heat generation, lighting, equipment, and number of people during occupied and unoccupied periods.

402.4.7 [Comm 63.0402] Use of approved calculation tool. The same calculation tool shall be used to estimate the annual energy usage for space heating and cooling of the Standard design and the Proposed design. The calculation tool shall be approved by the department.

402.5 Documentation. Proposed alternative designs, submitted as requests for exception to the Standard design criteria, shall be accompanied by an energy analysis comparison report. The report shall provide technical detail on the Standard and Proposed designs and on the data used in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of Chapter 4.

Exception: Proposed alternative designs for residential buildings having a conditioned floor area of 5,000 square feet (464 m²) or less are exempted from the hourly analysis described in Sections 402.3 and 402.4. However, comparison of energy consumption using correlation methods based on full-year hourly simulation analysis or other engineering methods that are capable of estimating the annual heating, cooling and hot water use between the proposed alternative design and the Standard design shall be provided.

SECTION 403
RENEWABLE ENERGY SOURCE ANALYSIS

403.1 General. A proposed building utilizing solar, geothermal, wind or other renewable energy sources for all or part of its energy source shall meet the requirements of Section 402, except such renewable energy shall be permitted to be excluded from the total annual energy consumption allowed for the building by that section.

403.1.1 Solar energy exclusion, one. To qualify for this exclusion, such renewable energy must be derived from a specific collection, storage, and distribution system. The solar energy passing through windows shall also be considered as qualifying if such windows meet the criteria specified in Sections 403.1.1.1 and 403.1.1.2.

403.1.1.1 Insulated shutters. The windows are provided with operable insulated shutters or other devices which, when drawn or closed, shall cause the window area to reduce maximum outward heat flows to those in accordance with Section 502.1.4.1.

403.1.1.2 Shading. The window areas are shaded or otherwise protected from direct rays of the sun during periods when mechanical cooling is required.

403.1.2 Solar energy exclusion, two. Exclusion shall be granted for solar energy passing through windows where such windows meet the criteria specified in Sections 403.1.2.1 and 403.1.2.2.

403.1.2.1 Insulated glass. The glass is double- or triple-pane insulating glass with a low-emittance coating on one or more airspace surfaces of the glass or insulating glass with a low-emittance plastic film suspended in the airspace.

403.1.2.2 Shading. The glass areas are shaded from direct solar radiation during periods when mechanical cooling is required.

403.1.3 Other criteria. Other criteria indicated in Section 402 shall apply to the proposed alternative designs utilizing renewable sources of energy.

403.2 Documentation. Proposed alternative designs submitted as requests for exception to the Standard design criteria shall be accompanied by an energy analysis, as specified in Section 402. The report shall provide technical detail on the alternative building and system designs and on the data employed in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of Sections 402 and 403.

The energy derived from renewable sources and the reduction in conventional energy requirements derived from nocturnal cooling shall be separately identified from the overall building energy use. Supporting documentation on the basis of the performance estimates for the aforementioned renewable energy sources or nocturnal cooling means must be submitted.

Energy usage must be calculated in accordance with the design conditions and methods specified in this code.

Exception: Proposed alternative designs for buildings of less than 20,000 square feet (1858 m^2) of conditioned floor area that derive a minimum of 30 percent of their total annual energy usage from renewable sources or from nocturnal cooling shall be exempt from the requirement of a full-year energy system analysis.

CHAPTER 5

RESIDENTIAL BUILDING DESIGN BY COMPONENT PERFORMANCE APPROACH

SECTION 501
SCOPE

501.1 General. Residential buildings or portions thereof that enclose conditioned space shall be constructed to meet the requirements of this chapter.

SECTION 502
BUILDING ENVELOPE REQUIREMENTS

502.1 General requirements. The building envelope shall comply with the applicable provisions of Sections 502.1.1 through 502.1.5 regardless of the means of demonstrating envelope compliance as set forth in Section 502.2.

502.1.1 [Comm 63.0502 (1)] Moisture control.

(a) **General.** Except as specified in par. (b), the design shall not create conditions of accelerated deterioration from moisture condensation. Vapor retarders shall be provided on all warm-in-winter sides of frame walls, floors and ceilings. The vapor retarder shall have a maximum permeance rating of 1.0 perm when tested in accordance with Procedure A of the ASTM E 96. The vapor retarder shall be installed on the warm-in-winter side of the thermal insulation.

(b) **Exception:** Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.

502.1.2 Masonry veneer. When insulation is placed on the exterior of a foundation supporting a masonry veneer exterior, the horizontal foundation surface supporting the veneer is not required to be insulated to satisfy any foundation insulation requirement.

502.1.3 Recessed lighting fixtures. When installed in the building envelope, recessed lighting fixtures shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.
2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 0.5-inch-thick (12.7 mm) gypsum wallboard or constructed from a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than 0.5 inch (12.7 mm) from combustible material and not less than 3 inches (76 mm) from insulation material.
3. Type IC rated, in accordance with ASTM E 283 admitting no more than 2.0 cubic feet per minute (cfm) (0.944 L/s) of air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested at 1.57 psi (75 Pa) pressure difference and shall be labeled.

502.1.4 Air leakage. Provisions for air leakage shall be in accordance with Sections 502.1.4.1 and 502.1.4.2.

502.1.4.1 Window and door assemblies. Window and door assemblies installed in the building envelope shall comply with the maximum allowable infiltration rates in Table 502.1.4.1.

Exception: Site-constructed windows and doors sealed in accordance with Section 502.1.4.2.

TABLE 502.1.4.1
ALLOWABLE AIR INFILTRATION RATES[a]

WINDOWS (cfm per square foot of window area)	DOORS (cfm per square foot of door area)	
	Sliders	Swinging
0.3[b,c]	0.3	0.5[d]

For SI: 1 cfm/ft^2 = 0.00508 m^3/(s · m^2).

a. When tested in accordance with ASTM E 283.

b. See AAMA/WDMA 101/I.S.2.

c. See ASTM D 4099.

d. Requirement based on assembly area.

502.1.4.2 Caulking and sealants. Exterior joints, seams or penetrations in the building envelope, that are sources of air leakage, shall be sealed with durable caulking materials, closed with gasketing systems, taped or covered with moisture vapor-permeable house-wrap. Sealing materials spanning joints between dissimilar construction materials shall allow for differential expansion and contraction of the construction materials.

This includes sealing around tubs and showers, at the attic and crawl space panels, at recessed lights and around all plumbing and electrical penetrations. These are openings located in the building envelope between conditioned space and unconditioned space or between the conditioned space and the outside.

502.1.5 Fenestration solar heat gain coefficient. In locations with heating degree days (HDD) less than 3,500, the combined solar heat gain coefficient (the area-weighted average) of all glazed fenestration products (including the effects of any permanent exterior solar shading devices) in the building shall not exceed 0.4.

502.2 Heating and cooling criteria. The building envelope shall meet the provisions of Table 502.2. Compliance shall be demonstrated in accordance with Section 502.2.1, 502.2.2, 502.2.3, 502.2.4 or 502.2.5, as applicable. Energy measure

trade-offs utilizing equipment meeting the requirements of Section 503, 504, or 505 shall only use the compliance method described in Chapter 4.

TABLE 502.2
HEATING AND COOLING CRITERIA[a]

ELEMENT	MODE	TYPE A-1 RESIDENTIAL BUILDINGS U_o	TYPE A-2 RESIDENTIAL BUILDINGS U_o
Walls	Heating or cooling	—	—
Roof/ceiling	Heating or cooling	—	—
Floors over unheated spaces	Heating or cooling	—	—
Heated slab on grade[b, f]	Heating	R-value =	R-value =
Unheated slab on grade[c, d, f]	Heating	R-value =	R-value =
Basement wall[e, f]	Heating or cooling	U-factor =	U-factor =
Crawl space wall[e, f]	Heating or cooling	U-factor =	U-factor =

For SI: 1 Btu/h · ft² · °F = 5.678 W/(m² · K), °C = [(°F)-32]/1.8.

a. Values shall be determined by using the graphs [Figures 502.2(1), 502.2(2), 502.2(3), 502.2(4), 502.2(5) and 502.2(6)] using HDD as specified in Section 302.

b. There are no insulation requirements for heated slabs in locations having less than 500 HDD.

c. There are no insulation requirements for unheated slabs in locations having less than 2,500 HDD.

d. Slab edge insulation is not required for unheated slabs in areas of very heavy termite infestation probability in accordance with Section 502.2.1.4, and as shown in Figure 502.2(7).

e. Basement and crawl space wall U-factors shall be based on the wall components and surface air films. Adjacent soil shall not be considered in the determination of the U-factor.

f. Typical foundation insulation techniques can be found in the DOE *Building Foundation Design Handbook*.

502.2.1 Compliance by performance on an individual component basis. Each component of the building envelope shall meet the provisions of Table 502.2 as provided in Sections 502.2.1.1 through 502.2.1.6.

502.2.1.1 Walls. The combined thermal transmittance value (U_o) of the gross area of exterior walls shall not exceed the value given in Table 502.2. Equation 5-1 shall be used to determine acceptable combinations to meet this requirement:

$$U_o = \frac{(U_w \times A_w) + (U_g \times A_g) + (U_d \times A_d)}{A_o}$$

(Equation 5-1)

where:

U_o = The average thermal transmittance of the gross area of the exterior walls.

A_o = The gross area of exterior walls.

U_w = The combined thermal transmittance of the various paths of heat transfer through the opaque exterior wall area.

A_w = Area of exterior walls that are opaque.

U_g = The combined thermal transmittance of all glazing within the gross area of exterior walls.

A_g = The area of all glazing within the gross area of exterior walls.

U_d = The combined thermal transmittance of all opaque doors within the gross area of exterior walls.

A_d = The area of all opaque doors within the gross area of exterior walls.

Notes: (1) When more than one type of wall, window or door is used, the U and A terms for those items shall be expanded into subelements as:

$$(U_{w1}A_{w1}) + (U_{w2}A_{w2}) + (U_{w3}A_{w3}) + \ldots \text{(etc.)}$$

(Equation 5-2)

(2) Access doors or hatches in a wall assembly shall be included as a subelement of the wall assembly.

502.2.1.1.1 Steel stud framed walls. When the walls contain steel stud framing, the value of U_w used in Equation 5-1 shall be recalculated using a series path procedure to correct for parallel path thermal bridging. The U_w for purposes of Equation 5-1 of steel stud walls shall be determined as follows:

$$U_w = \frac{1}{[R_s + (R_{ins} \times F_c)]}$$

(Equation 5-3)

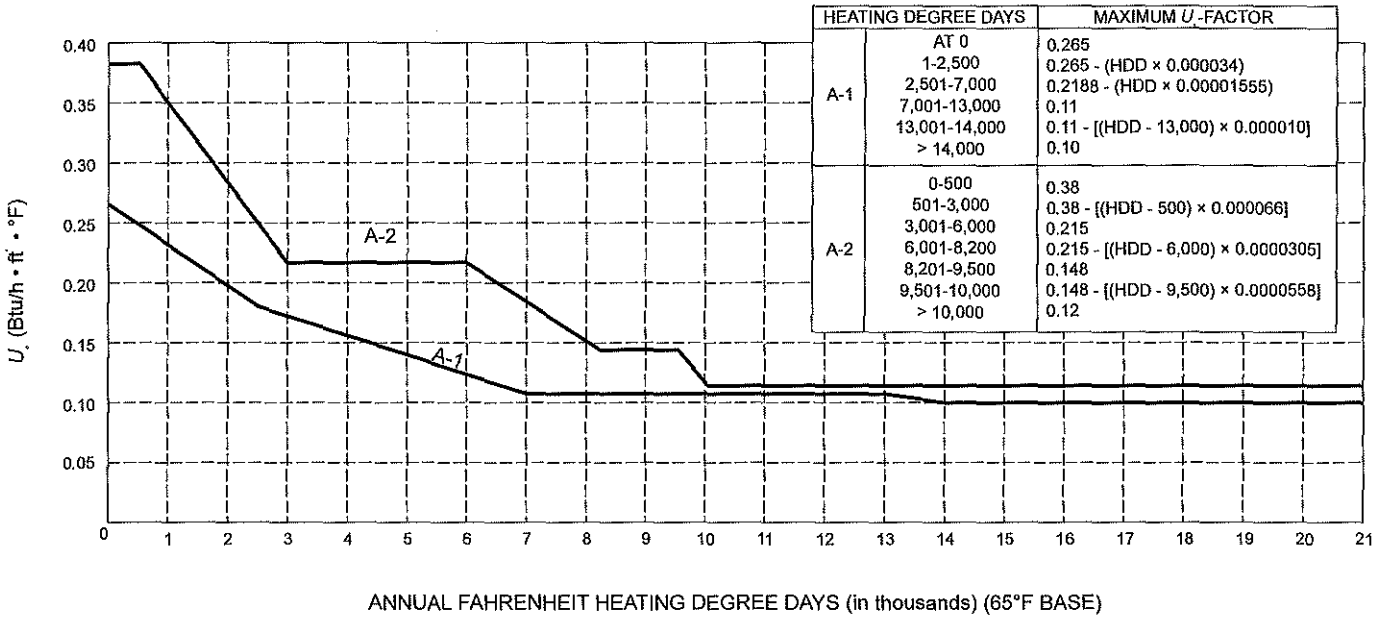
where:

R_s = The total thermal resistance of the elements comprising the wall assembly along the path of heat transfer, excluding the cavity insulation and the steel stud.

R_{ins} = The R-value of the cavity insulation.

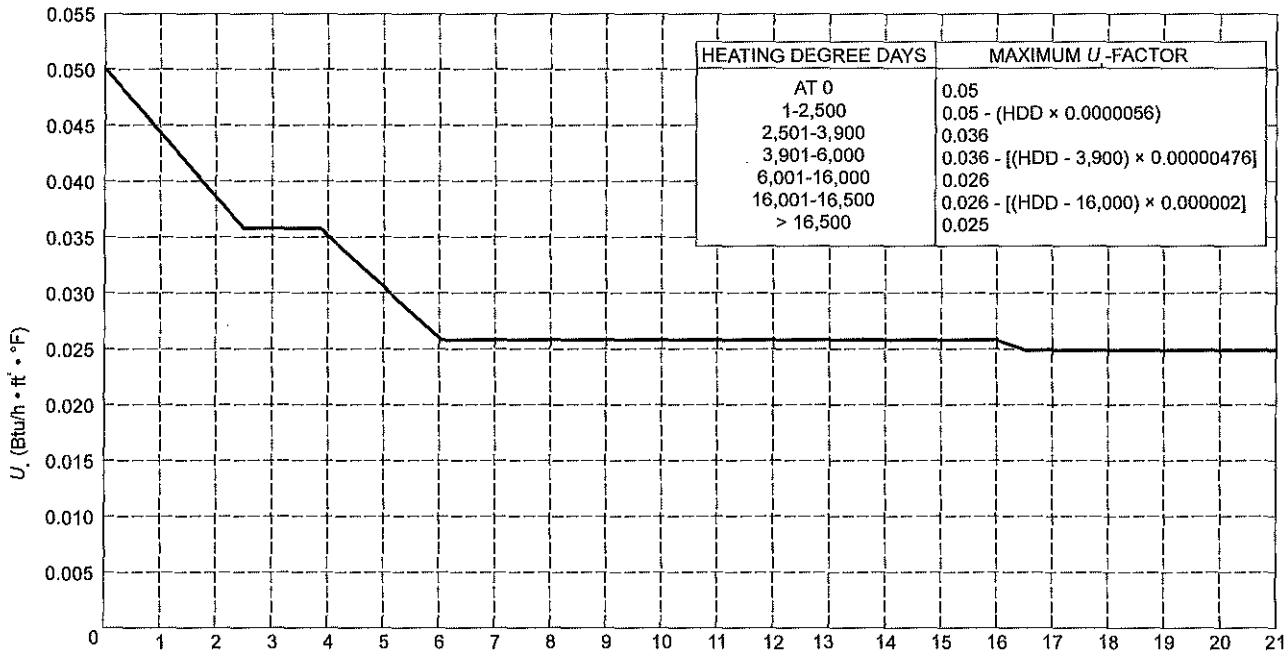
F_c = The correction factor listed in Table 502.2.1.1.1.

Exception: Overall system tested U_w values for steel stud framed walls from approved laboratories, when such data are acceptable to the code official.



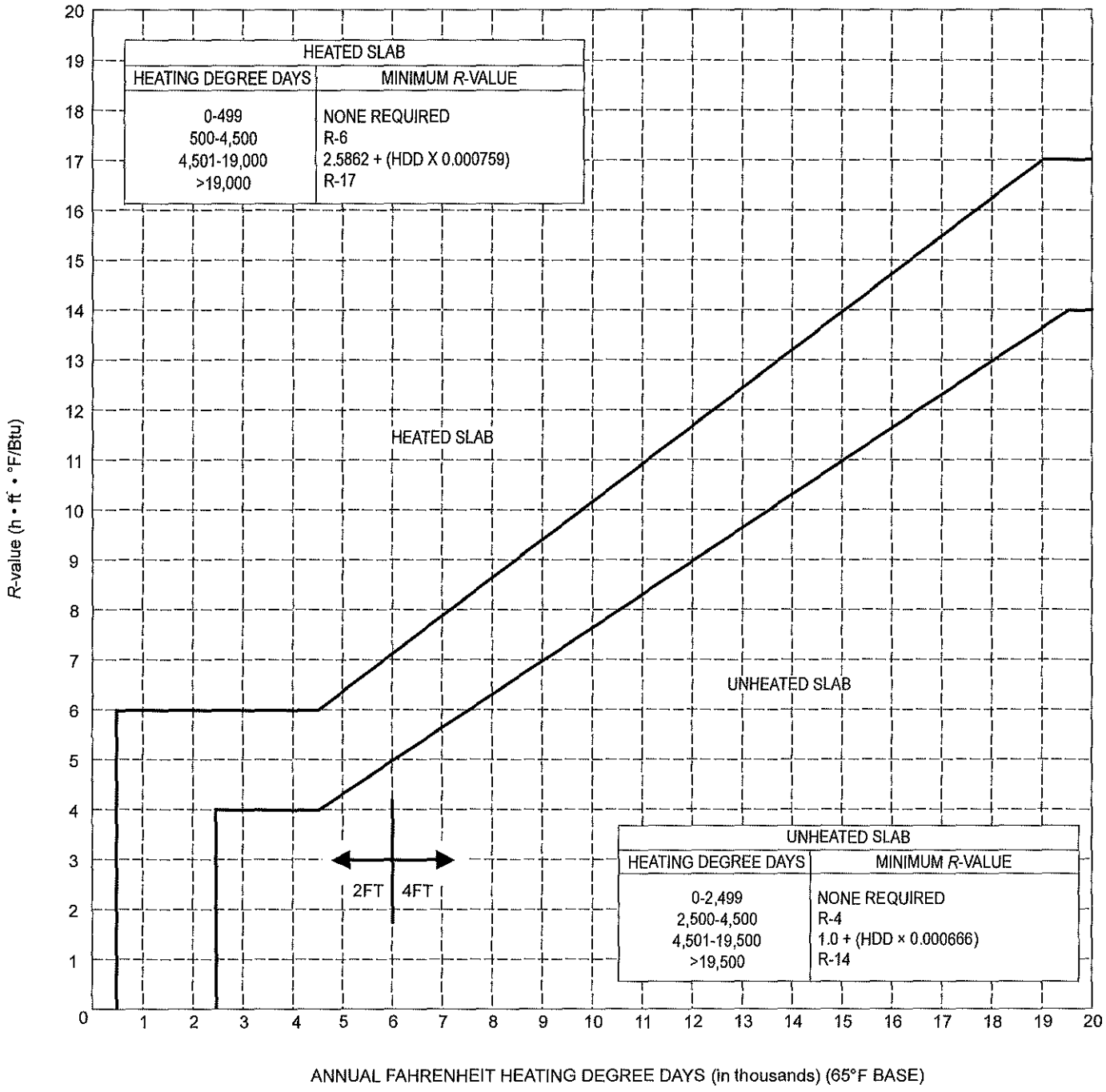
For SI: 1 Btu/h · ft² · °F = 5.678W/(m² · K), °C = [(°F)-32]/1.8.

FIGURE 502.2(1)
U_o-FACTORS—WALLS: TYPE A-1 AND A-2 RESIDENTIAL BUILDINGS



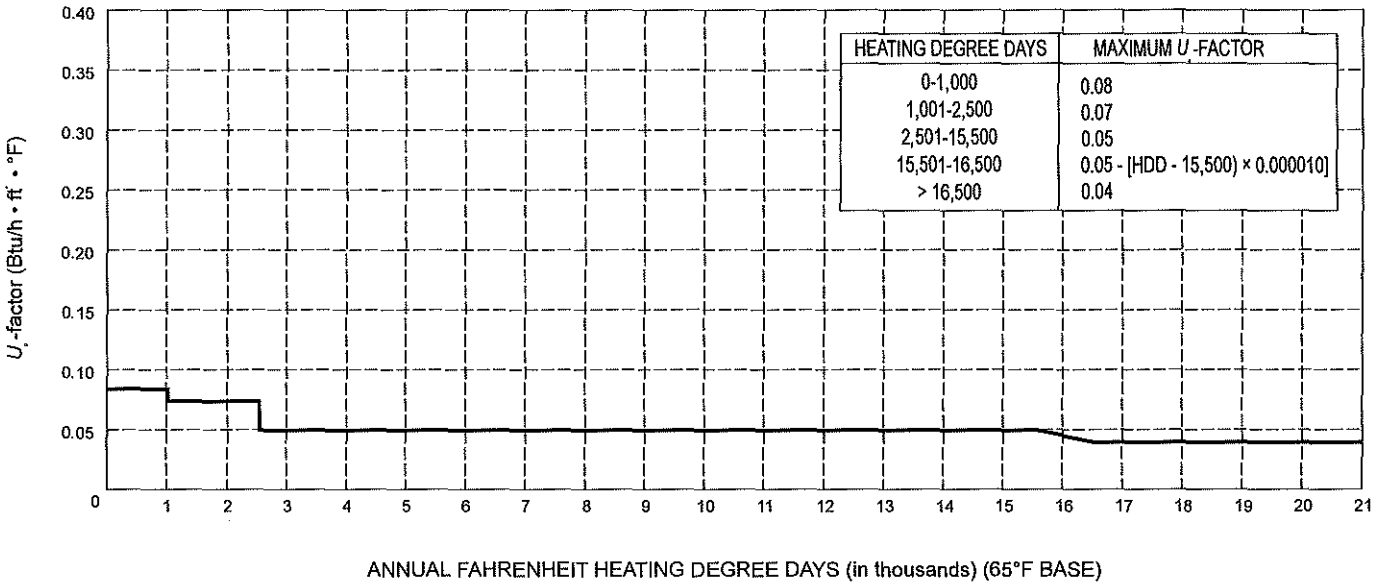
For SI: 1 Btu/h · ft² · °F = 5.678W/(m² · K), °C = [(°F)-32]/1.8.

FIGURE 502.2(2)
U_o-FACTORS—ROOF/CEILINGS



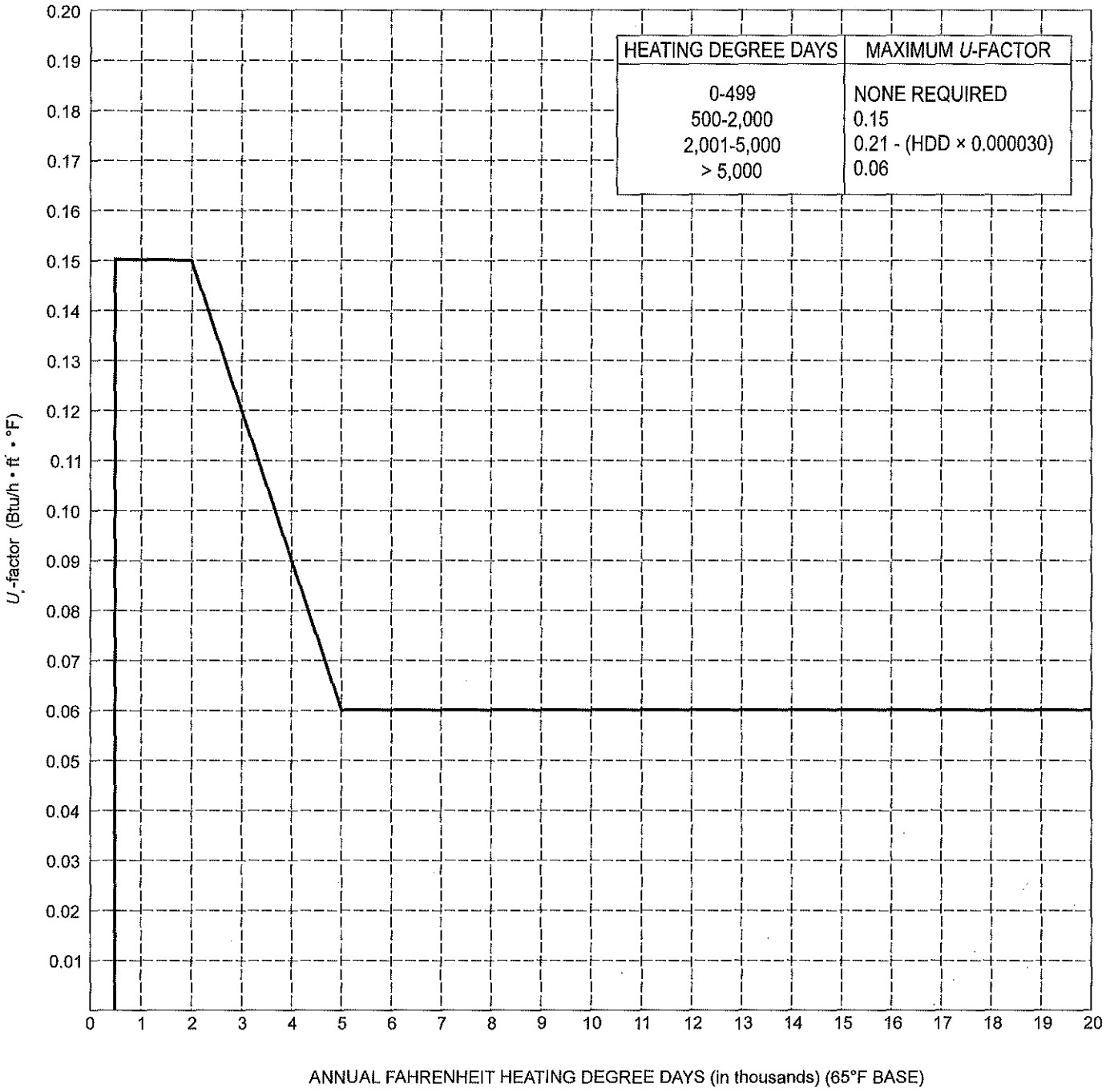
For SI: 1 Btu/h · ft² · °F = 5.678W/(m² · K), °C = [(°F)-32]/1.8.

FIGURE 502.2(3)
***R*-VALUES—SLAB ON GRADE**



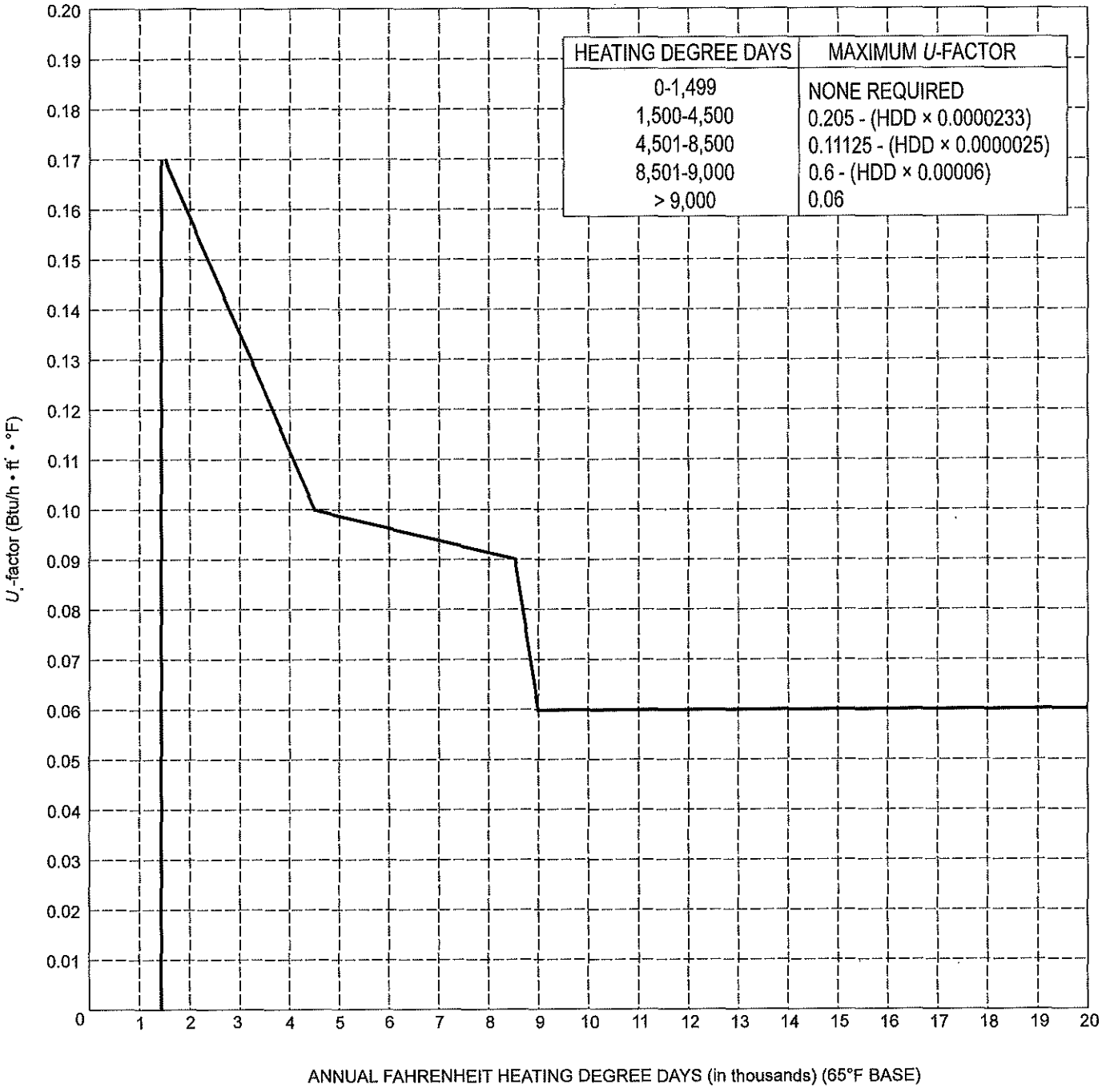
For SI: 1 Btu/h · ft² · °F = 5.678W/(m² · K), °C = [(°F)-32]/1.8.

FIGURE 502.2(4)
U_o-FACTORS—FLOOR OVER UNHEATED SPACES



For SI: 1 Btu/h · ft² · °F = 5.678W/(m² · K), °C = [(°F)-32]/1.8.

FIGURE 502.2(5)
***U*-FACTORS—CRAWL SPACE WALLS**



For SI: 1 Btu/h · ft² · °F = 5.678W/(m² · K), °C = [(°F)-32]/1.8.

FIGURE 502.2(6)
***U*-FACTORS—BASEMENT WALLS**

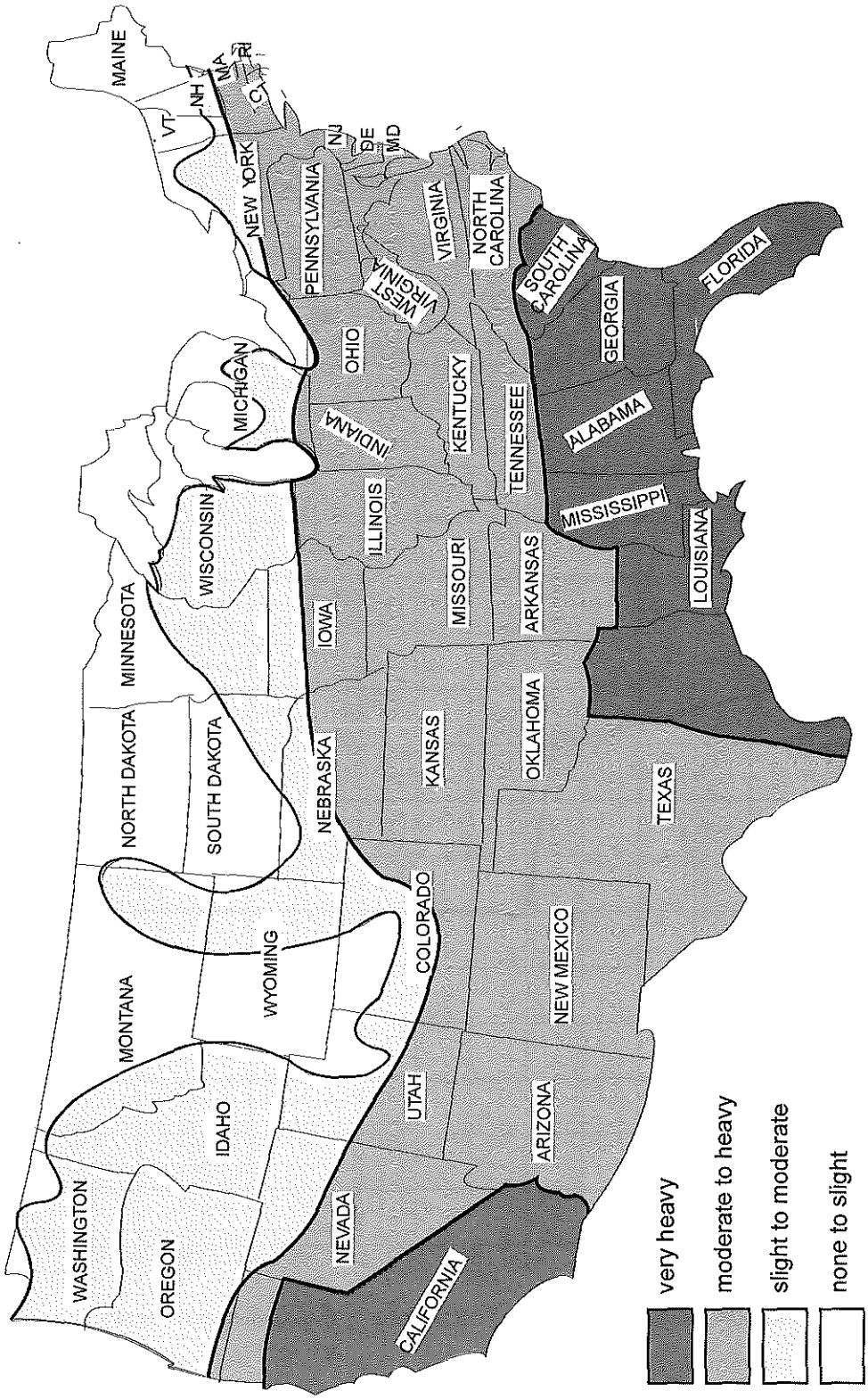


FIGURE 502.2(7)
TERMITE INFESTATION PROBABILITY MAP

TABLE 502.2.1.1.1
F_c VALUES FOR WALL SECTIONS WITH STEEL STUDS PARALLEL PATH CORRECTION FACTORS

NOMINAL STUD SIZE[a]	SPACING OF FRAMING (Inches)	CAVITY INSULATION *R*-VALUE	CORRECTION FACTOR
2 × 4	16 o.c.	R-11 R-13 R-15	0.50 0.46 0.43
2 × 4	24 o.c.	R-11 R-13 R-15	0.60 0.55 0.52
2 × 6	16 o.c.	R-19 R-21	0.37 0.35
2 × 6	24 o.c.	R-19 R-21	0.45 0.43
2 × 8	16 o.c.	R-25	0.31
2 × 8	24 o.c.	R-25	0.38

For SI: 1 inch = 25.4 mm.

a. Applies to steel studs up to a maximum thickness of 0.064 inches (16 gage).

502.2.1.1.2 Mass walls. When the thermal mass of the building components is considered, the U_w for exterior walls in Section 502.2.1.1 and having a heat capacity greater than or equal to 6 Btu/ft² · °F [1.06 kJ/(m² · K)] of exterior wall area shall be less than or equal to the values in Table 502.2.1.1.2(1), 502.2.1.1.2(2) or 502.2.1.1.2(3) based on that U_w required for walls with a heat capacity less than 6 Btu/ft² · °F [1.06 kJ/(m² · K)] of exterior wall area as determined by Equation 5-1 in Section 502.2.1.1 and Figure 502.2(1).

Note: Masonry or concrete walls having a mass greater than or equal to 30 lb/ft² (146 kg/m²) of exterior wall area and solid wood walls having a mass greater than or equal to 20 lb/ft² (98 kg/m²) of exterior wall area have heat capacities equal to or exceeding 6 Btu/ft² · °F [1.06 kJ/(m² · K)] of exterior wall area.

The heat capacity of the wall shall be determined as follows:

$$HC = w \times c \qquad \textbf{(Equation 5-4)}$$

where:

HC = Heat capacity of the exterior wall, Btu/ft² · °F [kJ/(m² · K)] of exterior wall area.

w = Mass of the exterior wall, lb/ft² (kg/m²) of exterior wall area is the density of the exterior wall material, lb/ft³ (kg/m³) multiplied by the thickness of the exterior wall, ft (m).

c = Specific heat of the exterior wall material, Btu/lb · °F [kJ/(kg · K)] of exterior wall area as determined from Chapter 24 of the ASHRAE *Handbook of Fundamentals*.

502.2.1.2 Roof/ceiling. The combined thermal transmittance value (U_o) of the gross area of the roof or ceiling assembly shall not exceed the value given in Table 502.2. Equation 5-5 shall be used to determine acceptable combinations to meet this requirement. Skylight shafts, 12 inches (305 mm) in depth and greater, shall be insulated to no less than R-13 in climates 0-4,000 HDD and R-19 in climates greater than 4,000 HDD. The skylight shaft thermal performance shall not be included in the roof thermal transmission coefficient calculation.

$$U_o = \frac{(U_R \times A_R) + (U_s \times A_s)}{A_o} \qquad \textbf{(Equation 5-5)}$$

where:

U_o = The average thermal transmittance of the gross roof/ceiling area.

A_o = The gross area of the roof/ceiling assembly.

U_R = The combined thermal transmittance of the various paths of heat transfer through the opaque roof/ceiling area.

A_R = Opaque roof/ceiling assembly area.

U_s = The combined thermal transmittance of the area of all skylight elements in the roof/ceiling assembly.

A_s = The area (including frame) of all skylights in the roof/ceiling assembly.

Notes: (1) When more than one type of roof/ceiling and/or skylight is used, the U and A terms for those items shall be expanded into their subelements as:

$$(U_{R1} \times A_{R1}) + (U_{R2} \times A_{R2}) + \ldots \text{ etc.} \qquad \textbf{(Equation 5-6)}$$

(2) Access doors or hatches in a roof/ceiling assembly shall be included as a subelement of the roof/ceiling assembly.

502.2.1.3 Floors over unheated spaces. The combined thermal transmittance factor (U_o) of the gross area of floors over unheated spaces shall not exceed the value given in Table 502.2. For floors over outdoor air, i.e., overhangs, U_o-factors shall not exceed the value for roofs given in Table 502.2. Equation 5-7 shall be used to determine acceptable combinations to meet this requirement.

$$U_o = \frac{(U_{f1} \times A_{f1}) + (U_{f2} \times A_{f2}) + \ldots + (U_{fn} \times A_{fn})}{A_o}$$

(Equation 5-7)

where:

U_o = The average thermal transmittance of the gross floor area.

A_o = The gross area of the different floor assemblies.

U_{fn} = The combined thermal transmittance of the various paths of heat transfer through the nth floor assembly.

A_{fn} = The area associated with the nth floor assembly.

Notes: Access doors or hatches in a floor assembly shall be included as a subelement of the floor assembly.

TABLE 502.2.1.1.2(1)
REQUIRED U_w FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 6 Btu/ft² · °F WITH INSULATION PLACED ON THE EXTERIOR OF THE WALL MASS

HEATING DEGREE DAYS	U_w REQUIRED FOR WALLS WITH A HEAT CAPACITY LESS THAN 6 Btu/ft² · °F AS DETERMINED BY USING EQUATION 5-1 AND FIGURE 502.2(1)										
	0.24	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08	0.06	0.04
0-2,000	0.33	0.31	0.28	0.26	0.23	0.21	0.18	0.16	0.13	0.11	0.08
2,001-4,000	0.32	0.30	0.27	0.25	0.22	0.20	0.17	0.15	0.13	0.10	0.08
4,001-5,500	0.30	0.28	0.25	0.23	0.21	0.18	0.16	0.14	0.11	0.09	0.07
5,501-6,500	0.28	0.26	0.23	0.21	0.19	0.17	0.15	0.12	0.10	0.08	0.06
6,501-8,000	0.26	0.24	0.22	0.19	0.17	0.15	0.13	0.11	0.09	0.07	0.05
> 8,001	0.24	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08	0.06	0.04

For SI: °C = [(°F)-32]/1.8, 1 Btu/ft² · °F = 0.176 kJ/(m² · K).

TABLE 502.2.1.1.2(2)
REQUIRED U_w FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 6 Btu/ft² · °F WITH INSULATION PLACED ON THE INTERIOR OF THE WALL MASS

HEATING DEGREE DAYS	U_w REQUIRED FOR WALLS WITH A HEAT CAPACITY LESS THAN 6 Btu/ft² · °F AS DETERMINED BY USING EQUATION 5-1 AND FIGURE 502.2(1)										
	0.24	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08	0.06	0.04
0-2,000	0.29	0.27	0.25	0.22	0.20	0.17	0.15	0.12	0.09	0.07	0.04
2,001-4,000	0.28	0.26	0.24	0.21	0.19	0.16	0.14	0.12	0.09	0.07	0.04
4,001-5,500	0.27	0.25	0.23	0.21	0.19	0.16	0.14	0.11	0.9	0.07	0.04
5,501-6,500	0.26	0.24	0.22	0.20	0.17	0.15	0.13	0.11	0.09	0.06	0.04
6,501-8,000	0.25	0.23	0.21	0.19	0.17	0.14	0.12	0.10	0.08	0.06	0.04
> 8,001	0.24	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08	0.06	0.04

For SI: °C = [(°F)-32]/1.8, 1 Btu/ft² · °F = 0.176 kJ/(m² · K).

TABLE 502.2.1.1.2(3)
REQUIRED U_w FOR WALL WITH A HEAT CAPACITY EQUAL TO OR EXCEEDING 6 Btu/ft² · °F WITH INTEGRAL INSULATION (INSULATION AND MASS MIXED, SUCH AS A LOG WALL)

HEATING DEGREE DAYS	U_w REQUIRED FOR WALLS WITH A HEAT CAPACITY LESS THAN 6 Btu/ft² · °F AS DETERMINED BY USING EQUATION 5-1 AND FIGURE 502.2(1)										
	0.24	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08	0.06	0.04
0-2,000	0.33	0.31	0.28	0.25	0.23	0.20	0.17	0.15	0.12	0.09	0.07
2,001-4,000	0.32	0.30	0.27	0.24	0.22	0.19	0.17	0.14	0.11	0.09	0.06
4,001-5,500	0.30	0.28	0.26	0.23	0.21	0.18	0.16	0.13	0.11	0.08	0.06
5,501-6,500	0.28	0.26	0.24	0.21	0.19	0.17	0.14	0.12	0.10	0.08	0.05
6,501-8,000	0.26	0.24	0.22	0.20	0.18	0.15	0.13	0.11	0.09	0.07	0.05
> 8,001	0.24	0.22	0.20	0.18	0.16	0.14	0.12	0.10	0.08	0.06	0.04

For SI: °C = [(°F)-32]/1.8, 1 Btu/ft² · °F = 0.176 kJ/(m² · K).

502.2.1.4 Slab-on-grade floors. The thermal resistance of the insulation around the perimeter of the floor shall not be less than the value given in Table 502.2. Where insulation is not required in accordance with Footnote d to Table 502.2, building envelope compliance shall be demonstrated by (a) using Section 502.2.2 or Chapter 4 with the actual slab insulation *R*-value in Table 502.2 or (b) using Section 502.2.4.

Insulation shall be of an approved type, and placed on the outside of the foundation or on the inside of a foundation wall. In climates below 6,000 annual Fahrenheit HDD, the insulation shall extend downward from the elevation of the top of the slab for a minimum distance of 24 inches (610 mm) or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 24 inches (610 mm). In all climates equal to or greater than 6,000 HDD, the insulation shall extend downward from the elevation of the top of the slab for a minimum of 48 inches (1219 mm) or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 48 inches (1219 mm). In all climates, horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 10 inches (254 mm) thick. 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 angle away from the exterior wall.

502.2.1.5 Crawl space walls. If the floor above a crawl space does not meet the requirements of Section 502.2.1.3 and the crawl space does not have ventilation openings which communicate directly with outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in Table 502.2. Where the inside ground surface is less than 12 inches (305 mm) below the outside finish ground level or the vertical wall insulation stops less than 12 inches (305 mm) below the outside finish ground level, crawl space wall insulation shall extend vertically and horizontally a minimum total distance of 24 inches (610 mm) linearly from the outside finish ground level [see Appendix Details 502.2.1.5(1), 502.2.1.5(2) and 502.2.1.5(3) and the DOE *Foundation Design Handbook*].

502.2.1.6 Basement walls. The exterior walls of conditioned basements shall have a transmittance value not exceeding the value given in Table 502.2 from the top of the basement wall to a depth of 10 feet (3048 mm) below the outside finish ground level, or to the level of the basement floor, whichever is less.

502.2.2 Compliance by total building envelope performance. The building envelope design of a proposed building shall be permitted to deviate from the U_o-factors, *U*-factors, or *R*-values specified in Table 502.2, provided the total thermal transmission heat gain or loss for the proposed building envelope does not exceed the total heat gain or loss resulting from the proposed building's conformance to the values specified in Table 502.2. For basement and crawl space walls that are part of the building envelope, the *U*-factor of the proposed foundation shall be adjusted by the *R*-value of the adjacent soil where the corresponding *U*-factor in Table 502.2 is similarly adjusted. Heat gain or loss calculations for slab edge and basement or crawl space wall foundations shall be determined using methods consistent with the ASHRAE *Handbook of Fundamentals*.

502.2.3 Compliance by acceptable practice on an individual component basis. Each component of the building envelope shall meet the provisions of Table 502.2 as provided in Sections 502.2.3.1 through 502.2.3.6. The various walls, roof and floor assemblies described in Section 502.2.3 are typical and are not intended to be all inclusive. Other assemblies shall be permitted, provided documentation is submitted indicating the thermal transmittance value of the opaque section. Documentation shall be in accordance with accepted engineering practice.

502.2.3.1 Walls. The U_o of the exterior wall shall be determined in accordance with Equation 5-8.

$$U_o = \frac{(U_f \times A_f) + U_w \times (100 - A_f)}{100} \qquad \textbf{(Equation 5-8)}$$

where:

U_o = The overall thermal transmittance of the gross exterior wall area.

U_f = The average thermal transmittance of the glazing area.

$$A_f = \frac{\text{Glazing Area}}{\text{Gross Exterior Wall Area}} \times 100$$

U_w = The average thermal transmittance of the opaque exterior wall area.

The *U*-factor for the opaque portion of the exterior wall (U_w) shall meet the provisions of Table 502.2 as determined by Equation 5-8, and be selected from Table 502.2.3.1(1), 502.2.3.1(2) or 502.2.3.1(3) listed in the Appendix. The glazing *U*-factor (U_f) and the percentage of glazing area (A_f) shall consist of all glazed surfaces in the building envelope measured using the rough opening and including the sash, curbing and other framing elements that enclose conditioned spaces. The value of U_f shall be determined in accordance with Section 102.5.2.

Exceptions:

1. When the exterior wall(s) is comprised of steel stud framing members, the procedure contained in Section 502.2.1.1.1 shall be used to correct the *U*-factor of the opaque sections of such walls prior to selection of the appropriate acceptable practice(s) from Appendix Table 502.2.3.1(1).
2. When the thermal mass of the exterior building walls is considered, the procedure contained in Section 502.2.1.1.2 shall be used to correct the *U*-factor of the opaque sections of such walls prior to the selection of the appropriate acceptable practice(s) from Table 502.2.3.1(2) or 502.2.3.1(3) listed in the Appendix.

502.2.3.2 Roof/ceiling. The roof/ceiling assembly shall be selected from Appendix Table 502.2.3.2 for a thermal transmittance value not exceeding the value specified for roofs/ceilings in Table 502.2.

502.2.3.3 [Comm 63.0502 (2)] Floors over unheated spaces. The floor section over an unheated space shall be selected from IECC Appendix Table 502.2.3.3 for the overall thermal transmittance factor (U_o) not exceeding the value specified for floors over unheated spaces in IECC Table 502.2. For floors over outdoor air, such as overhangs, U_o-factors for heating shall meet the same requirement as shown for floors over unheated spaces in IECC Table 502.2.

502.2.3.4 Slab-on-grade floors. Slab-on-grade floors shall meet the provisions of Table 502.2 as determined by Section 502.2.1.4.

502.2.3.5 Crawl space walls. Where the floor above a crawl space does not meet the requirements of Section 502.2.3.3 and the crawl space does not have ventilation openings that communicate directly with outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in Table 502.2. The *U*-factor of the exterior crawl space wall shall be determined by selecting the *U*-factor for the appropriate crawl space wall section from Appendix Table 502.2.3.5. Where the inside ground surface is less than 12 inches (305 mm) below the outside finish ground level or the vertical wall insulation stops less than 12 inches (305 mm) below the outside finish ground level, crawl space wall insulation shall extend vertically and horizontally a minimum total distance of 24 inches (610 mm) linearly from the outside finish ground level [see Appendix Details 502.2.1.5(1), 502.2.1.5(2) and 502.2.1.5(3) and the DOE *Building Foundation Design Handbook*].

502.2.3.6 Basement walls. The exterior walls of conditioned basements shall have a thermal transmittance value not exceeding the value given in Table 502.2 from the top of the basement wall to a depth of 10 feet (3048 mm) below grade, or to the level of the basement floor, whichever is less. The *U*-factor of the wall shall be determined by selecting the *U*-factor for the wall section from Appendix Table 502.2.3.6.

502.2.4 Compliance by prescriptive specification on an individual component basis. For buildings with a window area less than or equal to 8 percent, 12 percent, 15 percent, 18 percent, 20 percent, or 25 percent (Type A-1 residential buildings) or 20 percent, 25 percent, or 30 percent (Type A-2 residential buildings) of the gross exterior wall area, the thermal resistance of insulation applied to the opaque building envelope components shall be greater than or equal to the minimum *R*-values, and the thermal transmittance of all fenestration assemblies shall be less than or equal to the maximum *U*-factors shown in Table 502.2.4(1), 502.2.4(2), 502.2.4(3), 502.2.4(4), 502.2.4(5), 502.2.4(6), 502.2.4(7), 502.2.4(8), or 502.2.4(9), as applicable. Sections 502.2.4.1 through 502.2.4.17 shall apply to the use of these tables.

TABLE 502.2.4(1)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-1 RESIDENTIAL BUILDINGS
WINDOW AREA 8 PERCENT OF GROSS EXTERIOR WALL AREA

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	any	R-13	R-11	R-11	R-0	R-0	R-0
500-999	any	R-19	R-11	R-11	R-0	R-0	R-4
1,000-1,499	any	R-19	R-11	R-11	R-0	R-0	R-5
1,500-1,999	any	R-19	R-11	R-11	R-5	R-0	R-5
2,000-2,499	0.90	R-19	R-11	R-11	R-5	R-0	R-6
2,500-2,999	0.70	R-26	R-11	R-11	R-5	R-0	R-6
3,000-3,499	0.70	R-26	R-11	R-13	R-5	R-0	R-6
3,500-3,999	0.65	R-30	R-11	R-13	R-6	R-2, 2 ft.	R-7
4,000-4,499	0.59	R-30	R-11	R-15	R-8	R-2, 2 ft.	R-9
4,500-4,999	0.55	R-30	R-13	R-15	R-8	R-2, 2 ft.	R-12
5,000-5,499	0.52	R-30	R-13	R-19	R-9	R-7, 2 ft.	R-16
5,500-5,999	0.45	R-38	R-13	R-19	R-9	R-7, 2 ft.	R-16
6,000-6,499	0.45	R-38	R-16	R-19	R-10	R-7, 4 ft.	R-16
6,500-6,999	0.43	R-38	R-16	R-19	R-10	R-7, 4 ft.	R-16
7,000-8,499	0.42	R-38	R-16	R-19	R-11	R-8, 4 ft.	R-16
8,500-8,999	0.42	R-38	R-16	R-19	R-16	R-8, 4 ft.	R-16
9,000-12,999	0.42	R-38	R-16	R-19	R-16	R-11, 4 ft.	R-16

For SI: 1 foot = 304.8 mm.

TABLE 502.2.4(2)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-1 RESIDENTIAL BUILDINGS
WINDOW AREA 12 PERCENT OF GROSS EXTERIOR WALL AREA

HEATING DEGREE DAYS	MAXIMUM	MINIMUM					
	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-449	any	R-13	R-11	R-11	R-0	R-0	R-0
500-999	any	R-19	R-11	R-11	R-0	R-0	R-4
1,000-1,499	0.75	R-19	R-11	R-11	R-0	R-0	R-5
1,500-1,999	0.75	R-19	R-11	R-11	R-4	R-0	R-5
2,000-2,499	0.65	R-19	R-13	R-11	R-5	R-0	R-5
2,500-2,999	0.60	R-26	R-13	R-13	R-5	R-0	R-5
3,000-3,499	0.60	R-30	R-13	R-15	R-6	R-0	R-6
3,500-3,999	0.60	R-30	R-13	R-19	R-8	R-4, 2 ft.	R-10
4,000-4,499	0.55	R-38	R-13	R-19	R-9	R-4, 2 ft.	R-12
4,500-4,999	0.50	R-38	R-14	R-19	R-9	R-5, 2 ft.	R-16
5,000-5,499	0.45	R-38	R-16	R-19	R-9	R-6, 2 ft.	R-16
5,500-5,999	0.45	R-38	R-17	R-19	R-9	R-6, 2 ft.	R-16
6,000-6,499	0.40	R-38	R-18	R-19	R-10	R-6, 4 ft.	R-16
6,500-6,999	0.40	R-49	R-21	R-19	R-10	R-7, 4 ft.	R-17
7,000-8,499	0.40	R-49	R-21	R-19	R-10	R-9, 4 ft.	R-17
8,500-8,999	0.40	R-49	R-21	R-19	R-16	R-9, 4 ft.	R-17
9,000-12,999	0.40	R-49	R-21	R-19	R-16	R-11, 4 ft.	R-17

For SI: 1 foot = 304.8 mm.

TABLE 502.2.4(3)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-1 RESIDENTIAL BUILDINGS
WINDOW AREA 15 PERCENT OF GROSS EXTERIOR WALL AREA

HEATING DEGREE DAYS	MAXIMUM	MINIMUM					
	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	any	R-13	R-11	R-11	R-0	R-0	R-0
500-999	0.90	R-19	R-11	R-11	R-0	R-0	R-4
1,000-1,499	0.75	R-19	R-11	R-11	R-0	R-0	R-5
1,500-1,999	0.75	R-26	R-13	R-11	R-5	R-0	R-5
2,000-2,499	0.65	R-30	R-13	R-11	R-5	R-0	R-6
2,500-2,999	0.60	R-30	R-13	R-19	R-6	R-4, 2 ft.	R-7
3,000-3,499	0.55	R-30	R-13	R-19	R-7	R-4, 2 ft.	R-8
3,500-3,999	0.50	R-30	R-13	R-19	R-8	R-5, 2 ft.	R-10
4,000-4,499	0.45	R-38	R-13	R-19	R-8	R-5, 2 ft.	R-11
4,500-4,999	0.45	R-38	R-16	R-19	R-9	R-6, 2 ft.	R-17
5,000-5,499	0.45	R-38	R-18	R-19	R-9	R-6, 2 ft.	R-17
5,500-5,999	0.40	R-38	R-18	R-21	R-10	R-9, 2 ft.	R-19
6,000-6,499	0.35	R-38	R-18	R-21	R-10	R-9, 4 ft.	R-20
6,500-6,999	0.35	R-49	R-21	R-21	R-11	R-11, 4 ft.	R-20
7,000-8,499	0.35	R-49	R-21	R-21	R-11	R-13, 4 ft.	R-20
8,500-8,999	0.35	R-49	R-21	R-21	R-18	R-14, 4 ft.	R-20
9,000-12,999	0.35	R-49	R-21	R-21	R-19	R-18, 4 ft.	R-20

For SI: 1 foot = 304.8 mm.

TABLE 502.2.4(4)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-1 RESIDENTIAL BUILDINGS
WINDOW AREA 18 PERCENT OF GROSS EXTERIOR WALL AREA

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	0.80	R-19	R-11	R-11	R-0	R-0	R-0
500-999	0.75	R-19	R-11	R-11	R-0	R-0	R-4
1,000-1,499	0.70	R-26	R-13	R-11	R-0	R-0	R-5
1,500-1,999	0.65	R-30	R-13	R-11	R-5	R-0	R-5
2,000-2,499	0.55	R-30	R-13	R-11	R-5	R-0	R-6
2,500-2,999	0.52	R-30	R-13	R-19	R-6	R-0	R-7
3,000-3,499	0.50	R-38	R-13	R-19	R-7	R-0	R-8
3,500-3,999	0.46	R-38	R-13	R-19	R-8	R-6, 2 ft.	R-11
4,000-4,499	0.40	R-38	R-13	R-19	R-9	R-6, 2 ft.	R-13
4,500-4,999	0.37	R-38	R-15	R-19	R-9	R-6, 2 ft.	R-16
5,000-5,499	0.37	R-38	R-16	R-19	R-9	R-7, 2 ft.	R-17
5,500-5,999	0.37	R-38	R-19	R-19	R-10	R-8, 2 ft.	R-17
6,000-6,499	0.34	R-49	R-22	R-19	R-10	R-8, 4 ft.	R-17
6,500-6,999	0.33	R-49	R-22	R-25	R-11	R-14, 4 ft.	R-19
7,000-8,499	0.33	R-49	R-25	R-30	R-15	Note a	R-25
8,500-8,999	0.33	R-49	R-25	R-30	R-19	Note a	R-25
9,000-12,999	0.33	R-49	R-25	R-30	R-19	Note a	R-25

For SI: 1 foot = 304.8 mm.
a. See Section 502.2.4.13.

TABLE 502.2.4(5)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-1 RESIDENTIAL BUILDINGS
WINDOW AREA 20 PERCENT OF GROSS EXTERIOR WALL AREA

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	0.80	R-19	R-11	R-11	R-0	R-0	R-0
500-999	0.75	R-30	R-13	R-11	R-0	R-0	R-4
1,000-1,499	0.70	R-30	R-13	R-11	R-0	R-0	R-5
1,500-1,999	0.60	R-30	R-13	R-11	R-5	R-0	R-5
2,000-2,499	0.52	R-38	R-13	R-11	R-5	R-0	R-6
2,500-2,999	0.50	R-38	R-13	R-19	R-6	R-0	R-7
3,000-3,499	0.46	R-38	R-13	R-19	R-7	R-0	R-9
3,500-3,999	0.42	R-38	R-13	R-19	R-8	R-6, 2 ft.	R-10
4,000-4,499	0.37	R-38	R-13	R-19	R-9	R-6, 2 ft.	R-13
4,500-4,999	0.37	R-38	R-16	R-19	R-9	R-6, 2 ft.	R-16
5,000-5,499	0.36	R-38	R-19	R-19	R-9	R-6, 2 ft.	R-16
5,500-5,999	0.33	R-49	R-20	R-19	R-10	R-7, 2 ft.	R-17
6,000-6,499	0.31	R-49	R-24	R-19	R-10	R-7, 4 ft.	R-17
6,500-6,999	0.30	R-49	R-26	R-21	R-11	R-10, 4 ft.	R-17
7,000-8,499	0.30	R-49	R-26	R-21	R-11	R-12, 4 ft.	R-19
8,500-8,999	0.30	R-49	R-26	R-21	R-19	R-12, 4 ft.	R-19
9,000-12,999	0.30	R-49	R-26	R-21	R-19	R-16, 4 ft.	R-19

For SI: 1 foot = 304.8 mm.

TABLE 502.2.4(6)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-1 RESIDENTIAL BUILDINGS
WINDOW AREA 25 PERCENT OF GROSS EXTERIOR WALL AREA

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling R-value	Exterior wall *R*-value	Floor *R*-value	Basement Wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	0.70	R-30	R-11	R-11	R-0	R-0	R-0
500-999	0.65	R-30	R-13	R-11	R-0	R-0	R-4
1,000-1,499	0.55	R-30	R-13	R-11	R-0	R-0	R-5
1,500-1,999	0.52	R-30	R-13	R-13	R-6	R-0	R-6
2,000-2,499	0.50	R-38	R-13	R-19	R-8	R-0	R-10
2,500-2,999	0.46	R-38	R-16	R-19	R-6	R-0	R-7
3,000-3,499	0.45	R-38	R-19	R-19	R-7	R-0	R-9
3,500-3,999	0.41	R-38	R-19	R-19	R-8	R-6, 2 ft.	R-10
4,000-4,499	0.37	R-38	R-19	R-19	R-9	R-6, 2 ft.	R-13
4,500-4,999	0.33	R-38	R-19	R-19	R-9	R-6, 2 ft.	R-17
5,000-5,499	0.29	R-38	R-19	R-19	R-9	R-6, 2 ft.	R-17
5,500-5,999	0.27	R-38	R-19	R-21	R-10	Note a	R-22
6,000-6,499	0.25	R-49	R-19	R-21	R-10	R-9, 4 ft.	R-20
6,500-6,999	0.25	R-49	R-19	R-30	R-14	Note a	Note a
7,000-8,499	0.25	R-49	R-19	R-30	R-15	Note a	Note a
8,500-8,999	0.25	R-49	R-19	R-30	R-28	Note a	Note a
9,000-12,999	0.25	R-49	R-19	R-30	R-28	Note a	Note a

For SI: 1 foot = 304.8 mm.
a. See Section 502.2.4.13.

TABLE 502.2.4(7)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-2 RESIDENTIAL BUILDINGS
WINDOW AREA 20 PERCENT OF GROSS EXTERIOR WALL AREA

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	any	R-13	R-11	R-11	R-0	R-0	R-0
500-999	any	R-19	R-11	R-11	R-0	R-0	R-5
1,000-1,499	any	R-19	R-11	R-11	R-0	R-0	R-5
1,500-1,999	0.85	R-19	R-11	R-11	R-5	R-0	R-5
2,000-2,499	0.70	R-19	R-11	R-11	R-5	R-0	R-5
2,500-2,999	0.55	R-30	R-13	R-11	R-5	R-0	R-5
3,000-3,499	0.55	R-30	R-13	R-11	R-5	R-0	R-5
3,500-3,999	0.55	R-30	R-13	R-11	R-5	R-0	R-5
4,000-4,499	0.55	R-38	R-13	R-11	R-5	R-0	R-5
4,500-4,999	0.50	R-26	R-11	R-13	R-6	R-0	R-7
5,000-5,499	0.50	R-26	R-13	R-11	R-5	R-0	R-6
5,500-5,999	0.50	R-30	R-13	R-11	R-5	R-0	R-6
6,000-6,499	0.50	R-26	R-13	R-19	R-9	R-5, 4 ft.	R-14
6,500-6,999	0.45	R-30	R-13	R-19	R-10	R-7, 4 ft.	R-16
7,000-8,499	0.35	R-38	R-16	R-19	R-11	R-9, 4 ft.	R-18
8,500-8,999	0.35	R-38	R-16	R-19	R-17	R-10, 4 ft.	R-18
9,000-12,999	Note a	Note a	Note a	Note a	Note a	Note a	Note a

For SI: 1 foot = 304.8 mm.
a. See Section 502.2.4.13.

TABLE 502.2.4(8)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-2 RESIDENTIAL BUILDINGS
WINDOW AREA 25 PERCENT OF GROSS EXTERIOR WALL AREA

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	any	R-13	R-11	R-11	R-0	R-0	R-0
500-999	any	R-19	R-11	R-11	R-0	R-0	R-5
1,000-1,499	any	R-19	R-11	R-11	R-0	R-0	R-5
1,500-1,999	0.85	R-19	R-11	R-11	R-5	R-0	R-5
2,000-2,499	0.70	R-19	R-11	R-11	R-5	R-0	R-5
2,500-2,999	0.55	R-30	R-13	R-11	R-5	R-0	R-5
3,000-3,499	0.55	R-30	R-13	R-11	R-5	R-0	R-5
3,500-3,999	0.55	R-30	R-13	R-11	R-5	R-0	R-5
4,000-4,499	0.54	R-30	R-13	R-11	R-5	R-0	R-5
4,500-4,999	0.53	R-30	R-13	R-11	R-5	R-0	R-6
5,000-5,499	0.52	R-30	R-13	R-11	R-5	R-0	R-6
5,500-5,999	0.51	R-30	R-13	R-11	R-6	R-0	R-6
6,000-6,499	0.51	R-30	R-13	R-19	R-10	R-7, 4 ft.	R-16
6,500-6,999	0.45	R-30	R-13	R-19	R-10	R-7, 4 ft.	R-16
7,000-8,499	0.35	R-38	R-16	R-19	R-11	R-9, 4 ft.	R-18
8,500-8,999	0.35	R-38	R-16	R-19	R-17	R-10, 4 ft.	R-18
9,000-12,999	Note a	Note a	Note a	Note a	Note a	Note a	Note a

For SI: 1 foot = 304.8 mm.
a. See Section 502.2.4.13.

TABLE 502.2.4(9)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, TYPE A-2 RESIDENTIAL BUILDINGS
WINDOW AREA 30 PERCENT OF GROSS EXTERIOR WALL AREA

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling *R*-value	Exterior wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	0.90	R-13	R-11	R-11	R-0	R-0	R-0
500-999	0.75	R-19	R-11	R-11	R-0	R-0	R-3
1,000-1,499	0.70	R-19	R-11	R-11	R-0	R-0	R-4
1,500-1,999	0.65	R-26	R-11	R-11	R-5	R-0	R-5
2,000-2,499	0.57	R-38	R-13	R-11	R-5	R-0	R-6
2,500-2,999	0.47	R-38	R-13	R-19	R-7	R-0	R-8
3,000-3,499	0.47	R-38	R-13	R-19	R-7	R-0	R-9
3,500-3,999	0.46	R-38	R-13	R-19	R-8	R-4, 2 ft.	R-9
4,000-4,499	0.46	R-38	R-13	R-19	R-9	R-6, 2 ft	R-13
4,500-4,999	0.45	R-38	R-13	R-19	R-9	R-6, 2 ft	R-15
5,000-5,499	0.45	R-38	R-13	R-19	R-10	R-8, 2 ft.	R-18
5,500-5,999	0.44	R-38	R-13	R-19	R-10	R-8, 2 ft.	R-18
6,000-6,499	0.44	R-38	R-19	R-19	R-10	R-8, 4 ft.	R-18
6,500-6,999	0.38	R-38	R-19	R-19	R-10	R-8, 4 ft.	R-18
7,000-8,499	0.32	R-49	R-21	R-30	R-18	Note a	Note a
8,500-8,999	0.32	R-49	R-21	R-30	Note a	Note a	Note a
9,000-12,999	Note a	Note a	Note a	Note a	Note a	Note a	Note a

For SI: 1 foot = 304.8 mm.
a. See Section 502.2.4.13.

502.2.4.1 Walls. The sum of the thermal resistance of cavity insulation plus insulating sheathing (if used) shall meet or exceed the "Exterior wall *R*-value."

502.2.4.2 Wood construction only. The tables shall only be used for wood construction.

502.2.4.3 Window area. The actual window area of a proposed design shall be computed using the rough opening area of all skylights, above-grade windows and, where the basement is conditioned space, any basement windows.

502.2.4.4 Window area, exempt. One percent of the total window area computed under Section 502.2.4.3 shall be exempt from the "Glazing *U*-factor" requirement.

502.2.4.5 Truss/rafter construction. "Ceiling *R*-value" assumes standard truss or rafter construction. Where raised-heel trusses or other construction techniques are employed to obtain the full height of ceiling insulation over the exterior wall top plate, R-30 shall be permitted to be used where R-38 is required in the table, and R-38 shall be permitted to be used where R-49 is required.

502.2.4.6 Doors. Opaque doors in the building envelope shall have a maximum *U*-factor of 0.35. One door shall be exempt from this requirement.

502.2.4.7 Ceilings. "Ceiling *R*-value" shall be required for flat or "cathedral" (inclined) ceilings.

502.2.4.8 [Comm 63.0502 (3)] Floors. Floor *R*-values shall apply to floors over unconditioned spaces and floors over outside air.

502.2.4.9 Basement walls. Basement wall insulation shall be installed in accordance with Section 502.2.1.6.

502.2.4.10 Unheated slabs. Slab perimeter insulation shall be installed in accordance with Section 502.2.1.4.

502.2.4.11 Heated slabs. R-2 shall be added to the "Slab perimeter *R*-value" where the slab is heated.

502.2.4.12 Crawl space walls. "Crawl space wall *R*-value" shall apply to unventilated crawl spaces only. Crawl space insulation shall be installed in accordance with Section 502.2.1.5.

502.2.4.13 Tables not applicable. The particular climate range indicated by Note a in Tables 502.2.4(4), 502.2.4(6), 502.2.4(7), 502.2.4(8) and 502.2.4(9) shall not be used with the indicated envelope component(s) to demonstrate compliance under Section 502.2.4.

502.2.4.14 Climates greater than 13,000 HDD. These tables shall not be used for climates greater than or equal to 13,000 HDD.

502.2.4.15 Fenestration solar heat gain coefficient. In locations with HDD less than 3,500, fenestration products shall also meet the requirements of Section 502.1.5.

502.2.4.16 Steel-framed wall construction. Where steel framing is used in wall construction, the wall assembly shall meet the equivalent wall cavity and sheathing *R*-values in Table 502.2.4.16(1) or 502.2.4.16(2), based on the "on-center" (o.c.) dimension of the steel studs and the required *R*-value for wood-framed walls determined in accordance with Section 502.2.4, and utilizing any combination of cavity and sheathing insulation set off by commas in Table 502.2.4.16(1) or 502.2.4.16(2).

TABLE 502.2.4.16(1)
16-INCH O.C. STEEL-FRAMED WALL EQUIVALENT *R*-VALUES

WOOD-FRAMED WALL *R*-VALUE [a]	EQUIVALENT STEEL-FRAMED WALL CAVITY AND SHEATHING *R*-VALUE
R-11	R-0+R-9, R-11+R-4, R-15+R-3, R-21+R-2
R-13	R-11+R-5, R-15+R-4, R-21+R-3
R-14	R-11+R-6, R-13+R-5, R-19+R-4
R-15	R-11+R-6, R-15+R-5, R-19+R-4
R-16	R-11+R-8, R-15+R-7, R-21+R-6
R-17	R-11+R-9, R-13+R-8, R-19+R-7
R-18	R-11+R-9, R-15+R-8, R-21+R-7
R-19	R-11+R-10, R-13+R-9, R-19+R-8, R-25+R-7
R-20	R-11+R-10, R-13+R-9, R-19+R-8
R-21	R-13+R-10, R-19+R-9, R-25+R-8
R-22	R-13+R-10, R-19+R-9
R-24	R-19+R-10, R-25+R-9
R-25	R-19+R-10
R-26	R-19+R-11, R-21+R-10

For SI: 1 inch = 25.4 mm.

a. As required by Section 502.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 502.2.4(1) through 502.2.4(9), as applicable.

TABLE 502.2.4.16(2)
24-INCH O.C. STEEL FRAMED WALL EQUIVALENT *R*-VALUES

WOOD-FRAMED WALL *R*-VALUE[a]	EQUIVALENT STEEL-FRAMED WALL CAVITY AND SHEATHING *R*-VALUE
R-11	R-0+R-9, R-11+R-3, R-15+R-2, R-25+R-0
R-13	R-11+R-4, R-15+R-3, R-19+R-2
R-14	R-11+R-5, R-13+R-4, R-15+R-3, R-21+R-2
R-15	R-11+R-5, R-13+R-4, R-19+R-3, R-21+R-2
R-16	R-11+R-7, R-13+R-6, R-19+R-5, R-25+R-4
R-17	R-11+R-8, R-13+R-7, R-15+R-6, R-21+R-5
R-18	R-11+R-8, R-13+R-7, R-19+R-6, R-25+R-5
R-19	R-11+R-9, R-13+R-8, R-15+R-7, R-21+R-6
R-20	R-11+R-9, R-13+R-8, R-19+R-7, R-21+R-6
R-21	R-11+R-9, R-15+R-8, R-21+R-7
R-22	R-11+R-10, R-13+R-9, R-19+R-8, R-21+R-7
R-24	R-11+R-10, R-15+R-9, R-19+R-8
R-25	R-13+R-10, R-19+R-9, R-21+R-8
R-26	R-15+R-10, R-19+R-9, R-25+R-8

For SI: 1 inch = 25.4 mm.

a. As required by Section 502.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 502.2.4(1) through 502.2.4(9), as applicable.

502.2.4.17 High-mass wall construction. Exterior walls constructed of high-mass materials having heat capacity greater than or equal to 6 Btu/ $ft^2 \cdot °F$ [1.06 $kJ/(m^2 \cdot K)$] of exterior wall area shall meet the equivalent insulation *R*-values in Table 502.2.4.17(1) or 502.2.4.17(2), based on the placement of the insulation, the HDD of the building location, and the required *R*-value for wood-framed walls determined in accordance with Section 502.2.4.

TABLE 502.2.4.17(1)
HIGH-MASS WALL EQUIVALENT *R*-VALUES
INSULATION PLACED ON THE EXTERIOR OF THE WALL OR WITH INTEGRAL INSULATION

WOOD FRAMED WALL *R*-VALUE[a]	EQUIVALENT HIGH-MASS WALL *R*-VALUE					
	HDD 0-1,999	HDD 2,000-3,999	HDD 4,000-5,499	HDD 5,500-6,499	HDD 6,500-8,499	HDD ≥ 8,500
R-11	R-6	R-6	R-7	R-8	R-9	R-10
R-13	R-6	R-6	R-8	R-9	R-10	R-11
R-14	R-6	R-7	R-8	R-9	R-10	R-11
R-15	R-7	R-7	R-8	R-9	R-10	R-12
R-16	R-7	R-7	R-8	R-9	R-11	R-12
R-17	R-7	R-7	R-9	R-10	R-11	R-13
R-18	R-7	R-7	R-9	R-10	R-11	E-13
R-19	R-8	R-9	R-10	R-11	R-13	R-15
R-20	R-8	R-9	R-10	R-11	R-13	R-16
R-21	R-8	R-9	R-10	R-12	R-14	R-16
R-22	R-8	R-9	R-10	R-12	R-14	R-17
R-23	R-9	R-9	R-11	R-12	R-14	R-17
R-24	R-9	R-9	R-11	R-12	R-14	R-17
R-25	R-9	R-10	R-11	R-13	R-15	R-18
R-26	R-9	R-10	R-11	R-13	R-15	R-18

a. As required by Section 502.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 502.2.4(1) through 502.2.4(9), as applicable.

TABLE 502.2.4.17(2)
HIGH-MASS WALL EQUIVALENT *R*-VALUES
INSULATION PLACED ON THE INTERIOR OF THE WALL

WOOD FRAMED WALL *R*-VALUE[a]	EQUIVALENT HIGH-MASS WALL *R*-VALUE					
	HDD 0-1,999	HDD 2,000-3,999	HDD 4,000-5,499	HDD 5,500-6,499	HDD 6,500-8,499	HDD ≥ 8,500
R-11	R-10	R-10	R-11	R-11	R-12	R-12
R-13	R-11	R-11	R-12	R-12	R-14	R-14
R-14	R-12	R-12	R-12	R-12	R-15	R-15
R-15	R-13	R-13	R-13	R-13	R-15	R-15
R-16	R-13	R-13	R-13	R-14	R-15	R-15
R-17	R-14	R-14	R-14	R-15	R-16	R-16
R-18	R-15	R-15	R-15	R-15	R-16	R-16
R-19	R-16	R-16	R-16	R-19	R-19	R-19
R-20	R-16	R-16	R-16	R-20	R-20	R-20
R-21	R-17	R-17	R-17	R-21	R-21	R-21
R-22	R-17	R-17	R-17	R-21	R-21	R-21
R-23	R-18	R-18	R-18	R-22	R-22	R-22
R-24	R-19	R-19	R-19	R-22	R-22	R-22
R-25	R-20	R-20	R-20	R-22	R-22	R-22
R-26	R-21	R-21	R-21	R-23	R-23	R-23

a. As required by Section 502.2.4 and the tabular entry for "Exterior wall *R*-value" shown in Tables 502.2.4(1) through 502.2.4(9), as applicable.

502.2.5 Prescriptive path for additions and window replacements. As an alternative to demonstrating compliance with Section 402 or 502.2, additions with a conditioned floor area less than 500 square feet (46.5 m^2) to existing single-family residential buildings and structures shall meet the prescriptive envelope component criteria in Table 502.2.5 for the designated heating degree days (HDD) applicable to the location. The *U*-factor of each individual fenestration product (windows, doors and skylights) shall be used to calculate an area-weighted average fenestration product *U*-factor for the addition, which shall not exceed the applicable listed values in Table 502.2.5. For additions, the total area of fenestration products shall not exceed 40 percent of the gross wall and roof area of the addition. The *R*-values for opaque thermal envelope components shall be equal to or greater than the applicable listed values in Table 502.2.5. Replacement fenestration products (where the entire unit, including the frame, sash and glazing, is replaced) shall meet the prescriptive fenestration *U*-factor criteria in Table 502.2.5 for the designated HDD applicable to the location. Fenestration products used in additions and as replacement windows in accordance with this section shall also meet the requirements of Section 502.1.5 in locations with HDD less than 3,500.

Exception: Replacement skylights shall have a maximum *U*-factor of 0.50 when installed in any location above 1,999 HDD.

TABLE 502.2.5
PRESCRIPTIVE ENVELOPE COMPONENT CRITERIA ADDITIONS TO AND REPLACEMENT WINDOWS FOR EXISTING TYPE A-1 RESIDENTIAL BUILDINGS

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Fenestration *U*-factor	Ceiling *R*-value[a]	Wall *R*-value	Floor *R*-value	Basement wall *R*-value[b]	Slab perimeter *R*-value and depth[c]	Crawl space wall *R*-value[d]
0 - 1,999	0.75	R-26	R-13	R-11	R-5	R-0	R-5
2,000 - 3,999	0.5	R-30	R-13	R-19	R-8	R-5, 2 ft.	R-10
4,000 - 5,999	0.4	R-38	R-18	R-21	R-10	R-9, 2 ft.	R-19
6,000 - 8,499	0.35	R-49	R-21	R-21	R-11	R-13, 4 ft.	R-20
8,500 - 12,999	0.35	R-49	R-21	R-21	R-19	R-18, 4 ft.	R-20

For SI: 1 foot = 304.8 mm.

a. "Ceiling *R*-value" shall be required for flat or inclined (cathedral) ceilings. Floors over outside air shall meet "Ceiling *R*-value" requirements.

b. Basement wall insulation shall be installed in accordance with Section 502.2.1.6.

c. Slab perimeter insulation shall be installed in accordance with Section 502.2.1.4. An additional R-2 shall be added to "Slab perimeter *R*-value" in the table if the slab is heated.

d. "Crawl space wall *R*-value" shall apply to unventilated crawl spaces only. Crawl space insulation shall be installed in accordance with Section 502.2.1.5.

SECTION 503
BUILDING MECHANICAL SYSTEMS AND EQUIPMENT

503.1 General. This section covers mechanical systems and equipment used to provide heating, ventilating and air-conditioning functions. This section assumes that residential buildings and dwelling units therein will be designed with individual HVAC systems. Where equipment not shown in Table 503.2 is specified, it shall meet the provisions of Section 403 of ASHRAE/IESNA *Energy Code for Commercial and High-Rise Residential Buildings.*

503.2 Mechanical equipment efficiency. Equipment shown in Table 503.2 shall meet the specified minimum performance. Data furnished by the equipment supplier, or certified under a nationally recognized certification procedure, shall be used to satisfy these requirements. All such equipment shall be installed in accordance with the manufacturer's instructions.

503.3 HVAC systems. HVAC systems shall meet the criteria set forth in Sections 503.3.1 through 503.3.3.

[M] 503.3.1 [Comm 63.0503 (1)] Load calculations. Heating load calculations shall be determined in accordance with s. Comm 63.1023.

503.3.2 Temperature and humidity controls. Temperature and humidity controls shall be provided in accordance with Sections 503.3.2.1 through 503.3.2.4.

503.3.2.1 System controls. Each dwelling unit shall be considered a zone and be provided with thermostatic controls responding to temperature within the dwelling unit. Each heating and cooling system shall include at least one temperature control device.

TABLE 503.2
MINIMUM EQUIPMENT PERFORMANCE

EQUIPMENT CATEGORY	SUB-CATEGORY[e]	REFERENCED STANDARD	MINIMUM PERFORMANCE
Air-cooled heat pumps heating mode < 65,000 Btu/h cooling capacity	Split systems	ARI 210/240	6.8 HSPF [a,b]
	Single package		6.6 HSPF [a,b]
Gas-fired or oil-fired furnace < 225,000 Btu/h	—	DOE 10 CFR Part 430, Subpart B, Appendix N	AFUE 78%[b] E_t 80%[c]
Gas-fired or oil-fired steam and hot-water boilers < 300,000 Btu/h	—	DOE 10 CFR Part 430, Subpart B, Appendix N	AFUE 80%[b,d]
Air-cooled air conditioners and heat pumps cooling mode < 65,000 Btu/h cooling capacity	Split systems	ARI 210/240	10.0 SEER[b]
	Single package		9.7 SEER[b]

For SI: 1 Btu/h = 0.2931 W.

a. For multicapacity equipment, the minimum performance shall apply to each capacity step provided. Multicapacity refers to manufacturer-published ratings for more than one capacity mode allowed by the product's controls.

b. This is used to be consistent with the National Appliance Energy Conservation Act (NAECA) of 1987 (Public Law 100-12).

c. These requirements apply to combination units not covered by NAECA (three-phase power or cooling capacity 65,000 Btu/h).

d. Except for gas-fired steam boilers for which the minimum AFUE shall be 75 percent.

e. Seasonal rating.

503.3.2.2 Thermostatic control capabilities. Where used to control comfort heating, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors down to 55°F (13°C) or lower.

Where used to control comfort cooling, thermostatic controls shall be capable of being set locally or remotely by adjustment or selection of sensors up to 85°F (29°C) or higher.

Where used to control both comfort heating and cooling, thermostatic controls shall be capable of providing a temperature range or deadband of at least 5°F (Δ3°C) within which the supply of heating and cooling energy is shut off or reduced to a minimum.

Exceptions:

1. Special occupancy or special usage conditions approved by the code official.
2. Thermostats that require manual changeover between heating and cooling modes.

503.3.2.3 Heat pump auxiliary heat. Heat pumps having supplementary electric resistance heaters shall have controls that prevent heater operation when the heating load is capable of being met by the heat pump. Supplemental heater operation is not allowed except during outdoor coil defrost cycles not exceeding 15 minutes.

503.3.2.4 Humidistat. Humidistats used for comfort purposes shall be capable of being set to prevent the use of fossil fuel or electricity to reduce relative humidity below 60 percent or increase relative humidity above 30 percent.

503.3.3 Distribution system, construction and insulation. Distribution systems shall be constructed and insulated in accordance with Sections 503.3.3.1 through 503.3.3.7.

503.3.3.1 [Comm 63.0503 (2) (a)] Piping insulation. All system piping shall be thermally insulated in accordance with s. Comm 63.1029 (1) and (2).

503.3.3.2 Other insulation thicknesses. Insulation thicknesses in Table 503.3.3.1 are based on insulation having thermal resistivity in the range of 4.0 to 4.6 h · ft² · °F/Btu/inch (0.704 to 0.810 m² · K/W per 25 mm) of thickness on a flat surface at a mean temperature of 75°F (24°C).

Minimum insulation thickness shall be increased for materials having values less than 4.0, or shall be permitted to be reduced for materials having thermal resistivity values greater than 4.6 in accordance with Equation 5-9.

$$\frac{4.6 \times \text{Table 503.3.3.1 Thickness}}{\text{Actual Resistivity}} = \text{New Minimum Thickness} \quad \textbf{(Equation 5-9)}$$

TABLE 503.3.3.1
MINIMUM PIPE INSULATION
(thickness in inches)

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGE, °F	PIPE SIZES[a]					
		Runouts up to 2"[b]	1" and less	1.25" to 2"	2.5" to 4"	5" to 6"	8" and larger
HEATING SYSTEMS							
Steam and hot water:							
High pressure/temperature	306-450	1 1/2	2 1/2	2 1/2	3	3 1/2	3 1/2
Medium pressure/temperature	251-305	1 1/2	2	2 1/2	2 1/2	3	3
Low pressure/temperature	201-250	1	1 1/2	1 1/2	2	2	2
Low temperature	120-200	1/2	1	1	1 1/2	1 1/2	1 1/2
Steam condensate (for feed water)	Any	1	1	1 1/2	2	2	2
COOLING SYSTEMS							
Chilled water, refrigerant and brine:	40-55	1/2	1/2	3/4	1	1	1
	Below 40	1	1	1 1/2	1 1/2	1 1/2	1 1/2

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, °C = [(°F)-32]/1.8.

a. For piping exposed to outdoor air, increase insulation thickness by 0.5 inch.

b. Runouts not exceeding 12 feet in length to individual terminal units.

For materials with thermal resistivity values less than 4.0, the minimum insulation thickness shall be permitted to be increased in accordance with Equation 5-10.

$$\frac{4.0 \times \text{Table 503.3.3.1 Thickness}}{\text{Actual Resistivity}} = \text{New Minimum Thickness}$$

(Equation 5-10)

503.3.3.3 [Comm 63.0503 (2) (b)] Duct and plenum insulation. Duct and plenum insulation shall be provided in accordance with s. Comm 63.0803 (2) (f).

[M] 503.3.3.4 Duct construction. Ductwork shall be constructed and erected in accordance with the *International Mechanical Code.*

503.3.3.4.1 High- and medium-pressure duct systems. High-pressure and medium-pressure ducts shall be leak tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage not to exceed the maximum rate specified in that standard.

503.3.3.4.2 [Comm 63.0503 (2) (c)] Low-pressure duct systems. Low-pressure duct systems shall comply with all of the following:

1. Sections of supply and return ducts not located entirely within the conditioned space, and the unconditioned side of enclosed stud bays or joist cavities or spaces that are used to transport air shall be sealed.
2. Sealing shall be accomplished using welds, gaskets, mastics, mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's instructions.
3. Insulation that provides a continuous air barrier may be used in lieu of sealing metal ducts.
4. Tapes and mastics used with rigid fibrous glass ducts shall be listed and labeled as complying with UL 181A.
5. Tapes and mastics used with flexible air ducts shall be listed and labeled as complying with UL 181B.
6. Tapes with rubber-based adhesives may not be used.

Note: Standard duct tape has a rubber-based adhesive and does not comply with the requirements under this section.

Exception: Continuously welded and locking-type longitudinal joints and seams on ducts operating at static pressures less than 2 inches w.g. (500 Pa) pressure classification.

TABLE 503.3.3.3
MINIMUM DUCT INSULATION[a]

DUCT LOCATION	COOLING[b]		HEATING[c]	
	Annual cooling degree days	Insulation *R*-value[g] (h· ft² · °F)/Btu	Annual heating degree days	Insulation *R*-value[g] (h· ft² · °F)/Btu
Exterior of building	Below 500	3.3	Below 1,500	3.3
	500 to 1,150	5.0	1,500 to 4,500	5.0
	1,151 to 2,000	6.5	4,501 to 7,500	6.5
	Above 2,000	8.0	Above 7,500	8.0
In unconditioned spaces[d]				
TD[e] ≤ 15	—	None required	—	None required
40 ≥ TD[e] > 15	—	3.3	—	3.3
TD[e] > 40	—	5.0[f]	—	5.0[f]

For SI: 1 foot = 304.8 mm, °C = [(°F)-32] = 1.8, 1 (h · ft² · °F)/Btu = 0.176 (m² · K)/W.

a. Insulation *R*-values shown are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and condensation. Where control of condensation is required, additional insulation, vapor retarders, or both, shall be provided to limit vapor transmission and condensation. For ducts that are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of this section.

b. Cooling ducts are those designed to convey mechanically cooled air or return ducts in such systems.

c. Heating ducts are those designed to convey mechanically heated air or return ducts in such systems.

d. Unconditioned spaces include ventilated crawl spaces, ventilated attics, and framed cavities in those floor, wall and ceiling assemblies which (a) separate conditioned space from unconditioned space or outside air, and (b) are uninsulated on the side facing away from conditioned space.

e. TD is defined as the temperature difference at design conditions between the space within which the duct is located and the design air temperature in the duct.

f. Insulation resistance for runouts to terminal devices less than 10 feet in length is not required to exceed 3.3 ((h·ft² ·°F)/Btu.

g. Insulation resistance measured on a horizontal plane in accordance with ASTM C 518, at a mean temperature of 75°F at the installed thickness.

503.3.3.4.3 [Comm 63.0503 (2) (d)] Sealing required. High- and medium-pressure ducts shall be sealed in accordance with s. Comm 63.1029 (4).

503.3.3.5 [Comm 63.0503 (2) (e)] Mechanical ventilation. Each mechanical ventilation system (supply or exhaust, or both) shall be equipped with a readily accessible switch or other means for shutoff, or volume reduction and shutoff, when ventilation is not required. Automatic or gravity dampers that close when the system is not operating shall be provided for outdoor air exhausts. Motorized dampers that close when the system is not operating shall be provided on all outdoor air intakes.

503.3.3.6 Transport energy. The air-transport factor for each all-air system shall be not less than 5.5 when calculated in accordance with Equation 5-11. Energy for transfer of air through heat-recovery devices shall not be included in determining the air transport factor.

$$\text{Transport Factor} = \frac{\text{Space Sensible Heat Removal}^a}{\text{Supply + Return Fan(s) Power Input}^a}$$

(Equation 5-11)

a. Expressed in consistent units, either Btu/h or watts.

For purposes of these calculations, space sensible heat removal is equivalent to the maximum coincident design sensible cooling load of all spaces served for which the system provides cooling. Fan power input is the rate of energy delivered to the fan prime mover.

Air and water, all-water and unitary systems employing chilled, hot, dual-temperature or condenser water-transport systems to space terminals shall not require greater transport energy (including central and terminal fan power and pump power) than an equivalent all-air system providing the same space sensible heat removal and having an air-transport factor of not less than 5.5.

503.3.3.7 [Comm 63.0503 (2) (f)] Balancing. Balancing and documentation of the HVAC system shall conform to the IMC.

SECTION 504
SERVICE WATER HEATING

504.1 Scope. The purpose of this section is to provide criteria for design and equipment selection that will produce energy savings when applied to service water heating. Water supplies to ice-making machines and refrigerators shall be taken from a cold-water line of the water distribution system.

504.2 Water heaters, storage tanks and boilers. Water heaters, storage tanks and boilers shall meet the performance criteria set forth in Sections 504.2.1 and 504.2.2.

504.2.1 Performance efficiency. Water heaters and hot water storage tanks shall meet the minimum performance of water-heating equipment specified in Table 504.2. Where multiple criteria are listed, all criteria shall be met.

Exception: Storage water heaters and hot water storage tanks having more than 140 gallons (530 L) of storage capacity need not meet the standby loss (*SL*) or heat loss (*HL*) requirements of Table 504.2 if the tank surface area is thermally insulated to R-12.5 and if a standing pilot light is not used.

504.2.2 Combination service water-heating/space-heating boilers. Service water-heating equipment shall not be dependent on year-round operation of space-heating boilers; that is, boilers that have as another function winter space heating.

Exceptions:

1. Deleted.
2. For systems where the use of a single heating unit will lead to energy savings, such unit shall be utilized.

504.3 Deleted.

504.3.1 - 504.3.3 Deleted.

504.4 Pump operation. Circulating hot water systems shall be arranged so that the circulation pump(s) can be conveniently turned off, automatically or manually, when the hot water system is not in operation.

504.5 [Comm 63.504 (2)] Pipe insulation. Pipe insulation shall be provided in accordance with s. Comm 63.1029 (1) and (2).

504.6 Conservation of hot water. Hot water shall be conserved in accordance with Section 504.6.1.

504.6.1 Showers. Shower heads shall have a maximum flow rate of 2.5 gallons per minute (gpm) (0.158 L/s) at a pressure of 80 pounds per square inch (psi) (551 kPa) when tested in accordance with ASME A112.18.1.

TABLE 504.5
MINIMUM PIPE INSULATION
(thickness in inches)

SERVICE WATER-HEATING TEMPERATURES (°F)	PIPE SIZES[a]			
	Noncirculating runouts	Circulating mains and runouts		
	Up to 1″	Up to 1.25″	1.5″ to 2″	Over 2″
170-180	0.5	1.0	1.5	2.0
140-169	0.5	0.5	1.0	1.5
100-139	0.5	0.5	0.5	1.0

For SI: 1 inch = 25.4 mm, °C = [(°F)-32]/1.8,
1 Btu/h/inch · ft² · °F = 0.144 W/(m · K).

a. Nominal iron pipe size and insulation thickness. Conductivity, $k \cong 0.27$

504.7 Heat traps. Water heaters with vertical pipe risers shall have a heat trap on both the inlet and outlet of the water heater unless the water heater has an integral heat trap or is part of a circulating system.

TABLE 504.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

CATEGORY	TYPE	FUEL	INPUT RATING	V_T[a] (gallons)	INPUT TO V_T RATIO (Btuh/gal)	TEST METHOD	ENERGY FACTOR[b]	THERMAL EFFICIENCY E_t (percent)	STANDBY LOSS (percent/hour)[a]
NAECA-covered water-heating equipment[c]	All	Electric	≤ 12kW	All[e]	—	Note f	≥ 0.93-0.00132V*	—	—
	Storage	Gas	≤ 75,000 Btu/h	All[e]	—	Note f	≥ 0.62-0.0019V*	—	—
	Instantaneous	Gas	≤ 200,000Btu/h[e]	All	—	Note f	≥ 0.62-0.0019V*	—	—
	Storage	Oil	≤ 105,000 Btu/h	All	—	Note f	≥ 0.59-0.0019V*	—	—
	Instantaneous	Oil	≤ 210,000 Btu/h	All	—	Note f	≥ 0.59-0.0019V*	—	—
	Pool heater	Gas/oil	All	All	—	Note g	—	≥ 78%	—
Other water-heating equipment[d]	Storage	Electric	All	All	—	Note h	—	—	≤ 0.30+27/V_T*
	Storage/ instantaneous	Gas/oil	≤ 155,000 Btu/h	All	< 4,000	Note h	—	≥ 78%	≤ 1.3+114/V_T*
			> 155,000 Btu/h	All	< 4,000	Note h	—	≥ 78%	≤ 1.3+95/V_T*
				< 10	≥ 4,000	Note h	—	≥ 80%	—
				≥ 10	≥ 4,000			≥ 77%	≤ 2. 3+67/V_T*
Unfired storage tanks	—	—	—	All	—	—	—	—	≤ 6.5Btuh/ft^{2i}*

For SI: 1 Btu/ft^2 = 3.155 W/m^2, 1 Btu/h = 0.2931 W, 1 gallon = 3.785 L, °C = [(°F)-32]/1.8.

a. V_T is the storage volume in gallons as measured during the standby loss test. For the purpose of estimating the standby loss requirement using the rated volume shown on the rating plate, V_T should be no less than 0.95V for gas and oil water heaters and no less than 0.90V for electric water heaters.

b. V is rated storage volume in gallons as specified by the manufacturer.

c. Consistent with National Appliance Energy Conservation Act (NAECA) of 1987.

d. All except those water heaters covered by NAECA.

e. DOE CFR 10; Part 430, Subpart B, Appendix E applies to electric and gas storage water heaters with rated volumes 20 gallons and gas instantaneous water heaters with input ratings of 50,000 to 200,000 Btu/h.

f. DOE CFR 10; Part 430, Subpart B, Appendix E.

g. ANSI Z21.56.

h. ANSI Z21.10.3. When testing an electric storage water heater for standby loss using the test procedure of Section 2.9 of ANSI Z21.10.3, the electrical supply voltage shall be maintained within ± 1 percent of the center of the voltage range specified on the water heater nameplate. Also, when needed for calculations, the thermal efficiency (E_t) shall be 98 percent. When testing an oil water heater using the test procedures of Sections 2.8 and 2.9 of ANSI Z21.10.3, the following modifications will be made: A vertical length of the flue pipe shall be connected to the flue gas outlet of sufficient height to establish the minimum draft specified in the manufacturer's installation instructions. All measurements of oil consumption will be taken by instruments with an accuracy of ± 1 percent or better. The burner shall be adjusted to achieve an hourly Btu input rate within ± 2 percent of the manufacturer's specified input rate with the CO_2 reading as specified by the manufacturer with smoke no greater than 1 and the fuel pump pressure within ± 1percent of the manufacturer's specification.

i. Heat loss of tank surface area (Btu/h · ft^2) based on 80°F water-air temperature difference.

* Minimum efficiencies marked with an asterisk are established by preemptive federal law and are printed for the convenience of the user.

SECTION 505
ELECTRICAL POWER AND LIGHTING

505.1 Electrical energy consumption. In Type A-2 residential buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

505.2 [Comm 63.0505] Lighting power budget. Lighting systems shall comply with ss. Comm 63.1040 to 63.1053.

CHAPTER 6

SIMPLIFIED PRESCRIPTIVE REQUIREMENTS FOR RESIDENTIAL BUILDINGS, TYPE A-1 AND A-2

SECTION 601 GENERAL

601.1 Scope. This chapter sets forth energy-efficiency-related requirements for the design and construction of Type A-1 and A-2 residential buildings.

Exception: Portions of the building envelope that do not enclose conditioned space.

601.2 Compliance. Compliance shall be demonstrated in accordance with Section 601.2.1 or 601.2.2.

601.2.1 Residential buildings, Type A-1. Compliance for Type A-1 residential buildings shall be demonstrated by either:

1. Meeting the requirements of this chapter for buildings with a glazing area that does not exceed 15 percent of the gross area of exterior walls; or
2. Meeting the requirements of Chapter 4, or Chapter 5 for Type A-1 residential buildings.

601.2.2 Residential buildings, Type A-2. Compliance for Type A-2 residential buildings shall be demonstrated by either:

1. Meeting the requirements of this chapter for buildings with a glazing area that does not exceed 25 percent of the gross area of exterior walls; or
2. Meeting the requirements of Chapter 4, or Chapter 5 for Type A-2 residential buildings.

601.3 Materials and equipment. Materials and equipment shall be identified in a manner that will allow a determination of their compliance with the applicable provisions of this chapter. Materials and equipment used to conform to the applicable provisions of this chapter shall be installed in accordance with the manufacturer's installation instructions.

601.3.1 Insulation. The thermal resistance (*R*-value) shall be indicated on all insulation and the insulation installed such that the *R*-value can be verified during inspection, or a certification of the installed *R*-value shall be provided at the job site by the insulation installer. Where blown-in or sprayed insulation is applied in walls, the installer shall provide a certification of the installed density and *R*-value. Where blown-in or sprayed insulation is applied in the roof/ceiling assembly, the installer shall provide a certification of the initial installed thickness, settled thickness, coverage area, and number of bags of insulating material installed. Markers shall be provided for every 300 square feet (28 m^2) of area, attached to the trusses, rafters, or joists, and indicate in 1-inch-high (25 mm) numbers the installed thickness of the insulation.

601.3.2 Fenestration. The *U*-factor of fenestration shall be determined in accordance with NFRC 100 by an accredited, independent laboratory, and labeled and certified by the manufacturer. The solar heat gain coefficient (SHGC) of fenestration shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer.

601.3.2.1 Default fenestration performance. Where a manufacturer has not determined a fenestration product's *U*-factor in accordance with NFRC 100, compliance shall be determined by assigning such products a default *U*-factor from Tables 102.5.2(1) and 102.5.2(2). When a manufacturer has not determined a fenestration product's SHGC in accordance with NFRC 200, compliance shall be determined by assigning such products a default SHGC from Table 102.5.2(3).

601.3.2.2 Air leakage. The air leakage of prefabricated fenestration shall be determined in accordance with AAMA/WDMA 101/I.S.2 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Alternatively, the manufacturer shall certify that the fenestration is installed in accordance with Section 502.1.4.

601.3.3 Maintenance. Where mechanical or plumbing system components require preventive maintenance for efficient operation, regular maintenance requirements shall be clearly stated and affixed to the component, or the source for such information shall be shown on a label attached to the component.

SECTION 602 BUILDING ENVELOPE

602.1 Thermal performance criteria. The minimum required insulation *R*-value or maximum required *U*-factor for each element in the building thermal envelope (fenestration, roof/ceiling, opaque wall, floor, slab edge, crawl space wall, and basement wall) shall be in accordance with the criteria in Table 602.1.

Type A-1 residential buildings, with greater than 15-percent glazing area; Type A-2 residential buildings, with greater than 25-percent glazing area; and any residential building in climates with heating degree days (HDD) equal to or greater than 13,000; shall determine compliance using the building envelope requirements of Chapter 4 or Chapter 5.

602.1.1 Exterior walls. The sum of the *R*-values of the insulation materials installed in framing cavities and insulating sheathing (where used) shall meet or exceed the minimum required "Wall *R*-value" in Table 602.1. Framing, drywall, structural sheathing, or exterior siding materials shall not be considered as contributing, in any way, to the thermal performance of exterior walls. Insulation separated from the

TABLE 602.1
SIMPLIFIED PRESCRIPTIVE BUILDING ENVELOPE THERMAL COMPONENT CRITERIA
MINIMUM REQUIRED THERMAL PERFORMANCE (*U*-FACTOR AND *R*-VALUE)

	MAXIMUM	MINIMUM					
HEATING DEGREE DAYS	Glazing *U*-factor	Ceiling *R*-value	Wall *R*-value	Floor *R*-value	Basement wall *R*-value	Slab perimeter *R*-value and depth	Crawl space wall *R*-value
0-499	Any	R-13	R-11	R-11	R-0	R-0	R-0
500-999	0.90	R-19	R-11	R-11	R-0	R-0	R-4
1,000-1,499	0.75	R-19	R-11	R-11	R-0	R-0	R-5
1,500-1,999	0.75	R-26	R-13	R-11	R-5	R-0	R-5
2,000-2,499	0.65	R-30	R-13	R-11	R-5	R-0	R-6
2,500-2,999	0.60	R-30	R-13	R-19	R-6	R-4, 2 ft.	R-7
3,000-3,499	0.55	R-30	R-13	R-19	R-7	R-4, 2ft.	R-8
3,500-3,999	0.50	R-30	R-13	R-19	R-8	R-5, 2 ft.	R-10
4,000-4,499	0.45	R-38	R-13	R-19	R-8	R-5, 2 ft.	R-11
4,500-4,999	0.45	R-38	R-16	R-19	R-9	R-6, 2 ft.	R-17
5,000-5,499	0.45	R-38	R-18	R-19	R-9	R-6, 2 ft.	R-17
5,500-5,999	0.40	R-38	R-18	R-21	R-10	R-9, 4 ft.	R-19
6,000-6,499	0.35	R-38	R-18	R-21	R-10	R-9, 4 ft.	R-20
6,500-6,999	0.35	R-49	R-21	R-21	R-11	R-11, 4 ft.	R-20
7,000-8,499	0.35	R-49	R-21	R-21	R-11	R-13, 4 ft.	R-20
8,500-8,999	0.35	R-49	R-21	R-21	R-18	R-14, 4 ft.	R-20
9,000-12,999	0.35	R-49	R-21	R-21	R-19	R-18, 4 ft.	R-20

For SI: 1 foot = 304.8 mm.

conditioned space by a vented space shall not be counted towards the required *R*-value.

602.1.1.1 Mass walls. Mass walls shall be permitted to meet the criteria in Table 602.1.1.1(1) based on the insulation position and the climate zone where the building is located. Other mass walls shall meet the frame wall criteria for the building type and the climate zone where the building is located, based on the sum of interior and exterior insulation. Walls with "exterior insulation" position have the entire effective mass layer interior to an insulation layer. Walls with "integral insulation" position have either insulation and mass materials well mixed as in wood (logs); or substantially equal amounts of mass material on the interior and exterior of insulation as in concrete masonry units with insulated cores or masonry cavity walls. Walls with interior insulation position have the mass material located exterior to the insulating material(s). Walls not meeting the above descriptions for exterior or integral positions shall meet the requirements for "other mass walls" in Table 602.1.1.1(1). The *R*-value of the mass assembly for typical masonry construction shall be taken from Table 602.1.1.1(2). The mass assembly *R*-value for a solid concrete wall with a thickness of 4 inches or greater is R-1.1. *R*-values for other assemblies are permitted to be based on the hot box tests referenced in ASTM C 236 or ASTM C 976, two-dimensional calculations or isothermal plane calculations.

602.1.1.2 Steel-frame walls. The minimum required *R*-values for steel-frame walls shall be in accordance with Table 602.1.1.2.

TABLE 602.1.1.2
STEEL-FRAME WALL MINIMUM PERFORMANCE REQUIREMENTS (*R*-VALUE)

HDD	EQUIVALENT STEEL-FRAME WALL CAVITY AND SHEATHING *R*-VALUE[a]
0-1,999	R-11+R-5, R-15+R-4, R-21+R-3
2,000-3,999	R-11+R-5, R-15+R-4, R-21+R-3
4,000-5,999	R-11+R-9, R-15+R-8, R-21+R-7
6,000-8,499	R-13+R-10, R-19+R-9, R-25+R-8
8,500-12,999	R-13+R-10, R-19+R-9, R-25+R-8

a. The cavity insulation *R*-value requirement is listed first, followed by the sheathing *R*-value requirement.

602.1.2 Ceilings. The required "Ceiling *R*-value" in Table 602.1 assumes standard truss or rafter construction, and shall apply to all roof/ceiling portions of the building thermal envelope, including cathedral ceilings. Where the construction technique allows the required *R*-value of ceiling insulation to be obtained over the exterior wall top plate, R-30 shall be permitted to be used where R-38 is required in the table, and R-38 shall be permitted to be used where R-49 is required.

TABLE 602.1.1.1(1)
MASS WALL PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS

MASS WALL ASSEMBLY *R*-VALUE[a]			
Building Location		Exterior or Integral Insulation	Other Mass Walls
Zone	HDD	Residential Buildings Type A-1 or A-2	Residential Buildings Type A-1or A-2
1	0-499	R-3.8	R-9.7
2	500-999	R-4.8	R-9.7
3	1,000-1,499	R-4.8	R-9.7
4	1,500-1,999	R-8.1	R-10.8
5	2,000-2,499	R-8.9	R-10.8
6	2,500-2,999	R-8.9	R-10.8
7	3,000-3,499	R-8.9	R-10.8
8	3,500-3,999	R-8.9	R-10.8
9	4,000-4,499	R-8.9	R-10.9
10	4,500-4,999	R-10.4	R-12.3
11	5,000-5,499	R-11.9	R-15.2
12	5,500-5,999	R-11.9	R-15.2
13	6,000-6,499	R-11.9	R-15.2
14	6,500-6,999	R-15.5	R-18.4
15	7,000-8,499	R-15.5	R-18.4
16	8,500-8,999	R-18.4	R-18.4
17	9,000-12,999	R-18.4	R-18.4

a. The sum of the value in Table 602.1.1.1(2) and additional insulation layers.

TABLE 602.1.1.1(2)
MASS ASSEMBLY *R*-VALUES

ASSEMBLY TYPE	UNGROUTED CELLS, NOT INSULATED	UNGROUTED CELLS INSULATED		
		No grout	Vertical cells grouted at 10′ O. C. or greater	Vertical cells grouted at less than 10′ O.C.
6″ Lightweight concrete block	2.3	5.0	4.5	3.8
6″ Medium-weight concrete block	2.1	4.2	3.8	3.2
6″ Normal-weight concrete block	1.9	3.3	3.1	2.7
8″ Lightweight concrete block	2.6	6.7	5.9	4.8
8″ Medium-weight concrete block	2.3	5.3	4.8	4.0
8″ Normal-weight concrete block	2.1	4.2	3.8	3.3
12″ Lightweight concrete block	2.9	9.1	7.9	6.3
12″ Medium-weight concrete block	2.6	7.1	6.4	5.2
12″ Normal-weight concrete block	2.3	5.6	5.1	4.3
Brick cavity wall	3.7	6.7	6.2	5.4
Hollow clay brick	2.0	2.7	2.6	2.4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

602.1.3 Opaque doors. Opaque doors in the building envelope shall have a maximum *U*-factor of 0.35. One opaque door shall be exempt from this *U*-factor requirement.

602.1.4 [Comm 63.0602 (1)] Floor. The required *R*-value in Table 602.1 shall apply to all floors.

602.1.5 Basement walls. Where the basement is considered a conditioned space, the basement shall be insulated in accordance with Table 602.1. Where the basement is not considered a conditioned space, either the basement wall or the ceiling(s) separating the basement from conditioned space shall be insulated in accordance with Table 602.1. Where basement walls are required to be insulated, the required *R*-value shall be applied from the top of the basement wall to a depth of 10 feet (3048 mm) below grade or to the top of the basement floor, whichever is less.

602.1.6 Slab-on-grade floors. For slabs with a top edge 12 inches (305 mm) or less below finished grade, the required "Slab perimeter *R*-value and depth" in Table 602.1 shall be applied to the outside of the foundation or the inside of the foundation wall. The insulation shall extend downward from the top of the slab or downward from the top of the slab to the bottom of the slab and then horizontally to the interior or exterior, until the distance listed in Table 602.1 is reached.

Where installed between the exterior wall and the edge of the interior slab, the top edge of the insulation shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Insulation extending horizontally outside of the foundation shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil.

In locations of 500 HDD or greater, R-2 shall be added to the "Slab perimeter *R*-value" in Table 602.1 where uninsulated hot water pipes, air distribution ducts, or electric heating cables are installed within or under the slab.

Exception: Slab perimeter insulation is not required for unheated slabs in areas of very heavy termite infestation probability as shown in Figure 502.2(7). Where this exception is used, building envelope compliance shall be demonstrated by (a) using Section 502.2.2 or Chapter 4 with the actual "Slab perimeter *R*-value and depth" in Table 602.1, or (b) using Section 502.2.4.

602.1.7 Crawl space walls. Where the floor above the crawl space is uninsulated, insulation shall be installed on crawl space walls when the crawl space is not vented to outside air. The required "Crawl space wall *R*-value" in Table 602.1 shall be applied inside of the crawl space wall, downward from the sill plate to the exterior finished grade level and then vertically or horizontally or both for 24 inches (610 mm). The exposed earth in all crawl space foundations shall be covered with a continuous vapor retarder having a maximum permeance rating of 1.0 perm (5.72×10^{-8} g/Pa · s · m^2), when tested in accordance with ASTM E 96.

602.1.8 Masonry veneer. For exterior foundation insulation, the horizontal portion of the foundation which supports a masonry veneer is not required to be insulated.

602.1.9 Protection. Exposed insulating materials applied to the exterior of foundation walls shall have a rigid, opaque and weather-resistant protective covering. The protective covering shall extend 6 inches (152 mm) below finished grade level.

602.1.10 Caulking, sealants and gasketing. All joints, seams, penetrations (site-built windows, doors, and skylights), openings between window and door assemblies and their respective jambs and framing, and other sources of air leakage (infiltration and exfiltration) through the building envelope shall be caulked, gasketed, weatherstripped, wrapped, or otherwise sealed to limit uncontrolled air movement.

Comm 63.0602 (2) Additional caulking, sealants and gasketing requirements. When installed in the building envelope, recessed lighting fixtures shall comply with IECC Section 502.1.3.

602.2 Maximum solar heat gain coefficient for fenestration products. In locations with heating degree days (HDD) less than 3,500, the area-weighted-average solar heat gain coefficient (SHGC) for glazed fenestration installed in the building envelope shall not exceed 0.40.

602.3 Fenestration exemption. Up to 1 percent of the total glazing area shall be exempt from the "Glazing *U*-factor" requirement in Table 602.1.

602.4 Replacement fenestration. Where an entire fenestration product, including frame, sash, and glazed portion, is being replaced, the replacement fenestration product shall have a *U*-factor that does not exceed the "Fenestration *U*-factor" requirement in Table 502.2.5 applicable to the climate zone (HDD) where the building is located. The replacement fenestration product(s) must also satisfy the air leakage requirements and SHGC of Sections 601.3.2.2 and 602.2, respectively.

Exception: Replacement skylights shall have a maximum *U*-factor of 0.50 when installed in any location above 1,999 HDD.

SECTION 603
MECHANICAL SYSTEMS

603.1 Heating and air-conditioning equipment and appliances. Heating and air-conditioning equipment and appliances shall comply with the applicable requirements of Section 503.

SECTION 604
SERVICE WATER HEATING

604.1 Water-heating equipment and appliances. Water-heating equipment and appliances shall comply with the applicable requirements of Section 504.

CHAPTER 7

BUILDING DESIGN FOR ALL COMMERCIAL BUILDINGS

SECTION 701
SCOPE

701.1 [Comm 63.0701] General. Commercial buildings shall meet the requirements of subch. III of Comm 63 or they shall comply with the requirements specified in IECC Chapter 8.