2010 Oregon Energy Efficiency Specialty Code

Based on the 2009 International Energy Conservation Code®

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PREFACE

Introduction

Internationally, code officials recognize the need for a modern, up-to-date energy conservation code addressing the design of energy-efficient building envelopes and installation of energy efficient mechanical, lighting and power systems through requirements emphasizing performance. The *International Energy Conservation Code*®, in this 2009 edition, is designed to meet these needs through model code regulations that will result in the optimal utilization of fossil fuel and nondepletable resources in all communities, large and small.

This comprehensive energy conservation code establishes minimum regulations for energy efficient buildings using prescriptive and performance-related provisions. It is founded on broad-based principles that make possible the use of new materials and new energy efficient designs. This 2009 edition is fully compatible with all the *International Codes*® (I-Codes®) published by the International Code Council (ICC)®, including: the *International Building Code*®, *International Existing Building Code*®, *International Fire Code*®, *International Fuel Gas Code*®, *International Mechanical Code*®, ICC *Performance Code*®, *International Plumbing Code*®, *International Private Sewage Disposal Code*®, *International Property Maintenance Code*®, *International Residential Code*®, *International Wildland-Urban Interface Code*™ and *International Zoning Code*®.

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

Development

The first edition of the *International Energy Conservation Code* (1998) was based on the 1995 edition of the *Model Energy Code* promulgated by the Council of American Building Officials (CABO) and included changes approved through the CABO Code Development Procedures through 1997. CABO assigned all rights and responsibilities to the International Code Council and its three statutory members at that time, including Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO) and Southern Building Code Congress International (SBCCI). This 2009 edition presents the code as originally issued, with changes reflected in the 2000, 2003 and 2006 editions and further changes approved through the ICC Code Development Process through 2008. A new edition such as this is promulgated every three years.

This code is founded on principles intended to establish provisions consistent with the scope of an energy conservation code that adequately conserves energy; provisions that do not unnecessarily increase construction costs; provisions that do not restrict the use of new materials, products or methods of construction; and provisions that do not give preferential treatment to particular types or classes of materials, products or methods of construction.

Adoption

The *International Energy Conservation Code* is available for adoption and use by jurisdictions internationally. Its use within a governmental jurisdiction is intended to be accomplished through adoption by reference in accordance with proceedings establishing the jurisdiction's laws. At the time of adoption, jurisdictions should insert the appropriate information in provisions requiring specific local information, such as the name of the adopting jurisdiction. These locations are shown in bracketed words in small capital letters in the code and in the sample ordinance. The sample adoption ordinance on page vii addresses several key elements of a code adoption ordinance, including the information required for insertion into the code text.

Maintenance

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

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

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

Marginal Markings

➡ = Indicates where a paragraph or item has been deleted.

> = Indicates IBC model code language deleted by Oregon.

| = Indicates a technical change from the requirements of the ICC 2006 edition.

|| = Indicates a State of Oregon amendment has been made to the International Code.

Minor changes, such as section renumbering and removal of references to International Codes are not indicated with a double rule in the margin.

Italicized Terms

Selected terms set forth in Chapter 2, Definitions, are italicized where they appear in code text. Such terms are not italicized where the definition set forth in Chapter 2 does not impart the intended meaning in the use of the term. The terms selected have definitions which the user should read carefully to facilitate better understanding of the code.

Effective Use of the International Energy Conservation Code

The *International Energy Conservation Code* (IECC) is a model code that regulates minimum energy conservation requirements for new buildings. The IECC addresses energy conservation requirements for all aspects of energy uses in both commercial and residential construction, including heating and ventilating, lighting, water heating, and power usage for appliances and building systems.

The IECC is a design document. For example, before one constructs a building, the designer must determine the minimum insulation *R*-values and fenestration *U*-factors for the building exterior envelope. Depending on whether the building is for residential use or for commercial use, the IECC sets forth minimum requirements for exterior envelope insulation, window and door *U*-factors and SHGC ratings, duct insulation, lighting and power efficiency, and water distribution insulation.

Arrangement and Format of the 2009 IECC

Before applying the requirements of the IECC it is beneficial to understand its arrangement and format. The IECC, like other codes published by ICC, is arranged and organized to follow sequential steps that generally occur during a plan review or inspection. The IECC is divided into five different parts:

Chapters	Subjects
1–2	Administration and definitions
3	Climate zones and general materials requirements
4	Energy efficiency for residential buildings
5	Energy efficiency for commercial buildings
6	Referenced standards

The following is a chapter-by-chapter synopsis of the scope and intent of the provisions of the *International Energy Conservation Code*:

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

Chapter 2 Definitions. All terms that are defined in the code are listed alphabetically in Chapter 2. While a defined term may be used in one chapter or another, the meaning provided in Chapter 2 is applicable throughout the code.

Additional definitions regarding climate zones are found in Tables 301.3(1) and (2). These are not listed in Chapter 2.

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

Guidance regarding tense, gender and plurality of defined terms as well as guidance regarding terms not defined in this code is provided.

Chapter 3 Climate Zones. Chapter 3 specifies the climate zones that will serve to establish the exterior design conditions. In addition, Chapter 3 provides interior design conditions that are used as a basis for assumptions in heating and cooling load calculations, and provides basic material requirements for insulation materials and fenestration materials.

Climate has a major impact on the energy use of most buildings. The code establishes many requirements such as wall and roof insulation *R*-values, window and door thermal transmittance requirement (*U*-factors) as well as provisions that affect the mechanical systems based upon the climate where the building is located. This chapter will contain the information that will be used to properly assign the building location into the correct climate zone and will then be used as the basis for establishing requirements or elimination of requirements.

Chapter 4 Residential Energy Efficiency. Chapter 4 contains the energy-efficiency-related requirements for the design and construction of residential buildings regulated under this code. It should be noted that the definition of a *residential building* in this code is unique for this code. In this code, a *residential building* is an R-2, R-3 or R-4 building three stories or less in height. All other buildings, including residential buildings greater than three stories in height, are regulated by the energy conservation requirements of Chapter 5. The applicable portions of a residential building must comply with the provisions within this chapter for energy effi-

ciency. This chapter defines requirements for the portions of the building and building systems that impact energy use in new residential construction and promotes the effective use of energy. The provisions within the chapter promote energy efficiency in the building envelope, the heating and cooling system and the service water heating system of the building.

Chapter 5 Commercial Energy Efficiency. Chapter 5 contains the energy-efficiency-related requirements for the design and construction of most types of commercial buildings and residential buildings greater than three stories in height above grade. Residential buildings, townhouses and garden apartments three stories or less in height are covered in Chapter 4. Like Chapter 4, this chapter defines requirements for the portions of the building and building systems that impact energy use in new commercial construction and new residential construction greater than three stories in height, and promotes the effective use of energy. The provisions within the chapter promote energy efficiency in the building envelope, the heating and cooling system and the service water heating system of the building.

Chapter 6 Referenced Standards. The code contains numerous references to standards that are used to regulate materials and methods of construction. Chapter 6 contains a comprehensive list of all standards that are referenced in the code. The standards are part of the code to the extent of the reference to the standard. Compliance with the referenced standard is necessary for compliance with this code. By providing specifically adopted standards, the construction and installation requirements necessary for compliance with the code can be readily determined. The basis for code compliance is, therefore, established and available on an equal basis to the code official, contractor, designer and owner.

Chapter 6 is organized in a manner that makes it easy to locate specific standards. It lists all of the referenced standards, alphabetically, by acronym of the promulgating agency of the standard. Each agency's standards are then listed in either alphabetical or numeric order based upon the standard identification. The list also contains the title of the standard; the edition (date) of the standard referenced; any addenda included as part of the ICC adoption; and the section or sections of this code that reference the standard.

ORDINANCE

The International Codes are designed and promulgated to be adopted by reference by ordinance. Jurisdictions wishing to adopt the 2009 *International Energy Conservation Code* as an enforceable regulation governing energy efficient building envelopes and installation of energy efficient mechanical, lighting and power systems should ensure that certain factual information is included in the adopting ordinance at the time adoption is being considered by the appropriate governmental body. The following sample adoption ordinance addresses several key elements of a code adoption ordinance, including the information required for insertion into the code text.

SAMPLE ORDINANCE FOR ADOPTION OF THE *INTERNATIONAL ENERGY CONSERVATION CODE* ORDINANCE NO._____

An ordinance of the **[JURISDICTION]** adopting the 2009 edition of the *International Energy Conservation Code*, regulating and governing energy efficient building envelopes and installation of energy efficient mechanical, lighting and power systems in the **[JURISDICTION]**; providing for the issuance of permits and collection of fees therefor; repealing Ordinance No. _____ of the **[JURISDICTION]** and all other ordinances and parts of the ordinances in conflict therewith.

The **[GOVERNING BODY]** of the **[JURISDICTION]** does ordain as follows:

Section 1.That a certain document, three (3) copies of which are on file in the office of the **[TITLE OF JURISDICTION'S KEEPER OF RECORDS]** of **[NAME OF JURISDICTION]**, being marked and designated as the *International Energy Conservation Code*, 2009 edition, as published by the International Code Council, be and is hereby adopted as the Energy Conservation Code of the **[JURISDICTION]**, in the State of **[STATE NAME]** for regulating and governing energy efficient building envelopes and installation of energy efficient mechanical, lighting and power systems as herein provided; providing for the issuance of permits and collection of fees therefor; and each and all of the regulations, provisions, penalties, conditions and terms of said Energy Conservation Code on file in the office of the **[JURISDICTION]** are hereby referred to, adopted, and made a part hereof, as if fully set out in this ordinance, with the additions, insertions, deletions and changes, if any, prescribed in Section 2 of this ordinance.

Section 2.The following sections are hereby revised:

Section 101.1. Insert: **[NAME OF JURISDICTION]**.

Section 108.4. Insert: **[DOLLAR AMOUNT]** in two places.

Section 3.That Ordinance No. _____ of **[JURISDICTION]** entitled **[FILL IN HERE THE COMPLETE TITLE OF THE ORDINANCE OR ORDINANCES IN EFFECT AT THE PRESENT TIME SO THAT THEY WILL BE REPEALED BY DEFINITE MENTION]** and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

Section 4.That if any section, subsection, sentence, clause or phrase of this ordinance is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this ordinance. The **[GOVERNING BODY]** hereby declares that it would have passed this ordinance, and each section, subsection, clause or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses and phrases be declared unconstitutional.

Section 5.That nothing in this ordinance or in the Energy Conservation Code hereby adopted shall be construed to affect any suit or proceeding impending in any court, or any rights acquired, or liability incurred, or any cause or causes of action acquired or existing, under any act or ordinance hereby repealed as cited in Section 3 of this ordinance; nor shall any just or legal right or remedy of any character be lost, impaired or affected by this ordinance.

Section 6.That the **[JURISDICTION'S KEEPER OF RECORDS]** is hereby ordered and directed to cause this ordinance to be published. (An additional provision may be required to direct the number of times the ordinance is to be published and to specify that it is to be in a newspaper in general circulation. Posting may also be required.)

Section 7.That this ordinance and the rules, regulations, provisions, requirements, orders and matters established and adopted hereby shall take effect and be in full force and effect **[TIME PERIOD]** from and after the date of its final passage and adoption.

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CHAPTER 1
ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION 101
SCOPE AND GENERAL REQUIREMENTS

101.1 Title. This code shall be known as the *Oregon Energy Efficiency Specialty Code*, and may be cited as such. It is referred to herein as "this code."

101.2 Scope. This code applies to *residential* and *commercial buildings* designed and constructed under the *Oregon Structural Specialty Code*.

101.3 Intent. This code shall regulate the design and construction of buildings for the effective use of energy. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve the effective use of energy. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

101.4 Applicability. Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general require-ment and a specific requirement, the specific requirement shall govern.

101.4.1 Existing buildings. Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing building or building system lawfully in existence at the time of adoption of this code.

101.4.2 Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply. Additions, alterations, renovations or repairs shall not create an unsafe or hazardous condition or overload existing building systems. An addition shall be deemed to comply with this code if the addition alone complies or if the existing building and addition comply with this code as a single building.

Exception: The following need not comply provided the energy use of the building is not increased:

1. Storm windows installed over existing fenestration.
2. When 25 percent or less of the glazing in any one wall is being replaced, it may be replaced with glazing that has a *U*-factor and SHGC equal or better than the existing glazing.
3. Glass only replacements in an existing sash and frame.
4. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.
5. Construction where the existing roof, wall or floor cavity is not exposed.
6. Reroofing for roofs where neither the sheathing nor the insulation is exposed. Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either above or below the sheathing.
7. Replacement of existing doors that separate *conditioned space* from the exterior shall not require the installation of a vestibule or revolving door, provided, however, that an existing vestibule that separates a *conditioned space* from the exterior shall not be removed,
8. Alterations that replace less than 10 percent of the luminaires or 10 fixtures in a space, provided that such alterations do not increase the installed interior lighting power.
9. Alterations that replace only the bulb and ballast within up to 50 percent of the existing luminaires in a space provided that the alteration does not increase the installed interior lighting power. Alterations do not include routine maintenance and repair.

101.4.3 Change in space conditioning. Any nonconditioned space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.

101.4.4 Mixed occupancy. Where a building includes both *residential* and *commercial* occupancies, each occupancy shall be separately considered and meet the applicable provisions of Chapter 4 for *residential* and Chapter 5 for *commercial*.

101.4.5 Historic buildings. See Section 3407 of the *Building Code*.

101.5 Compliance. *Residential buildings* shall meet the provisions of Chapter 4. *Commercial buildings* shall meet the provisions of Chapter 5.

101.5.1 Low energy buildings. The following buildings, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this code shall be exempt from the *building thermal envelope* provisions of this code:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h · ft^2 (10.7 W/m^2) or 1.0 watt/ft^2 (10.7 W/m^2) of floor area for space conditioning purposes.
2. Those that do not contain *conditioned space.*

SECTION 102
ALTERNATE MATERIALS—METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS

102.1 General. This code is not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been *approved* by the *code official* as meeting the intent of this code.

PART 2—ADMINISTRATION AND ENFORCEMENT

This code is administered and enforced under the provisions and authority granted in Chapter 1 of the *Building Code.*

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CHAPTER 2
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SECTION 201
GENERAL

201.1 Scope. Unless stated otherwise, the following words and terms in this code shall 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 includes the singular.

201.3 Terms defined in other codes. Terms that are not defined in this code but are defined in the *Building Code, Fire Code, Fuel Gas Code, Mechanical Code, Plumbing Code* or the *Residential Code* shall have the meanings ascribed to them in those codes.

201.4 Terms not defined. Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies. Words of common usage are given their plain, natural and ordinary meanings. Words that have well-defined legal meanings are given those meanings.

SECTION 202
GENERAL DEFINITIONS

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

ACCESSIBLE. Admitting close approach as a result of not being guarded by locked doors, elevation or other effective means (see "Readily *accessible*").

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

AFUE (Annual Fuel Utilization Efficiency). The energy output divided by the energy input, calculated on an annual basis and including part load and cycling effects. AFUE ratings shall be determined using the U.S. Department of Energy test procedures (10 CFR Part 430) and listings in the Gas Appliance Manufacturers Association (GAMA) *Consumer Directory of Certified Furnace and Boiler Efficiency Ratings*.

AIR BARRIER. Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.

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

APPROVED. Approval by the code official as a result of investigation and tests conducted by him or her, or by reason of accepted principles or tests by nationally recognized organizations.

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

BASEMENT WALL. A wall 50 percent or more below gradeand enclosing *conditioned space*.

BTU (British Thermal Unit). The amount of heat required to raise the temperature of 1 pound (0.454 kg) of water (about 1 pint) from 59ºF to 60ºF (15ºC to 16ºC).

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

BUILDING CODE. For the purpose of this code shall mean the *Oregon Structural Specialty Code* (OSSC) as adopted by OAR 918-460-0010.

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

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

C-FACTOR (THERMAL CONDUCTANCE). The coefficient of heat transmission (surface to surface) through a building component or assembly, equal to the time rate of heat flow per unit area and the unit temperature difference between the warm side and cold side surfaces (Btu/h ft^2 x °F) [W/(m^2 x K)].

CODE OFFICIAL. See "Building Official."

COMMERCIAL BUILDING. For this code, all buildings that are not included in the definition of "Residential buildings."

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the *conditioned space*.

CONDITIONED SPACE. An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent *conditioned space*.

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

CURTAIN WALL. Fenestration products used to create an external nonload-bearing wall that is designed to separate the exterior and interior environments.

DAYLIGHT ZONE.

1. **Under skylights.** The area under skylights whose hori-zontal dimension, in each direction, is equal to the

skylight dimension in that direction plus either 70 percent of the floor-to-ceiling height or the dimension to a ceiling height opaque partition, or one-half the distance to adjacent skylights or vertical fenestration, whichever is least.

2. **Adjacent to vertical fenestration.** The area adjacent to vertical fenestration which receives daylight through the fenestration. For purposes of this definition , the daylight *zone* depth is assumed to extend into the space a distance equal to the window head height or to the nearest ceiling height opaque partition, whichever is less. The daylight *zone* width is assumed to be the width of the window plus 2 feet (610 mm) on each side, or the window width plus the distance to an opaque partition, or the window width plus one-half the distance to adjacent skylight or vertical fenestration, whichever is least.

DEMAND CONTROLED VENTILATION (DCV). A ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

DEMISING ELEMENT. A building element consisting of walls, windows, doors, floors or ceilings that separates conditioned space from unconditioned space(s).

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 transmis-sion of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

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

ECONOMIZER, AIR. A duct and damper arrangement and automatic control system that allows a cooling system to supply outside air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

ECONOMIZER, WATER. A system where the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling.

EER (ENERGY EFFICIENCY RATIO). EER is calculated by dividing the cooling capacity in Btu per hour (Btu/hr) by the power input in watts at any given set of rating conditions, expressed in Btu/hr per watt.

ELECTRICAL CODE. For the purpose of this code, electrical code shall mean the *Oregon Electrical Specialty Code* (OESC) as adopted by OAR 918-305-0100.

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

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

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

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

ENTRANCE DOOR. Fenestration products used for ingress, egress and access in nonresidential buildings, including, but not limited to, exterior entrances that utilize latching hardware and automatic closers and contain over 50-percent glass specifically designed to withstand heavy use and possibly abuse.

EXTERIOR WALL. Walls including both above-grade walls and basement walls.

FAN BRAKE HORSEPOWER (BHP). The horsepower delivered to the fan's shaft. Brake horsepower does not include the mechanical drive losses (belts, gears, etc.).

FAN SYSTEM BHP. The sum of the fan brake horsepower of all fans that are required to operate at fan system design conditions to supply air from the heating or cooling source to the *conditioned space(s)* and return it to the source or exhaust it to the outdoors.

FAN SYSTEM DESIGN CONDITIONS. Operating conditions that can be expected to occur during normal system operation that result in the highest supply fan airflow rate to conditioned spaces served by the system.

FAN SYSTEM MOTOR NAMEPLATE HP. The sum of the motor nameplate horsepower of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the *conditioned space(s)* and return it to the source or exhaust it to the outdoors.

FENESTRATION. Skylights, roof windows, vertical windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors. Fenestration includes products with glass and nonglass glazing materials.

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

FUEL GAS CODE. For the purpose of this code, fuel gas code shall mean the *Oregon Mechanical Specialty Code* (OMSC) as adopted by OAR 918-440-0010.

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

HEATED SLAB. Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab.

HIGH-EFFICACY LAMPS. Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

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

HSPF (HEATING SEASONAL PERFORMANCE FACTOR). The total heating output of a heat pump during its normal annual usage period for heating divided by the total electric power input in watt-hours during the same period.

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

HVAC (HEATING, VENTILATING AND AIR-CONDITIONING) SYSTEM. The equipment, distribution network, and terminals that provide either collectively or individually the heating, ventilating, and/or air-conditioning processes to a building.

IPLV (INTEGRATED PART LOAD VALUE). A single number figure 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.

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

INSULATING SHEATHING. An insulating board with a core material having a minimum *R*-value of R-2.

LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

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

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

LUMINAIRE. A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps and to connect the lamps to their power supply. Many luminaires include one or more ballasts.

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

MECHANICAL CODE. For the purpose of this code, mechanical code shall mean the *Oregon Mechanical Specialty Code* (OMSC) as adopted by OAR 918-440-0010.

NAMEPLATE HORSEPOWER. The nominal motor horse power rating stamped on the motor nameplate.

PACKAGED TERMINAL AIR CONDITIONER. A factory-selected combination of heating and cooling components, assemblies or sections, intended to serve a room or zone.

PLUMBING CODE. For the purpose of this code, plumbing code shall mean the *Oregon Plumbing Specialty Code* (OPSC) as adopted by OAR 918-750-0110.

PROPOSED DESIGN. A description of the proposed building used to estimate annual energy use for determining compli-ance based on total building performance.

READILY ACCESSIBLE. Capable of being reached quickly for operation, renewal or inspection without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders or access equipment (see *"Accessible"*).

REPAIR. The reconstruction or renewal of any part of an existing building.

RESIDENTIAL BUILDING. For this code, includes R-3 buildings, as well as R-2 and R-4 buildings three stories or less in height above grade.

RESIDENTIAL CODE. For the purpose of this code, residential code shall mean the *Oregon Residential Specialty Code* (ORSC) as adopted by OAR 918-480-0005.

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

***R*-VALUE (THERMAL RESISTANCE).** The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area ($h \cdot ft^2 \cdot °F/Btu$) [$(m^2 \cdot K)/W$].

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

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

SKYLIGHT. Glass or other transparent or translucent glazing material installed at a slope of 15 degrees (0.26 rad) or more from vertical. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition.

SLEEPING UNIT. A room or space in which people sleep, which can also include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also part of a dwelling unit are not *sleeping units*.

SOLAR HEAT GAIN COEFFICIENT (SHGC). The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation which is then reradiated, conducted or convected into the space.

STANDARD REFERENCE DESIGN. A version of the *proposed design* that meets the minimum requirements of this code and is used to determine the maximum annual energy use requirement for compliance based on total building performance.

STOREFRONT. A nonresidential system of doors and windows mulled as a composite fenestration structure that has been designed to resist heavy use. *Storefront* systems include, but are not limited to, exterior fenestration systems that span from the floor level or above to the ceiling of the same story on commercial buildings.

SUNROOM. A one-story structure attached to a structure with a glazing area in excess of 40 percent of the gross area of the structure's exterior walls and roof.

THERMAL ISOLATION. Physical and space conditioning separation from *conditioned space(s)*. The *conditioned space(s)* shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.

THERMOSTAT. An automatic control device used to maintain temperature at a fixed or adjustable set point.

U-FACTOR (THERMAL TRANSMITTANCE). The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h · ft^2 · °F) [W/(m^2 · K)].

VAULTED CEILING. In a residential building, a ceiling with a minimum pitch of 2 in 12.

VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

VENTILATION AIR. That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

ZONE. A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.

CHAPTER 3
CLIMATE ZONES

SECTION 301
CLIMATE ZONES

301.1 General. Climate *zones* from Figure 301.1 or Table 301.1 shall be used in determining the applicable requirements from Chapters 4 and 5.

TABLE 301.1
CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY COUNTY

OREGON	
Climate Zone 4C	**Climate Zone 5B**
Benton	Baker
Clackamas	Crook
Clatsop	Deschutes
Columbia	Gilliam
Coos	Grant
Curry	Harney
Douglas	Hood River
Jackson	Jefferson
Josephine	Klamath
Lane	Lake
Lincoln	Malheur
Linn	Morrow
Marion	Sherman
Multnomah	Umatilla
Polk	Union
Tillamook	Wallowa
Washington	Wasco
Yamhill	Wheeler

Key: B - Dry, C - Marine.

SECTION 302
DESIGN CONDITIONS

302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

SECTION 303
MATERIALS, SYSTEMS AND EQUIPMENT

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

303.1.1 Building thermal envelope insulation. An *R*-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and R-value of insulation installed in each element of the *building thermal envelope.* For blown or sprayed insulation (fiberglass and cellulose), the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be *listed* on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and *R*-value of installed thickness shall be *listed* on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

303.1.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed at least one for every 300 square feet (28 m^2) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed *R*-value shall be *listed* on certification provided by the insulation installer.

303.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable upon inspection.

303.1.3 Fenestration product rating. *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 or be determined using the commercial size category values listed in Chapter 15 of the 2009 ASHRAE *Handbook of Fundamentals*, Table No.4 and shall include the effects of the window frame. 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 or be determined using the Solar Heat Gain Coefficients (SHGC) in Chapter 15 of the 2009 ASHRAE *Handbook of Fundamentals*, Table No.10. The overall values shall consider type of frame material and operator for the SHGC at normal incidence.

303.1.3.1 Certification and labeling. Windows shall be certified and labeled in accordance with Section 303.1.3. Windows shall have a temporary label not to be removed prior to inspection.

Exception: Site-built windows shall have a single certificate specifying glazing type, special coatings, spacers, gas fills, center-of-glass and overall *U*-factor, and center-of-glass SHGC for every type of site built glass used. These certificates shall be maintained on the job site and made available to the inspector.

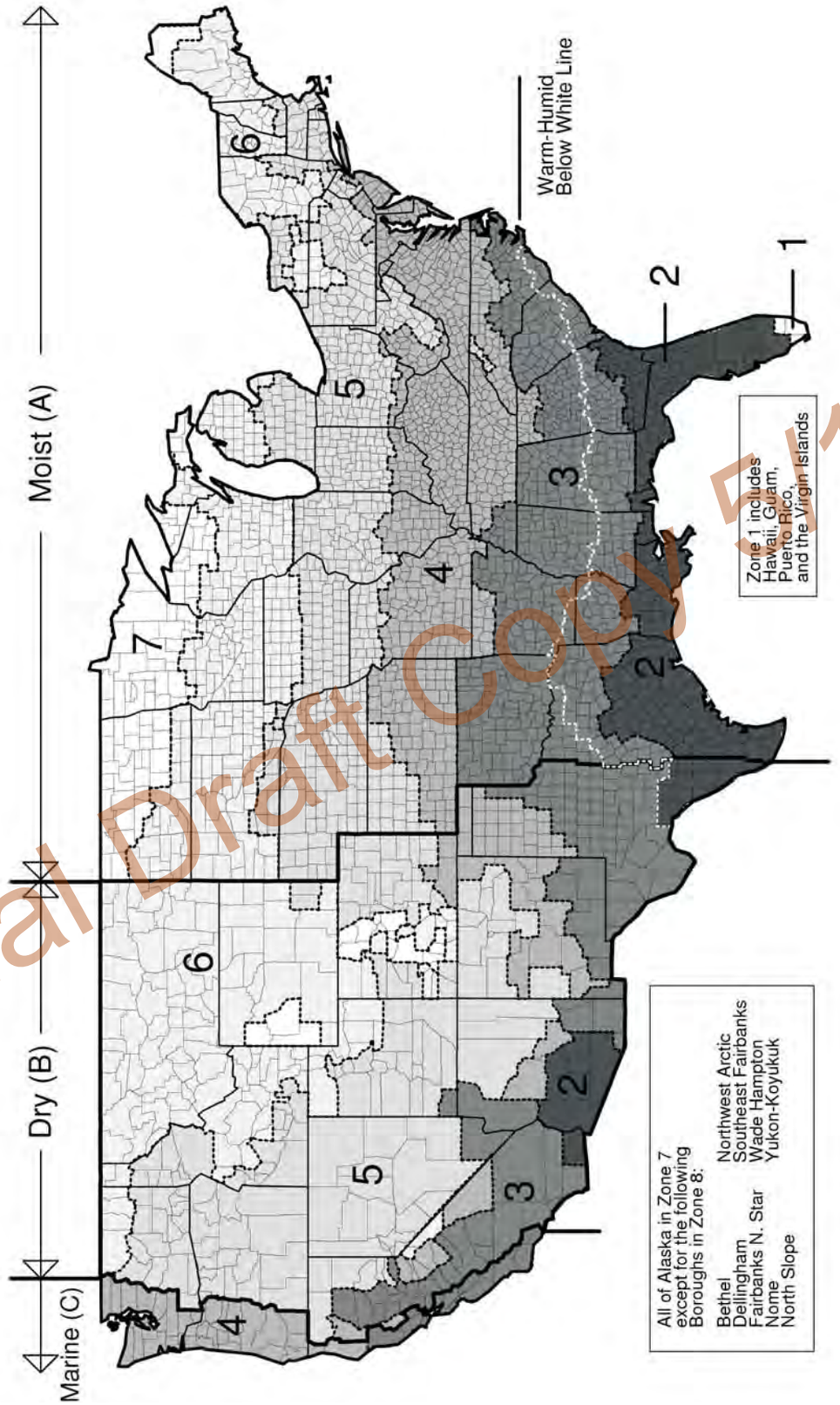

FIGURE 301.1
CLIMATE ZONES

>

303.1.4 Insulation product rating. The thermal resistance (R-value) of insulation shall be determined in accordance with the U.S. Federal Trade Commission R-value rule (CFR Title 16, Part 460, May 31, 2005) in units of $h \times ft^2 \times °F/Btu$ at a mean temperature of 75°F (24°C).

303.2 Installation. All materials, systems and equipment shall be installed in accordance with the manufacturer's installation instructions and the *Building Code*.

303.2.1 Protection of exposed foundation insulation. Insulation applied to the exterior of basement walls, crawl-space walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend a minimum of 6 inches (153 mm) below grade.

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

CHAPTER 4
RESIDENTIAL ENERGY

PART I—ENERGY CONSERVATION

SECTION 401
SCOPE

401.1 General. The provisions of this chapter regulate the exterior envelope, as well as, the design, construction and selection of heating, ventilating and air-conditioning systems, lighting and piping insulation, required for the purpose of effective conservation of energy within a building or structure governed by this code.

All conditioned spaces within residential buildings shall comply with Table 401.1(1) and one additional measure from Table 401.1(2).

401.2 Application to existing buildings. Alteration and repairs, historic buildings, and change of use or occupancy to buildings, structures or portions thereof shall comply with the requirements in Sections 401.2.1 through 401.2.3.

401.2.1 Alteration and repair. Alterations and repairs affecting energy conservation measures shall conform to the requirements specified in this chapter.

Alterations or repairs which affect components of existing conditioned spaces regulated in this chapter shall comply with this chapter.

Exception: The minimum component requirements as specified in Note d of Table 404.1(2) may be used to the maximum extent practical.

401.2.2 Historic buildings. The building official may modify the specific requirements of this chapter for historic buildings and require in lieu thereof alternative requirements that will result in a reasonable degree of energy efficiency. This modification may be allowed for those buildings specifically designated as historically significant by the state historic preservation office(r) or by official action the local government.

401.2.3 Change of occupancy or use. Definition of "Change of use" for purposes of Section 401.2.3 is a change of use in an existing residential building and shall include any of the following; any unconditioned spaces such as an attached garage, basement, porch, or canopy that are to become conditioned spaces; any unconditioned, inhabitable space that is to become conditioned space, such as a large attic.

401.2.3.1 Change of use. A building that changes use, without any changes to the components regulated in this chapter, are required to comply with the minimum component requirements as specified in Note d of Table 404.1(2) to the greatest extent practical.

401.2.3.2 Change of occupancy. Alteration and repair of nonresidential buildings, such as a small church or school, that change the occupancy to residential may use the minimum component requirements as specified in Note d of Table 404.1(2) to the greatest extent practical.

Exception: The minimum component requirements may be disregarded when thermal performance calculations are completed for change of use to Group R occupancy.

401.3 Additions. Additions to existing buildings or structures may be made without making the entire building or structure comply, if the new additions comply with the requirements of this chapter.

401.4 Information on plans and specifications. Plans and specifications shall show in sufficient detail all pertinent data and features of the building and the equipment and systems as herein governed, including, but not limited to, exterior envelope component materials; *R*-values of insulating materials; HVAC equipment efficiency performance and system controls, lighting and other pertinent data to indicate conformance to the requirements of this chapter.

SECTION 402
DEFINITIONS

402.1 Definitions. See Section 202 of this code.

SECTION 403
ALTERNATIVE SYSTEMS

Alternative designs may be approved by the building official when it can be demonstrated that the proposed annual energy consumption will not exceed that of a similar building with similar forms of energy requirements designed in accordance with the provisions of this chapter. The only allowed trade-offs in this analysis are between building envelope components.

Proposed alternative designs submitted as requests for exception to the standard design criteria must be accompanied by an energy analysis prepared in accordance with criteria specified in Part II, Alternative Systems Analysis.

403.1 Design parameters. For calculations under this section, the following design parameters shall apply:

The outside temperature shall be taken from the 99 percent winter temperature values and the 1 percent summer temperature values listed in ASHRAE *Handbook of Fundamentals*. For areas not listed, the designer should obtain the most reliable design temperatures available. Selected values are subject to approval of the building official.

TABLE 401.1(1)
PRESCRIPTIVE ENVELOPE REQUIREMENTS[a]

BUILDING COMPONENT	STANDARD BASE CASE		LOG HOMES ONLY	
	Required Performance	Equivalent Value[b]	Required Performance	Equivalent Value[b]
Wall insulation—above grade	U-0.060	R-21[c]	Note d	Note d
Wall insulation—below grade[e]	F-0.565	R-15	F-0.565	R-15
Flat ceilings[f]	U-0.031	R-38	U-0.025	R-49
Vaulted ceilings[g]	U-0.042	R-38[g]	U-0.027	R-38A[h]
Underfloors	U-0.028	R-30	U-0.028	R-30
Slab edge perimeter	F-0.520	R-15	F-0.520	R-15
Heated slab interior[i]	n/a	R-10	n/a	R-10
Windows[j]	U-0.35	U-0.35	U-0.35	U-0.35
Window area limitation[j]	n/a	n/a	n/a	n/a
Skylights[k]	U-0.60	U-0.60	U-0.60	U-0.60
Exterior doors[l]	U-0.20	U-0.20	U-0.54	U-0.54
Exterior doors w/ > 2.5 ft^2 glazing[m]	U-0.40	U-0.40	U-0.40	U-0.40
Forced air duct insulation	n/a	R-8	n/a	R-8

For SI: 1 square foot = 0.0929m^2.

a. As allowed in Section 404.1, thermal performance of a component may be adjusted provided that overall heat loss does not exceed the total resulting from conformance to the required *U*-value standards. Calculations to document equivalent heat loss shall be performed using the procedure and approved *U*-values contained in Table 404.1(1).

b. *R*-values used in this table are nominal, for the insulation only in standard wood framed construction and not for the entire assembly.

c. Wall insulation requirements apply to all exterior wood framed, concrete or masonry walls that are above grade. This includes cripple walls and rim joist areas. R-19 Advanced Frame or 2 x 4 wall with rigid insulation may be substituted if total nominal insulation *R*-value is 18.5 or greater.

d. The wall component shall be a minimum solid log or timber wall thickness of 3.5 inches (90 mm).

e. Below-grade wood, concrete or masonry walls include all walls that are below grade and does not include those portions of such wall that extend more than 24 inches above grade.

f. Insulation levels for ceilings that have limited attic/rafter depth such as dormers, bay windows or similar architectural features totaling not more than 150 square feet (13.9 m^2) in area may be reduced to not less than R-21. When reduced, the cavity shall be filled (except for required ventilation spaces).

g. The maximum vaulted ceiling surface area shall not be greater than 50 percent of the total heated space floor area unless area has a *U*-factor no greater than U-0.031. The *U*-factor of 0.042 is representative of a vaulted scissor truss. A 10-inch (254 mm) deep rafter vaulted ceiling with R-30 insulation is U-0.033 and complies with this requirement, not to exceed 50 percent of the total heated space floor area.

h. A = advanced frame construction, which shall provide full required insulating value to the outside of exterior walls.

i. Heated slab interior applies to concrete slab floors (both on and below grade) that incorporate a radiant heating system within the slab. Insulation shall be installed underneath the entire slab.

j. Sliding glass doors shall comply with window performance requirements. Windows exempt from testing in accordance with Section 411.2, Item 3 shall comply with window performance requirements if constructed with thermal break aluminum or wood, or vinyl, or fiberglass frames and double-pane glazing with low-emissivity coatings of 0.10 or less.

k. Reduced window area may not be used as a trade-off criterion for thermal performance of any component.

l. Skylight area installed at 2 percent or less of total heated space floor area shall be deemed to satisfy this requirement with vinyl, wood, or thermally broken aluminum frames and double-pane glazing with low-emissivity coatings. Skylight *U*-factor is tested in the 20 degree (0.35 rad) overhead plane per NFRC standards.

m. A maximum of 28 square feet (2.6 m^2) of exterior door area per dwelling unit can have a *U*-factor of 0.54 or less.

n. Glazing that is either double pane with low-e coating on one surface, or triple pane shall be deemed to comply with this U-0.40 requirement.

TABLE 401.1(2)
ADDITIONAL MEASURES (select one)[a]

	MEASURE
1	High efficiency HVAC system: Gas-fired furnace or boiler with minimum AFUE of 90%[a], or Air-source heat pump with minimum HSPF of 8.5, or Closed-loop ground source heat pump with minimum COP of 3.0
2	High efficiency duct sealing: Certified performance tested duct systems[b] or All ducts and air handler are contained within building envelope[a]
3	High efficiency building envelope: Replace corresponding Table 401.1(1) components with all of the following: Wall insulation–above grade – U-0.047/R-24, and Vaulted ceilings – U-0.033/R-30A[c, d], and Flat ceilings – U-0.025/R-49, and Windows – U-0.32
4	Zonal electric, ductless furnace or ductless heat pumps: 75 percent of lamps in permanently installed lighting fixtures as CFL or linear fluorescent or a min efficacy of 40 lumens per watt, or Windows – U-0.32, or Flat ceilings – U-0.025/R-49 and vaulted ceilings – U-0.033/R-30A, or Exterior walls – U-0.047/R24
5	High efficiency ceilings & windows/lighting: Replace corresponding Table 401.1(1) components with all of the following: Vaulted ceilings – U-0.033/R-30A[c, d], and Flat ceilings – U-0.025/R-49, and Windows – U-0.32, and 75 percent of lamps in permanently installed lighting fixtures as CFL or linear fluorescent or a min efficacy of 40 lumens per watt
6	High efficiency ceilings & windows/water heating: Replace corresponding Table 401.1(1) components with all of the following: Vaulted ceilings – U-0.033 / R-30A[c, d], and Flat ceilings – U-0.025 / R-49, and Windows – U-0.32, and Natural gas/propane, on-demand water heating with min EF of 0.80
7	High efficiency water heating/lighting: Natural gas/propane, on-demand water heating with min EF of 0.80, and 75 percent of lamps in permanently installed lighting fixtures as CFL or linear fluorescent or a min. efficacy of 40 lumens per watt
8	Solar photovoltaic: Minimum 1 Watt/sq ft. conditioned floor space[e]
9	Solar water heating: Minimum of 40 ft^2 of gross collector area[f]

For SI: 1 square foot = 0.0929m^2.

a. Furnaces located within the building envelope shall have sealed combustion air installed. Combustion air shall be ducted directly from the outdoors.

b. Documentation of performance tested ductwork shall be submitted to the building official upon completion of work. This work shall be performed by a contractor that is certified by the Oregon Department of Energy's (ODOE) Residential Energy Tax Credit program and documentation shall be provided that work demonstrates conformance to ODOE duct performance standards.

c. A = advanced frame construction, which shall provide full required ceiling insulation value to the outside of exterior walls.

d. The maximum vaulted ceiling surface area shall not be greater than 50 percent of the total heated space floor area unless vaulted area has a U-factor no greater than U-0.026.

e. Solar electric system size shall include documentation indicating that total solar resource fraction is not less than 75 percent.

f. Solar water heating panels shall be Solar Rating and Certification Corporation (SRCC) Standard OG-300 certified and labeled, with documentation indicating that total solar resource fraction is not less than 75 percent.

SECTION 404
EXTERIOR ENVELOPE REQUIREMENTS

404.1 General. This section provides minimum requirements for exterior envelope construction.

Exterior building envelope shall comply with Table 401.1(1) or may be demonstrated using Table 404.1(1). The requirements specified in Table 401.1(2) shall apply to both Tables 401.1(1) and 404.1(1).

Buildings designed to incorporate passive solar elements may use Table 404.1(1) to demonstrate building envelope requirements of this code, in addition to requirements specified in Table 401.1(2)

404.2 Insulation materials. Insulation materials shall be installed per manufacturer's listing and specifications and this section. Insulation *R*-values shall be specified as required in 16 CFR Ch. I (1-1-91 Edition) Part 460—Labeling and Advertising of Home Insulation. Some general requirements for insulation are mentioned in the following subsections:

404.2.1 Loose-fill insulation. Blown, poured and spray-on type insulation complying with Section R316 of the *Oregon Residential Specialty Code* may be used in attic spaces where roof slope is 4 units vertical in 12 units horizontal (33.3 percent slope) or greater, and there is at least 44 inches (1118 mm) of headroom at the roof ridge. (Clear headroom is defined as the distance from the top of the bottom chord of the truss or ceiling joists to the underside of the roof sheathing.) Adequate baffling of the vent opening shall be provided so as to deflect the incoming air above the surface of the blown or poured insulation. Baffles shall be of weather-resistant, rigid material capable of retaining the insulation and shall be in place at the time of framing inspection.

404.2.2 Batt-type insulation. Batt-type insulation shall be installed flush against the warm side of the cavity insofar as practicable.

404.2.3 Insulation protection. Insulation exposed to the exterior shall be protected from physical and solar damage.

TABLE 404.1(1)
RESIDENTIAL THERMAL PERFORMANCE CALCULATIONS

BUILDING COMPONENTS[b]	STANDARD BASE CASE[a]			PROPOSED ALTERNATIVE			
	Areas[c]	*U-factor*	Areas x U	*R*-value[d]	Areas[c]	*U-factor*[e]	Areas x U
Flat ceilings Vaulted ceilings[f] Conventional wood-framed walls Underfloor Slab edge		0.031 0.042 0.060 0.028 (perimeter ft. =) F = 0.52[g]					
Windows Skylights < 2%[h] Skylights > 2%[h]		0.35 0.75 0.60					
Exterior doors[i] Doors with > 2.5 ft² glazing		0.20 0.40					
		CODE UA =				PROPOSED UA[J] =	

For SI: 1 square foot = 0.0929 m², 1 Btu/(hr · ft² · °F) = 5.6782 W/m² · K.

a. Base path 1 represents standard base case from Table 401.1(1).

b. Performance trade-offs are limited to those listed in column 1. Heat plant efficiency, duct insulation levels, passive and active solar heating, air infiltration and similar measures including those not regulated by code may not be considered in this method of calculation.

c. Areas from plan take-offs. All areas must be the same for both standard base case and proposed alternate. The vaulted ceiling surface area for standard base case must be the actual surface area from the plan take-off not to exceed 50 percent of the total heated space floor area. Any areas in excess of 50 percent for base case must be entered at U-0.031 (R-38) with "Flat Ceilings" area.

d. Minimum Component Requirements: Walls R-15; Floors R-21; Flat Ceilings R-38; Vaults R-21; Below-Grade Wood, Concrete or Masonry Walls R-15; Slab Edge R-10; Duct Insulation R-8. R-values used in this table are nominal, for the insulation only and not for the entire assembly. Window and skylight *U*-values shall not exceed 0.65 (CL65). Door *U*-values shall not exceed 0.54 (Nominal R-2). A maximum of 28 square feet (2.6 m²) of exterior door area per dwelling unit can have a *U*-factor of 0.54 or less and shall not be included in calculations.

e. *U*-values for wood frame ceilings, walls and floor assemblies shall be as specified in Table 404.1(2). *U*-values for other assemblies, which include steel framing, brick or other masonry, stucco, etc., shall be calculated using standard ASHRAE procedures.

f. Vaulted area, unless insulated to R-38, U-0.031, may not exceed 50 percent of the total heated space floor area.

g. F = The heat loss coefficient, Btu/hr./ft.²/°F per foot of perimeter.

h. Whenever skylight area for proposed alternative exceeds 2 percent of the total heated space floor area, enter 2 percent of area under standard base case at U-0.75 then the remaining area under Standard Base Case at U-0.60. For proposed alternative skylights, enter the actual skylight area and *U*-factor of those to be installed in residence.

i. A maximum of 28 square feet (2.6 m²) of exterior door area per dwelling unit can have a *U*-factor of 0.54 or less. Default *U*-factor for an unglazed wood door is 0.54.

j. Proposed UA must be less than or equal to Code UA.

TABLE 404.1(2)
APPROVED DEFAULT *U*-FACTORS

FLAT CEILINGS[a]		
Insulation	**Type**	***U*-Factor**
R-38	Conventional framing	0.031
R-38	= > 8/12 roof pitch	0.028
R-38	Advance framing[c]	0.026
R-49	Conventional framing	0.025
R-49	= > 8/12 roof pitch	0.024
R-49	Advance framing[c]	0.020
VAULTED CEILINGS [a]		
Insulation	**Type**	***U*-Factor**
R-21	Rafter framing	0.047
R-30	Rafter framing	0.033
R-38	Rafter framing	0.027
R-21	Scissors truss	0.055
R-30	Scissors truss	0.046
R-38	Scissors truss	0.042
R-49	Scissors truss	0.039
R-30	Advance scissors truss[c]	0.032
R-38	Advance scissors truss[c]	0.026
R-49	Advance scissors truss[c]	0.020
EPS FOAM CORE PANEL VAULTED CEILINGS		
Insulation	**Type**	***U*-Factor**
R-29	8-1/4" EPS foam core panel	0.037
R-37	10-1/4" EPS foam core panel	0.030
R-44	12-1/4" EPS foam core panel	0.025
FLOORS[a]		
Insulation	**Type**	***U*-Factor**
R-21	Underfloor	0.035
R-25	Underfloor	0.032
R-30	Underfloor	0.028
SLAB-ON-GRADE		
Insulation	**Type**	***F*-Factor[f]**
R-10	Slab edge	0.54
R-15	Slab edge	0.52
EPS FOAM CORE PANEL EXTERIOR WALLS		
Insulation	**Type**	***U*-Factor**
R-14.88	4-1/4" EPS foam core panel	0.065
R-22.58	6-1/4" EPS foam core panel	0.045
R-29.31	8-1/4" EPS foam core panel	0.035

EXTERIOR WALLS[a]			
Insulation	**Insulation Sheathing**	**Framing**	***U*-Factor**
R-15	0	Conventional framing	0.080
R-15	0	Intermediate framing[b]	0.075
R-19	0	Conventional framing	0.065
R-19	0	Intermediate framing[b]	0.063
R-19	0	Advance framing[d]	0.061
R-21	0	Conventional framing	0.060
R-21	0	Intermediate framing[b]	0.058
R-21	0	Advance framing[d]	0.055
R-11	3.5[e]	Conventional framing	0.069
R-11	5[e]	Conventional framing	0.063
R-11	7[e]	Conventional framing	0.055
R-11	3.5[e]	Advance framing[d]	0.067
R-11	5[e]	Advance framing[d]	0.061
R-11	7[e]	Advance framing[d]	0.054
R-13	3.5[e]	Conventional framing	0.064
R-13	5[e]	Conventional framing	0.058
R-13	7[e]	Conventional framing	0.052
R-13	3.5[e]	Advance framing[d]	0.062
R-13	5[e]	Advance framing[d]	0.056
R-13	7[e]	Advance framing[d]	0.050
R-15	3.5[e]	Conventional framing	0.060
R-15	5[e]	Conventional framing	0.055
R-15	7[e]	Conventional framing	0.049
R-15	3.5[e]	Advance framing[d]	0.057
R-15	5[e]	Advance framing[d]	0.052
R-15	7[e]	Advance framing[d]	0.047
R-19	3.5[e]	Conventional framing	0.052
R-19	5[e]	Conventional framing	0.047
R-19	7[e]	Conventional framing	0.043
R-19	3.5[e]	Advance framing[d]	0.049
R-19	5[e]	Advance framing[d]	0.045
R-19	7[e]	Advance framing[d]	0.041
R-21	5[e]	Conventional framing	0.044
R-21	7[e]	Conventional framing	0.040
R-21	3.5[e]	Advance framing[d]	0.044
R-21	5[e]	Advance framing[d]	0.042
R-21	7[e]	Advance framing[d]	0.038

For SI: 1 inch = 25.4 mm, 1 Btu/(hr · ft^2 · °F) = 5.6782 W/m^2 · K.

a. *U*-factors are for wood frame construction. *U*-factors for other assemblies which include steel framing, brick or other masonry, stucco, etc., shall be calculated using standard ASHRAE procedures.

b. Intermediate framing consists of wall studs placed at a minimum 16 inches on-center with insulated headers. Voids in headers shall be insulated with rigid insulation having a minimum *R*-value of 4 per one-inch (w/m^3-k) thickness.

c. Advanced framing construction for ceilings as defined in Section 404.6

d. Advanced framing construction for walls as defined in Section 404.5

e. Insulation sheathing shall be rigid insulation material, installed continuously over entire exterior or interior of wall (excluding partition walls).

f. *F*-Factor is heat loss coefficient in Btu/hr/°F per lineal foot of concrete slab perimeter.

404.2.4 Clearances. Recessed light fixtures shall not be installed in cavities intended to be insulated.

Exception: Fixtures designed and labeled as suitable for being installed in direct contact with insulation; i.e., insulation coverage (IC) rated.

Thermal insulation shall not be installed within 3 inches (76 mm) of any metal chimney or gas vent that is not listed for insulation clearances.

Thermal insulation shall not be installed in a manner that would obstruct openings required for attic ventilation.

A permanent sleeve of fine wire mesh screen, sheet metal or other noncombustible material shall be installed to maintain the required clearances.

Cellulose insulation shall conform to Interim Safety Standard for Cellulose Insulation (16 CFR Part 1209) issued by the Consumer Product Safety Commission July 6, 1979 (44FR 39938). For other insulation, see Section R320 of the *Residential Code*. Foam plastic shall be as specified in Section R318 of the *Residential Code*.

404.2.5 Below grade exterior insulation. Below grade exterior insulation shall meet the following conditions:

1. The insulation shall be a materials that is approved for below-grade applications in wet environments
2. Insulation shall be installed from the top of the footing to the top of the concrete basement wall.
3. Insulation shall be adequately protected from the elements (ultraviolet and mechanical) per manufacturer's specifications.
4. The top of the insulation shall be installed in a manner to allow water run-off and prevent pooling.

404.2.6 Recessed lighting fixtures. Recessed lighting fixtures installed within the building envelope 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 the annular space between the ceiling cutout and lighting fixture shall be sealed.
2. Type IC rated in accordance with ASTM E283, with no more than 2.0 cubic feet per minute (cfm) (0.944 L/s) air movement from the conditioned space to the ceiling cavity at 1.57 psi pressure (75 Pa) difference and shall be labeled and the annular space between the ceiling cutout and lighting fixture shall be sealed.
3. Type 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.

404.3 Exterior doors. Doors shall be tested according to the requirements of Section 404.4. When calculating the energy performance of the exterior envelope, the area of doors shall be the actual unit size.

Exceptions:

1. Unglazed doors that are not tested according to the requirements of Section 404.4 shall be assigned a default *U*-value of 0.54.
2. Sliding glass doors and swinging glass doors shall meet the specifications for windows and shall be treated as such.
3. Doors that incorporate glazed areas more than 2.5 square feet (0.23 m^2) in area shall be considered exterior doors with greater than or equal to 2.5 square feet (0.23 m^2) glazing.

Doors shall meet the air leakage requirements of Section 404.8.

404.4 Windows. All windows installed in Oregon shall meet the requirements of Part III, Fenestration Standard.

1. Decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area is exempt from thermal performance requirements and do not need to be included in Table 404.1(1) thermal performance calculations.
2. Glass block assemblies may use a *U*-factor of 0.51.
3. The *U*-factor for windows may be a weighted average of total window area when all other building envelope measures are in compliance with performance requirements specified in this code. This calculation shall be provided to the building official and the windows that are less than required for prescriptive compliance shall be identified on the plans.

404.4.1 Thermal performance labeling. Labels shall be either:

1. National Fenestration Rating Council (NFRC) certified product; or
2. State-approved for windows produced in low volume.

All windows shall have labeling:

1. That is imprinted, not handwritten,
2. Facing the interior of the room,
3. Attached to the window until the building inspector inspects and verifies the labeling, and
4. List the *U*-factor.

Exceptions:

1. Labeling is not required for decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area.
2. Portions of labels for windows produced in low volume may be handwritten.

404.4.2 Combined products. When different window types are combined, mulled together by the manufacturer or manufactured to fit a framed rough opening, a single label may be used.

Exception: A solarium shall have one label providing a description of each of the glazed surfaces, such as the front, overhead and each side.

404.4.3 Air leakage requirements. Windows shall comply with the air leakage requirements of Section 404.8.

Exception: Site-built windows.

404.4.4 Alterations. New windows shall have a maximum *U*-factor of 0.40.

Exceptions:

1. Decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area may be exempt from thermal performance requirements and Table 404.1(1) calculations.
2. Where necessary to retain architectural consistency with remaining windows in the building, new windows shall have a maximum *U*-value of 0.65.

404.5 Walls.

404.5.1 Advanced framing for walls. Advanced framing for walls is an optional construction method. Advanced framing, when used to qualify a design under the requirements of Section 404.1(1), shall meet the following requirements:

1. **Walls.** Walls shall be framed with 2X studs at 24 inches (610 mm) on center and shall include the following, as detailed in Items 2 and 3.
2. **Corners and intersections.** Exterior wall and ceiling corners shall be fully insulated through the use of three-stud corners configured to allow full insulation into the corner, or two-stud corners and drywall backup clips or other approved technique. Intersections of interior partition walls with exterior walls shall be fully insulated through the use of single backer boards, midheight blocking with drywall clips or other approved technique.
3. **Headers.** Voids in headers 1 inch (25.4 mm) or greater in thickness shall be insulated with rigid insulation that has a value of R-4 per 1 inch (25.4 mm) or greater. Nonstructural headers (such as in gable end walls) can be eliminated and replaced with insulation to achieve equivalent levels as the surrounding area.

404.5.2 Intermediate framing for walls. Intermediate framing for walls is an optional construction method. Intermediate framing, when used to achieve improved wall performance under the requirements of Table 404.1(2), shall meet the following requirements:

1. **Walls.** Walls shall be framed with 2X studs at 16 inches (610 mm) on center and shall include the following, as detailed in Items 2 and 3.
2. **Corners and intersections.** Exterior wall and ceiling corners shall be fully insulated through the use of three-stud corners configured to allow full insulation into the corner, or two-stud corners and drywall backup clips or other approved technique. Intersections of interior partition walls with exterior walls shall be fully insulated through the use of single backer boards, midheight blocking with drywall clips or other approved technique.
3. **Headers.** Voids in headers 1 inch (25.4 mm) or greater in thickness shall be insulated with rigid insulation that has a value of R-4 or greater per 1 inch (25.4 mm) thickness. Nonstructural headers (such as in gable end walls) can be eliminated and replaced with insulation to achieve equivalent levels as the surrounding area.

404.5.3 Below-grade walls. Walls enclosing heated spaces below grade shall be insulated from the bottom of the above-grade sub-floor downward to the top of the below-grade finished floor.

404.6 Roof/ceiling: Advanced framing for ceilings. Advanced framing for ceilings is an optional construction method. Advanced framing, when used to qualify a design under the requirements of Section 404.1, shall meet the following requirements:

Framing techniques shall be used in attics and ceilings to provide full insulating value to the outside of exterior walls. This may be accomplished through the use of extra-depth or oversized trusses, double rafters, special insulation components installed at the edge of the wall, or other approved combinations of framing and insulation. The entire surface of the exterior ceiling shall be insulated to the required value including attic hatches, structural members, electrical fixtures (where allowed by the code) and plumbing penetrations.

404.7 Slab-on-grade floors. For slab-on-grade floors, the perimeter of the floor shall be insulated.

The insulation shall extend downward from the top of the slab for a minimum of 24 inches (610 mm) or downward to the bottom of the slab, then horizontally beneath the slab for a minimum total distance of 24 inches (610 mm).

Exception: For monolithic slabs, the insulation shall extend downward from the top of the slab to the bottom of the thickened edge.

404.7.1 Slab-on-grade floors with hydronic heat. For slab-on-grade floors that incorporate hydronic heating, in addition to perimeter insulation, the entire underside of slab shall be insulated to R-10.

404.8 Air leakage. The requirements of this subsection shall apply only to those locations separating outdoor ambient conditions from interior spaces that are heated or mechanically cooled and are not applicable to separation of interior spaces from each other. Compliance with the criteria for air leakage shall be determined by tests based on applicable engineering principles.

404.8.1 Acceptance criteria. Where specified, compliance with air infiltration rates for all exterior windows, swinging doors and sliding glass doors shall be certified using ASTM E 283 “Standard Test Methods for Rate of Air Leakage

through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen." Tests shall be conducted at a differential pressure of 1.57 pounds per square foot (75 Pa) [equivalent to 25 mph (40 km/h) wind condition].

1. Windows — 0.37 cubic feet per minute (cfm) per foot (0.17 L/s per m) of sash crack.
2. Swinging doors — 0.37 cfm per square foot (0.17 L/s per m^2) of door area.
3. Sliding doors — 0.37 cfm per square foot (0.17 L/s per m^2) of door area.

404.8.2 Sealing required. Exterior joints around windows and door frames; between wall cavities and window or door frames, between wall and foundation; between wall and roof; between wall panels; at penetrations or utility services through walls; floors and roofs and all other openings in the exterior envelope shall be sealed in a manner approved by the building official.

404.9 Moisture control. To ensure the effectiveness of insulation materials and reduce the hazard of decay and other degradation due to condensation within the structure, moisture-control measures shall be included in all buildings and structures or portions thereof regulated by this chapter.

404.9.1 Vapor retarders. A one-perm, dry cup rating vapor retarder shall be installed on the warm side (in winter) of all insulation.

Exceptions:

1. When insulation is installed in ceilings inside an existing structure and ventilation is provided as specified in Section R806 of the *Residential Code*, a vapor retarder need not be installed.
2. Below grade walls are not required to have a vapor retarder.
3. Slab-on-grade floors need not have a warm-side vapor retarder.

404.9.2 Ground cover. A ground cover shall be installed in the crawl space for both new and existing buildings when insulation is installed. Ground cover shall be 6-mil (0.15 mm) black polyethylene or other approved material of equivalent perm rating. Ground cover shall be lapped 12 inches (305 mm) at all joints and cover the entire surface area extending full width and length of the crawl space and turn 12 inches (305 mm) up the foundation wall. Ground cover of 6-mil (0.15 mm) polyethylene or an approved equal (that is as durable) shall be installed on the ground beneath concrete floor slabs located in conditioned spaces.

SECTION 405
HEATING, VENTILATING AND AIR-CONDITIONING SYSTEMS

405.1 General. This section provides minimum requirements for heating, ventilating and air-conditioning systems.

405.2 Insulation of ducts. All new duct systems, or new portions thereof, exposed to unconditioned spaces shall be insulated according to Table 401.1(1).

Exception: The replacement or addition of a furnace, air conditioner or heat pump shall not require existing ducts to be insulated to current code.

405.3 HVAC controls. All heating, ventilating and air-conditioning systems shall be provided controls as specified herein.

405.3.1 Temperature. Each heating, ventilating and air-conditioning system shall be provided with at least one thermostat for the regulation of temperature. Each thermostat shall be capable of being set from 55ºF to 75ºF (13ºC to 24ºC) where used to control heating only and from 70ºF to 85ºF (21ºC to 29ºC) where used to control cooling only. Where used to control both heating and cooling, it shall be capable of being set from 55ºF to 85ºF (13ºC to 29ºC) and shall be capable of operating the system heating and cooling in sequence. It shall be capable of providing a temperature range of at least 5ºF (-15ºC) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

405.3.2 Humidity. If a heating, ventilating and air-conditioning system is equipped with a means for adding moisture to maintain specific selected relative humidity in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent new energy from being used to produce space relative humidity above 30 percent. Where a humidistat is used in a heating, ventilating and air-conditioning system for controlling moisture removal to maintain specific selected relative humidity in spaces or zones, it shall be capable of being set to prevent new energy from being used to produce a space-relative humidity below 60 percent.

405.3.3 Temperature zoning. Each separate heating, ventilating and air-conditioning system shall be provided at least one thermostat for regulation of space temperature. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating or cooling input to each zone or floor, excluding unheated or noncooled basements and garages.

405.3.4 Setback and shutoff. The thermostat, or an alternate means such as switch or clock, shall provide a readily accessible manual or automatic means for reducing the energy required for heating and cooling during periods of nonuse or reduced need.

Exceptions:

1. Where it can be shown that setback or shutdown will not result in a decrease in overall building energy.
2. Equipment with full load demand of 2 kilowatt (6.826 Btu/h) or less may be controlled by readily accessible off-hour controls.

Lowering thermostat set points to reduce energy consumption of heating system shall not cause energy to be expended to reach the reduced setting.

405.3.4.1 Heat pump controls. All heat pump system thermostats shall be capable of manual setback and limiting the use of supplemental heat during warm-up periods.

405.3.4.1.1 Outdoor thermostat required. The cut-on temperature for the compression heating shall be higher than the cut-on temperature for the supplementary heat, and the cut-off temperature for the compression heating shall be higher than the cut-off temperature for the supplementary heat.

405.4 Outside combustion air. See Section R1006 of the *Residential Code* for required outside combustion air for masonry fireplaces, factory-built fireplace(s) and factory-built stoves.

405.5 Equipment performance requirements.

405.5.1 Heat pumps. Single phase, air-cooled split and packaged system heat pumps of less than 65,000 Btu/h (19 052W) capacity shall have a heating seasonal performance factor (HSPF) of not less than 7.7 and seasonal energy efficiency ratio (SEER) of not less than 13.

405.5.2 Air conditioners. Single phase, air-cooled split and packaged system air conditioners of less than 65,000 Btu/hr capacity shall have a SEER of not less than 13.0.

405.5.3 Furnaces.

405.5.3.1 Oil-fired furnaces. Oil-fired furnaces shall have an annual fuel utilization efficiency (AFUE) of not less than 78 percent.

405.5.3.2 Gas-fired furnaces. Gas-fired furnaces shall have an AFUE of not less than 78 percent.

405.5.4 Boilers. Gas-fired boilers shall have an AFUE not less than 80 percent, and gas-fired steam boilers shall have an AFUE of not less than 75 percent.

405.5.5 Packaged terminal air conditioners. Packaged terminal air conditioners shall meet performance requirements as specified in Table 405.5.5.

405.5.6 Packaged terminal heat pumps. Packaged terminal heat pumps shall meet performance requirements as specified in Table 405.5.5.

405.6 Economizer cooling. Each fan system with mechanical cooling shall have an air economizer system capable of modulating outside air and return dampers to provide up to 100 percent of the design supply air quantity as outdoor air.

Exceptions:

1. Cooling equipment rated at less than 54,000 Btu/h (15 827 W) total cooling capacity.
2. HVAC systems serving guest rooms or dwelling units.
3. One- and two-family dwellings.

TABLE 405.5.5
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS (PTAC) AND PACKAGED TERMINAL HEAT PUMPS (PTHP) - MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATINGS CONDITIONS	MINIMUM EFFICIENCY REQUIRED	TEST PROCEDURE
PTAC, cooling mode New construction	All Capacities	95°F db Outdoor Air	12.5-(0.213x Cap/1000) EER[a]	ARI 310/380-93
PTAC, cooling mode Replacements[b]	All Capacities	95°F db Outdoor Air	10.9-(0.213x Cap/1000) EER[a]	
PTHP, (Cooling Mode) New construction	All Capacities	95°F db Outdoor Air	12.3-(0.213x Cap/1000) EER[a]	ARI 310/380-93
PTHP, (Cooling Mode) Replacements[b]	All Capacities	95°F db Outdoor Air	10.8-(0.213x Cap/1000) EER[a]	
PTHP, cooling mode New construction	All Capacities	—	3.2-(0.026 x Cap/1000) EER[a]	—
PTHP, (Heating Mode) Replacements [b]	All Capacities	—	2.9-(0.026 x Cap/1000) EER[a]	

For SI: 1 inch = 25.4 mm, 1 Btu/h = 0.2931W.

a. Cap means the rated cooling capacity of the product in Btu/h. If the unit capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

b. Replacement efficiencies shall only apply to units with existing sleeves less than 16 inches high and less than 42 inches wide. Replacement units shall be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS."

SECTION 406
PIPING INSULATION

406.1 Heating and cooling systems. All piping serving as part of a heating or cooling system shall be thermally insulated as shown in Table 406.1.

406.2 Domestic and service hot water systems. All piping serving as part of a domestic or service hot water system shall be thermally insulated as shown in Table 406.1.

Exception: One- and two-family dwellings.

406.3 Minimum thickness. Insulation thicknesses shall be no less than specified in Table 406.1. However, a greater thickness insulation may be required for freeze protection where piping is exposed to subfreezing ambient temperatures.

406.4 Water vapor transmission. The minimum insulation thicknesses specified do not consider water vapor transmission and condensation. Additional insulation, vapor retarders, or both, may be required to limit water vapor transmission and condensation.

Exception: Piping insulation, except when needed to prevent condensation, is not required in any of the following cases:

1. Factory-installed piping within HVAC equipment.
2. Piping that conveys fluids that have a design operating temperature range between 55ºF and 105ºF (13ºC and 40.5ºC).
3. Piping installed in basements, cellars or unventilated crawl spaces with insulated walls.

SECTION 407
LIGHTING

407.1 General. The provisions of this section apply to lighting equipment, related controls and electric circuits serving all conditioned and unconditioned interior floor space and exterior building facades of all dwelling units and guest rooms within residential buildings and structures, or portions thereof.

407.2 High-efficiency lighting systems. A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be compact or linear fluorescent, or a lighting source that has a minimum efficacy of 40 lumens per input watt.

The building official shall be notified in writing at the final inspection that a minimum of 50 percent of the lamps in permanently installed lighting fixtures are compact or linear fluorescent, or a minimum efficacy of 40 lumens per input watt.

TABLE 406.1
MINIMUM PIPE INSULATION (INCHES)[a, b]

FLUID DESIGN OPERATING TEMPERATURE RANGE, °F	INSULATION CONDUCTIVITY		NOMINAL PIPE DIAMETER (IN.)				
	Conductivity range (Btu-in)/(hr.-ft²-°F)	Mean rating temperature °F	1 and less	1 1/4 to 2	2 1/2 to 4	5 & 6	8 & up
Heating systems (steam, steam condensate and hot water)[c]							
Above 350	0.32 - 0.34	250	2.5	3.0	3.0	4.0	4.0
251 - 350	0.29 - 0.31	200	2.0	2.5	3.0	3.5	3.5
201 - 250	0.27 - 0.30	150	1.5	1.5	2.0	2	3.5
141 - 200	0.25 - 0.29	125	1.5	1.5	1.5	1.5	1.5
105 - 140	0.24 - 0.28	100	1.0	1.0	1.0	1.5	1.5
Domestic and Service Hot Water System[d]							
105 and greater	0.24 - 0.28	100	1[e]	1	1.5	1.5	1.5
Cooling systems (chilled water, brine and refrigerant)[c]							
40-55	0.23 - 0.27	75	0.5	0.75	1.0	1.0	1.0
Below 40	0.23 - 0.27	75	1.0	1.5	1.5	1.5	1.5

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, ºF = 1.8ºC + 32

a. For insulation outside the stated conductivity range, minimum thickness (T) shall be determined as follows:
$T = r\{(1 + t/r)K/k - 1\}$
Where
T = minimum thickness (in.)
r = actual outside radius of pipe (in.)
t = insulation thickness in this table for applicable fluid temperature and pipe size.
K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu-in.[h · ft² · ºF]) and
k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b. These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability, surface condensation, or safety considerations sometimes require vapor retarders or additional insulation.

c. Piping insulation is not required between the control valve and coil on run-outs when control valve is located within 4 feet of the coil and pipe diameter is 1 inch or less.

d. Applies to recirculating sections of service or domestic hot water systems and first 8 feet (2.4 mm) from storage tank for noncirculating systems.

e. Piping less than 1 inch in diameter and less than 12 feet in length shall be insulated with 1/2 inch insulation with a minimum conductivity of 0.24 Btu- in/hr-ft²-?F.

PART II—ALTERNATIVE SYSTEMS ANALYSIS

SECTION 408
ALTERNATIVE SYSTEMS ANALYSIS

This section provides an alternate method of demonstrating code compliance with this chapter by demonstrating that such deviation will result in an annual energy consumption equal to or less than a building that is in compliance with this chapter.

408.1 Equivalent annual energy consumption. The baseline design, conforming to requirements specified in this chapter and the proposed design shall be analyzed using the same procedures. The analyses shall use equal floor area and equal environmental requirements. The comparison shall be expressed in Btu input per gross building square foot of conditioned space per year (MJ/m² per year).

408.2 Basis for comparison. Both baseline and proposed alternative designs shall include parameters as specified in Table 408.2.

408.2.1 Internal heat gain. The total internal heat gain shall be calculated by Equation 408.2.1(1). For single zone calculations, the daily total sensible internal gains (Btu/day) shall be determined by Equation 408.2.1(2). For multiple zone HVAC systems, the daily total sensible internal gains (Btu/day) shall be determined by Equation 408.2.1(2) for the living zone and Equation 408.2.1(3) for the sleeping zone. The daily total latent load for each zone shall be determined using Equation 408.2.1(4).

Internal heat gains shall be distributed over the day according to the profile in Table 408.2.1(2). The load for each hour is the daily total gain multiplied by the factor from the appropriate column.

Where multiple zone space conditioning is modeled, the profile shown for Zone 2 shall be used for bedrooms and bathrooms; the profile shown for Zone 1 shall be used for all other conditioned rooms. Where single zone space conditioning is modeled, the hourly profile for single-zone designs shall be used.

Equation 408.2.1(1)
Total Heat Gains = Sensible Heat Gains + Latent Heat Gains

Equation 408.2.1(2)
Single Zone or Living Zone:
Sensible Heat Gains = (Floor Area of Zone × 15 Btu/day · ft²) + (Number of living units × 20,000 Btu/day)

Equation 408.2.1(3)
Sleeping Zone:
Sensible Heat Gains = Floor Area of Zone × 15 Btu/day · ft²

Equation 408.2.1(4)
Latent Heat Gains = 0.2 × Sensible Heat Gains

TABLE 408.2
BASIS FOR COMPARISON

INPUT PARAMETERS FOR ANALYSIS		
Parameter	**Proposed Building**	**Code Baseline**
Building Envelope		
Opaque construction materials	As designed	Code minimum
Fenestration performance	As designed	Code minimum
Shading devices	As designed	Same as proposed
Window area	As designed	Same as proposed[a]
Skylight area	As designed	Same as proposed[b]
Building orientation	As designed	Same as proposed
Solar gain	As designed	Same as proposed
Building infiltration	0.35 ACH Natural	Same as proposed
HVAC Systems		
HVAC system type(s)	As designed	Same as proposed
HVAC efficiency	Code efficiencies[c]	Same as proposed[c]
Heating fuel	As designed	Same as proposed
Cooling fuel	As designed	Same as proposed
Temperature setpoints	As designed	Same as proposed
Equipment capacity	As designed	Same as proposed
Mechanical ventilation	As designed	Same as proposed
Lighting		
Artificial lighting	As designed	Code required
Daylighting	As designed	Same as proposed
Design Conditions		
Building occupancy	As designed	Same as proposed
Building operational schedules	As designed	Same as proposed
Climatic data	As designed	Same as proposed
Internal loads	As designed	Same as proposed
Cooking fuel	As designed	Same as proposed

a. For a single family dwelling unit, detached or attached (rowhouse), only, code baseline window area may be set at 13 percent of heated space floor area when proposed building has less than 13 percent of heated space floor area in windows.
b. Code baseline skylight area shall be same as proposed up to a maximum of 2 percent of the heated space floor area.
c. Systems not regulated by code, such as electric heat, shall comply with standard equipment efficiency for such equipment.

408.2.2 Thermostat set-points. In the analysis for both the baseline and proposed designs, all conditioned spaces shall be maintained at the specified thermostat set-points at all times except for minor deviations at thermostat setback and setup and when outdoor conditions exceed normal design conditions.

If the specified equipment in the proposed design is too small to meet the load, its capacity shall be increased in the

calculations. If equipment to meet a load is not included in the design, such equipment shall be assumed in the calculations and its energy use included. In no case shall the energy use of proposed design be reduced by not conditioning its spaces.

For central space conditioning systems without zonal control, the entire conditioned floor area shall be one thermostatically controlled zone. The thermostat settings shall be those listed for a single zone in Table 408.2.2. For multiple zone designs, the multi-zone thermostat settings in Table 408.2.2 shall be used. Zone 1 represents all conditioned spaces other than Zone 2 (bedrooms and bathrooms). The effect of heat transfer between zones including nonclosable openings shall be included in the calculation.

TABLE 408.2.2
THERMOSTAT SETTINGS (ºF)

	SINGLE ZONE		MULTIPLE ZONE			
			Zone 1 Living		Zone 2 Sleeping	
TIME OF DAY	Heat	Cool	Heat	Cool	Heat	Cool
6-9 A.M.	68	78	68	78	68	78
9 A.M. – 5 P.M.	68	78	68	78	60	85
5-11 P.M.	68	78	68	78	68	78
11 P.M. – 6 A.M.	68	78	60	85	60	78

408.3 Analysis procedure. The analysis of the annual energy usage of the standard and the proposed alternative building and system designs shall meet the following criteria:

408.3.1 The building heating/cooling load calculation procedure used for annual energy consumption analysis shall be of sufficient detail to permit the evaluation of effect of building data (such as orientation, size, shape, transfer characteristics of mass, air, moisture, and heat) and hourly climatic data.

408.3.2 The calculation procedure used to simulate the operation of the building and its service systems through a full year operating period shall be of sufficient detail 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 all systems and equipment. The calculation procedure shall be based upon 8760 hr of operation of the building and its service systems and shall utilize techniques recommended in the appropriate ASHRAE publications or produce results consistent with such recommended procedures.

408.3.2.1 The calculation procedure shall explicitly cover the following items:

1. Climatic data: coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.
2. Building data: orientation, size, shape, mass, air, moisture and heat transfer characteristics.
3. Operational characteristics: temperature, humidity, ventilation, illumination, control mode for occupied and nonoccupied hours.
4. Mechanical equipment: design capacity, part load profile.
5. Internal heat generation, lighting, equipment, number of people during occupied and non- occupied periods.

408.4 Documentation. Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report prepared by a registered engineer. The report shall provide sufficient technical detail describing the differences between the two building and systems designs and on the data used in and resulting from the comparative analysis.

408.4.1 The documentation shall demonstrate that the analysis used is consistent with the techniques and procedures specified in this section and the following ASHRAE documents:

1. 2001 ASHRAE *Handbook of Fundamentals.*
2. 2000 ASHRAE *Handbook of HVAC Systems and Equipment.*
3. ASHRAE *Principles of Heating, Ventilating and Air Conditioning.*

PART III—FENESTRATION STANDARD

SECTION 409
SCOPE

409.1 General. All windows installed in Oregon shall meet the requirements of this section.

SECTION 410
DEFINITIONS

410.1 General. For purposes of this section the following definitions are provided;

1. "Windows produced in low volume" are a manufacturer's product installed in Oregon during a calendar year that does not exceed: 750 windows, 500 glazed doors, 1,000 skylights and 25 complete solariums.
2. A "manufacturer" produces windows, assembles window components or does both. A "manufacturer" includes its subsidiaries, divisions and all other companies under common control or ownership.

SECTION 411
INSULATED GLASS CERTIFICATION

411.1 General. Sealed insulated glass units shall conform to, or be in test for, ASTM E 774-97 Standard Specification for the Classification of the Durability of Sealed Insulating Glass Units Class CBA or ASTM E2190-02 Standard Specification for Insulating Glass Unit Performance and Evaluation under

the IGMA (Insulating Glass Manufacturers Alliance) approved certification program or equal and be installed in accordance to the latest IGMA Glazing Guidelines.

SECTION 412
WINDOW THERMAL PERFORMANCE DESIGNATION FOR NEW BUILDINGS AND ADDITIONS

The requirements of this section are not intended to waive or supersede any window thermal performance requirements under state or federal laws.

412.1 Manufactured windows. *U*-factors for manufactured fenestration products (windows, skylights and doors) shall be determined in accordance with the National Fenestration Rating Council (NFRC) 100 2004 Procedure for Determining Fenestration Product *U*-Factors The *U*-factors shall be labeled and certified in accordance with the NFRC Product Certification.

412.2 Windows products exempt from testing. Thermal performance testing is not required for:

1. Solariums and sunrooms with a minimum of $^1/_2$-inch (12.7 mm) space between the panes.
2. Skylights constituting no more than 10 percent of total glazing in a dwelling.
3. Windows, glazed doors, skylights and solariums produced in low volume.
4. Skylights constructed with wood, thermal break aluminum or aluminum with vinyl frames with a glazing configuration of either: A minimum $^1/_2$-inch (12.7 mm) space between the panes and low-*e* glass; or triple layered acrylic.
5. Decorative or unique architectural glazing not exceeding one percent of the heated space floor area.

412.3 Thermal performance of exempted products. The thermal performance of window products exempted from testing shall be determined by the following procedures:

1. Windows produced in low volume are assigned default *U*-factors prescribed in Section 412.4, Item 1.
2. Glazed doors produced in low volume are assigned default *U*-factors prescribed in Section 412.4, Item 2.
3. The procedures specified in ASHRAE *Handbook of Fundamentals*, Chapter 30, Table 4 using the vertical installation categories or its certified *U*-factor according to the NFRC procedure as specified in Section 412.1 for the vertical and overhead glazing contained in solariums.
4. The procedures specified in ASHRAE *Handbook of Fundamentals*, Chapter 30, Table 4 using sloped installation or its certified *U*-factor according to the NFRC procedure as specified in Section 412.2, Item 2.
5. Skylights specified in Section 412.2, Item 3 shall be assigned a default *U*-factor of 0.50.

412.4 Thermal performance validation for windows produced in low volume or site-built. Windows, glazed doors, skylights and solariums produced in low volume and meeting the requirements of this subsection may validate default *U*-factors by using:

1. Table 412.4(1) for windows, or
2. Table 412.4(2) for glazed doors, or
3. Table 412.4(1) for overhead glazing such as those installed in solariums, or
4. By assuming a *U*-0.50 default for skylights, not exempted by Section 412.2, Item 3 when constructed with thermal-break aluminum, or wood, or vinyl frames; with glazing constructed of either a minimum:
   - 4.1. 0.5 inch (12.7 mm) airspace between the glazing with low-*e* and argon gas-filled; or
   - 4.2. Two 0.5 inch (12.7 mm) airspace triple glazing, measured at the center of glazing.

SECTION 413
THERMAL PERFORMANCE LABELING

The requirements of this section are not intended to waive or supersede any window label or disclosure requirements under state or federal laws.

413.1 Labeling. Labeling is not required for decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area and is exempt from Table 404.1(1) thermal performance calculations.

413.2. Except as provided in Section 413.1, all windows shall have labeling that is:

1. Imprinted, not handwritten;
2. Facing the interior of the room; and
3. Attached to the window until the building inspector inspects and verifies the labeling; and

413.3. Manufactured window labels shall also list the *U*-factor or *U*-factor Class.

413.4 Skylights exempt from thermal performance standards. Labels for skylights exempted from thermal performance standards under Section 412.2, Item 4, due to its frame and glazing configuration shall:

1. Contain the statement, “This skylight is not required to be tested or evaluated for thermal performance”;
2. State “EXEMPT” in 0.75 inch (19.1 mm) high letters;
3. Specify “Issued (*Date of issue*)”;
4. Specify the skylight components; and
5. Contain the statement, “Under ORS 455.525(4) this skylight is deemed to comply with Oregon’s thermal performance standards regardless of *U*-factor.”

TABLE 412.4 (1)
APPROVED WINDOW DEFAULT U-VALUES[a, b]

DESCRIPTION[c, d, e, f, g] (inches)	FRAME TYPE[h]		
	ALUM. THERMAL BREAK[i]	WOOD/VINYL	ALUM CLAD WOOD/ REINFORCED VINYL[j]
Double, Clear 1/4	N/A	0.56	0.59
Double, Clear 1/4 + argon	0.63	0.53	0.56
Double, Low-*e* 4 1/4	0.61	0.52	0.54
Double, Low-*e* 2 1/4	0.58	0.49	0.51
Double, Low-*e* 1 1/4	0.55	0.47	0.49
Double, Low-*e* 4 1/4 + argon	0.55	0.47	0.49
Double, Low-*e* 2 1/4 + argon	0.52	0.43	0.46
Double, Low-*e* 1 1/4 + argon	0.50	0.41	0.43
Double, Clear 3/8	0.63	0.54	0.57
Double, Clear 3/8 + argon	0.60	0.51	0.54
Double, Low-*e* 4 3/8	0.57	0.48	0.51
Double, Low-*e* 2 3/8	0.54	0.45	0.48
Double, Low-*e* 1 3/8	0.51	0.43	0.46
Double, Low-*e* 4 3/8 + argon	0.53	0.44	0.47
Double, Low-*e* 2 3/8 + argon	0.49	0.41	0.44
Double, Low-*e* 1 3/8 + argon	0.47	0.39	0.41
Double, Clear 1/2	0.60	0.50	0.54
Double, Clear 1/2 + argon	0.58	0.48	0.51
Double, Low-*e* 4 1/2	0.53	0.44	0.47
Double, Low-*e* 2 1/2	0.50	0.41	0.44
Double, Low-*e* 1 1/2	0.47	0.39	0.42
Double, Low-*e* 4 1/2 + argon	0.50	0.42	0.44
Double, Low-*e* 2 1/2 + argon	0.46	0.37	0.40
Double, Low-*e* 1 1/2 + argon	0.43	0.35	0.38
Triple, Clear 1/4	0.52	0.42	0.44
Triple, Clear 1/4 + argon	0.49	0.39	0.42
Triple, Low-*e* 4 1/4	0.50	0.40	0.40
Triple, Low-*e* 2 1/4	0.48	0.39	0.41
Triple, Low-*e* 1 1/4	0.47	0.38	0.40
Triple, Low-*e* 4 1/4 + argon	0.46	0.37	0.39
Triple, Low-*e* 2 1/4 + argon	0.43	0.34	0.37
Triple, Low-*e* 1 1/4 + argon	0.42	0.34	0.36
Triple, Clear 1/2	0.46	0.37	0.40
Triple, Clear 1/2 + argon	0.45	0.36	0.38
Triple, Low-*e* 4 1/2	0.43	0.35	0.37
Triple, Low-*e* 2 1/2	0.41	0.32	0.35
Triple, Low-*e* 1 1/2	0.39	0.31	0.33
Triple, Low-*e* 4 1/2 + argon	0.41	0.32	0.35
Triple, Low-*e* 2 1/2 + argon	0.38	030	0.32
Triple, Low-*e* 1 1/2 + argon	0.37	0.29	0.31

For SI: 1 inch = 25.4 mm.

a. Subtract 0.02 from the listed default *U*-factor for insulated spacers. Insulated spacer material includes fiberglass, wood and butyl or other material with an equivalent *K*-value.

b. Solariums may subtract 0.03 from the default *U*-factor.

c. 1/4″ = a minimum dead air space of 0.25 inch between the panes of glass.
3/8″ = a minimum dead air space of 0.375 inch between the panes of glass.
1/2″ = a minimum dead air space of 0.5 inch between the panes of glass.
Products with air spaces different than those listed above shall use the value for the next smaller air space; i.e. 3/4″ = 1/2″ *U*-factors, 7/16″ = 3/8″ *U*-factors, 5/16″ = 1/4″ *U*-factors.

d. Low-*e*4 (emissivity) shall be 0.4 or less.
Low-*e*2 (emissivity) shall be 0.2 or less.
Low-*e*1 (emissivity) shall be 0.1 or less.

(continued)

TABLE 412.4 (1)—continued
APPROVED WINDOW DEFAULT U-VALUES[a, b]

e. *U*-factors listed for argon shall consist of sealed, gas-filled, insulated units for argon, CO_2, SF6 and argon/SF6 mixtures.
The following conversion factor shall apply to Krypton gas-filled units: $^1/_4$″ or greater airspace with Krypton gas fill = $^1/_2$″ airspace with Argon gas-fill.

f. Dividers placed between glazing: The *U*-factors listed shall be used where the divider has a minimum gap of $^1/_8$-inch between the divider and lite of each inside glass surface. Add 0.03 to the listed *U*-factor for true divided lite windows.

g. "Glass block" assemblies may use a *U*-factor of 0.51.

h. Insulated fiberglass framed products shall use wood/vinyl *U*-factors.

i. Alum. Thermal Break = An aluminum thermal break framed window shall incorporate the following minimum design characteristics:
   1) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/hr/ft^2/ºF;
   2) The thermal break material shall not be less than 0.210 inch; and
   3) All metal framing members of the product to interior and exterior air must incorporate a thermal break meeting the criteria in 1) and 2) above.

j. Aluminum clad wood windows shall use the *U*-factors listed for aluminum clad wood/reinforced vinyl windows. Vinyl clad windows shall use the *U*-factors listed for wood/vinyl windows. Any vinyl frame window with metal reinforcement in more than one rail shall use the *U*-factors listed for aluminum clad wood reinforced vinyl windows.

TABLE 412.4 (2)
APPROVED GLAZED DOOR DEFAULT U-VALUES[a]

DESCRIPTION[b, c, d, e] (inches)	DOOR MATERIAL			
	INSULATED[f]		WOOD[g]	
	Full-Lite[h, i]	Half-Lite[j, k]	Full-Lite[h]	Half-Lite[j]
Double, Clear ¼	0.39	0.31	0.47	0.42
Double, Clear ¼ + argon	0.37	0.30	0.45	0.41
Double, Low-*e* 4¼	0.36	0.30	0.44	0.41
Double, Low-*e* 2¼	0.35	0.29	0.43	0.40
Double, Low-e 1¼	0.24	0.28	0.41	0.39
Double, Low-*e* 4¼ + argon	0.33	0.28	0.41	0.39
Double, Low-*e* 2¼ + argon	0.31	0.26	0.39	0.38
Double, Low-*e* 1¼ + argon	0.31	0.26	0.38	0.37
Double, Clear $^3/_8$	0.37	0.30	0.45	0.41
Double, Clear $^3/_8$ + argon	0.36	0.29	0.44	0.41
Double, Low-*e* $4^3/_8$	0.34	0.28	0.42	0.40
Double, Low-*e* $2^3/_8$	0.33	0.28	0.41	0.39
Double, Low-*e* $1^3/_8$	0.21	0.26	0.38	0.37
Double, Low-*e* $4^3/_8$ + argon	0.32	0.27	0.40	0.38
Double, Low-*e* $2^3/_8$ + argon	0.29	0.25	0.37	0.37
Double, Low-*e* $1^3/_8$ + argon	0.29	0.25	0.36	0.36
Double, Clear ½	0.36	0.29	0.44	0.41
Double, Clear ½ + argon	0.34	0.28	0.42	0.40
Double, Low-*e* 4½	0.32	0.27	0.40	0.38
Double, Low-*e* 2½	0.30	0.26	0.38	0.37
Double, Low-*e* 1½	0.19	0.25	0.36	0.36
Double, Low-*e* 4½ + argon	0.30	0.26	0.38	0.37
Double, Low-*e* 2½ + argon	0.28	0.25	0.36	0.36
Double, Low-*e* 1½ + argon	0.28	0.24	0.34	0.35
Triple, Clear ¼	0.31	0.26	0.39	0.38
Triple, Clear ¼ + argon	0.29	0.25	0.37	0.37
Triple, Low-*e* 4¼	0.30	0.26	0.38	0.37
Triple, Low-*e* 2¼	0.29	0.25	0.37	0.36
Triple, Low-*e* 4¼ + argon	0.27	0.24	0.35	0.35
Triple, Low-*e* 2¼ + argon	0.26	0.24	0.34	0.35

For SI: 1 inch = 25.4 mm.

a. Subtract 0.02 from the listed default *U*-factor for insulated spacers. Insulated spacer material includes fiberglass, wood and butyl or other material with an equivalent *K*-value.

b. $^1/_4$″ = a minimum dead air space of 0.25 inch between the panes of glass.
$^3/_8$″ = a minimum dead air space of 0.375 inch between the panes of glass.
$^1/_2$″ = a minimum dead air space of 0.5 inch between the panes of glass.
Products with air spaces different than those listed above shall use the value for the next smaller air space; i.e. ¾-inch = ½-inch *U*-factors, $^7/_{16}$-inch = $^3/_8$-inch *U*-factors, $^5/_{16}$″ = $^1/_4$″ *U*-factors.

c. Low-*e4* (emissivity) shall be 0.4 or less.
Low-*e2* (emissivity) shall be 0.2 or less.
Low-*e1* (emissivity) shall be 0.1 or less.

d. *U*-factors listed for argon shall consist of sealed, gas-filled, insulated units for argon, CO_2, SF_6 and argon/SF_6 mixtures.
The following conversion factor shall apply to Krypton gas-filled units:
¼-inch or greater airspace with Krypton gas fill = ½-inch airspace with Argon gas-fill.

e. Dividers placed between glazing: The *U*-factors listed shall be used where the divider has a minimum gap of $^1/_8$-inch between the divider and lite of each inside glass surface. Add 0.03 to the listed *U*-factor for True Divided Lite windows.

f. Insulated = Any urethane insulated foam core door with a thermal break. Thermal Break = A thermal break door shall incorporate the following minimum design characteristics:
1) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/hr/ft^2/°F; and
2) The thermal break material shall not be less than 0.210 inch.

g. Wood = Any wood door.

h. Full Lite = A door that consists of more than 35 percent glazing.

i. Add 0.05 to the listed *U*-factor for full-lite values if insulated door does not have a thermal break.

j. Half Lite = A door that consists of 35 percent or less glazing.

k. Add 0.06 to the listed *U*-factor for half-lite values if the insulated door does not have a thermal break.

413.5 Solariums and skylights exempted from testing. Labels for solariums and sunrooms with 0.5 inch (12.7 mm) airspace between the glazing and skylights less than 10 percent of the total glazing in a dwelling exempt from thermal performance testing under Section 412.2, Items 1, 2 and 4 shall:

1. Specify the window components and configuration; and
2. Show the *U*-value determined by Section 412.3, Item 3.

Exception: Exempt solariums and skylights may be labeled as certified through the NFRC procedure as specified in Section 412.1.

413.6 Windows produced in low volume or site-built. Labeling and disclosure shall comply with the following subsections:

413.6.1 Labels for windows and glazed doors produced in low volume shall:

1. Specify window components;
2. Show the allowed *U*-factor in the appropriate location;
3. Show a production count number that does not exceed the maximums established in Section 410, Item 1; and
4. Imprint "(*Manufacturer's name*) certifies the attached window is constructed in a manner to obtain the specified *U*-factor."

413.6.2 Labels for skylights produced in low volume, when constructed with thermal-break aluminum, or wood, or vinyl frames; with glazing constructed of either a minimum 0.5 inch (12.7 mm) airspace between the glazing with low-e and argon gas-filled; or of two 0.5 inch (12.7 mm) airspace triple glazing, measured at the center of glazing; for the U-0.50 requirement shall:

1. Specify window components;
2. State "U-0.50 Default *U*-factor";
3. State "Limited Production Skylight Compliance *U*-factor Label" and "Maximum Allowable Skylight Area Shall Not Exceed Two Percent of the Heated Space Floor Area";
4. Show a production count number that does not exceed the maximums established in Section 410.1, Item 1; and
5. Imprint "(*Manufacturer's name*) certifies the attached skylight complies with the criteria specified in the Oregon building codes."

413.6.3 Labels for skylights produced in low volume, not meeting the construction and configuration requirements of Section 413.6.2 and not otherwise exempt under Section 412.2, Item 4 shall:

1. Specify window components;
2. State "Calculated *U*-factor Skylight Compliance Label";
3. Show the *U*-factor determined by Section 412.3, Item 4; and
4. Show a production count number that does not exceed the maximums established in Section 410.1, Item 1.

413.6.4 Labels for solariums produced in low volume shall:

1. Specify the window components for each of the glazed surfaces, such as the front, overhead, and each side;
2. Show a production count number that does not exceed the maximums established in Section 410, Item 1;
3. Show the *U*-factor determined by Sections 412.4 Items 1 and 3 for each of the glazed surfaces;
4. Imprint "(Manufacturer's name) certifies the components of this solarium are constructed in a manner to obtain the specified *U*-factors"; and
5. Have one label providing a description of each of the glazed surfaces.

Exception: Products specified in Sections 413.6.1, 413.6.2 and 413.6.3, may be labeled as certified through the NFRC procedure as specified in Section 412.1.

413.7 Combined products. When different window types are combined, mulled together by the manufacturer or manufactured to fit a framed rough opening, a single label may be used.

Exception: A solarium shall have one label providing a description of each of the glazed surfaces, such as the front, overhead, and each side.

413.8 Label distribution. Labels under Sections 412.2 through 412.4 shall be designed by the division and sold by persons authorized by the agency and shall not be sold in lots exceeding the maximums for each window type per manufacturer during any calendar year.

SECTION 414
AIR LEAKAGE REQUIREMENTS

Windows shall comply with the air leakage requirements of Section 404.8.

Exception: Site-built windows.

SECTION 415
ALTERATIONS

New windows shall have maximum *U*-factor of 0.40. Windows shall be tested and labeled in accordance with Sections 404.4.

Exceptions:

1. Skylights allowed under Section 412.2, Item 4.
2. Decorative or unique architectural feature glazing not exceeding 1 percent of the heated space floor area may be exempt from thermal performance testing and labeling, and Table 404.1(1) calculations.
3. Where necessary to retain architectural consistency with remaining windows in the building, new windows shall have a maximum *U*-factor of 0.65.

CHAPTER 5

COMMERCIAL ENERGY EFFICIENCY

SECTION 501
GENERAL

501.1 Scope. The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings. These commercial buildings shall meet the requirements contained in this chapter.

501.2 Application. The *commercial building* project shall comply with the requirements in Sections 502 (Building envelope requirements), 503 (Building mechanical systems), 504 (Service water heating) and 505 (Electrical power and lighting systems) in its entirety.

Exception: Buildings conforming to Section 506, provided Sections 502.4, 503.2, 504, 505.2, 505.3, 505.4, 505.6 and 505.7 are each satisfied.

SECTION 502
BUILDING ENVELOPE REQUIREMENTS

502.1 General (Prescriptive).

502.1.1 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Tables 502.2(1) and 502.3 based on the climate zone specified in Chapter 3. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *R*-values from the "Group R" column of Table 502.2(1). Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *R*-values from the "All other" column of Table 502.2(1). Buildings with a vertical fenestration area or skylight area that exceeds that allowed in Table 502.3 shall comply with Section 502.1.3, Simplified trade-off approach or Section 506.1, Whole Building Approach.

Exception: Mass walls complying with Table 502.1.3.

502.1.2 *U*-factor alternative. An assembly with a *U*-factor, *C*-factor, or *F*-factor equal or less than that specified in Table 502.1.2 shall be permitted as an alternative to the *R*-value in Table 502.2(1). Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *U*-factor, *C*-factor, or *F*-factor from the "Group R" column of Table 502.1.2. Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *U*-factor, *C*-factor or *F*-factor from the "All other" column of Table 502.1.2.

Exception: Mass walls complying with Table 502.1.3.

502.1.3 Simplified trade-off approach. Buildings may demonstrate compliance with the thermal performance standards of this section by using the Simplified Trade-off Approach (STA). The STA is an analytical method to determine if the energy performance of a proposed building's envelope is at least equivalent to a similar building meeting the prescriptive path approach. Information and criteria for demonstrating compliance using the STA is available at

TABLE 502.1.2
BUILDING ENVELOPE REQUIREMENTS
OPAQUE ELEMENT, MAXIMUM *U*-FACTORS

CLIMATE ZONE	5 AND MARINE 4	
	All other	Group R
Roofs		
Insulation entirely above deck	U-0.048	U-0.048
Metal buildings	U-0.055	U-0.055
Attic and other	U-0.027	U-0.027
Walls, Above Grade		
Mass[b]	U-0.150[c]	U-0.090
Metal building	U-0.069	U-0.069
Metal framed	U-0.064	U-0.064
Wood framed and other	U-0.064	U-0.051
Walls, Below Grade		
Below-grade wall[a]	C-0.119	C-0.119
Floors		
Mass	U-0.074	U-0.064
Joist/Framing	U-0.033	U-0.033
Slab-on-Grade Floors		
Unheated slabs	F-0.730	F-0.540
Heated slabs[a]	F-0.860	F-0.860

a. When heated slabs are placed below-grade, below grade walls must meet the *F*-factor requirements for perimeter insulation according to the heated slab-on-grade construction.
b. Effective 1-1-2012.
c. Exception: Integral insulated concrete block walls complying with ASTM C90 with all cores filled and meeting both of the following: 1) At least 50 percent of cores must be filled with vermiculite or equivalent fill insulation, and 2) the structure encloses one of the following uses: Gymnasiums, Auditorium, Church Chapel, Arena, Kennel, Manufacturing Plant, Indoor Swimming Pool, Pump station, Water and Waste Water Treatment Facility, Storage Facility, Storage Area, Warehouse (Storage and retail), Motor vehicle service Facility.

TABLE 502.1.3
MASS WALL PERFORMANCE REQUIREMENTS[a]

COMPONENT	MAXIMUM GLAZING FRACTION	MAXIMUM *U*-FACTOR	MINIMUM *R*-VALUE
Masonry, with integral insulation[b]	15%	0.300	—
Masonry, with integral insulation[c]	30%	0.210	—
Masonry or concrete with interior insulation	30%	0.130	11
Masonry or concrete with continuous exterior insulation	15%	0.300	1.4
Masonry or concrete with continuous exterior insulation	30%	0.210	2.8

a. Effective 7-1-2010 through 12-31-2011.
b. All cores to be filled. At least 50 percent of cores must be filled with vermiculite or equivalent fill insulation.
c. All cores except bond beams must contain rigid insulation inserts approved for use in reinforced masonry walls.

502.2 Specific insulation requirements (Prescriptive). Opaque assemblies shall comply with Table 502.2(1).

502.2.1 Roof assembly. The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table 502.2(1), based on construction materials used in the roof assembly.

Exception: Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted *U*-factor is equivalent to the same assembly with the *R*-value specified in Table 502.2(1).

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

502.2.2 Classification of walls. Walls associated with the building envelope shall be classified in accordance with Section 502.2.2.1 or 502.2.2.2.

TABLE 502.2(1)
BUILDING ENVELOPE REQUIREMENTS - OPAQUE ASSEMBLIES

CLIMATE ZONE	5 AND MARINE 4	
	All other	Group R
Roofs		
Insulation entirely above deck	R-20ci	R-20ci
Metal buildings (with R-5 thermal blocks[a, b])	R-13 + R-13	R-19
Attic and other	R- 38	R-38
Walls, Above Grade		
Mass	R-11.4ci	R-13.3ci
Metal building[b]	R-13 + R-5.6ci	R-13 + R-5.6ci
Metal framed	R-13 + R-7.5ci	R-13 + R-7.5ci
Wood framed and other	R-13 + R-3.8ci	R-13 +R-3.8ci
Walls, Below Grade		
Below grade wall[d]	R-7.5ci	R-7.5ci
Floors		
Mass	R-10ci	R-12.5ci
Joist/Framing (steel/wood)	R-30	R-30
Slab-on-Grade Floors		
Unheated slabs	NR	R-10 for 24 in. below
Heated slabs	R-15 for 24 in. below	R-15 for 24 in. below
Opaque Doors		
Swinging	U-0.70	U-0.70
Roll-up or sliding	U-0.50	U-0.50

For SI: 1 inch = 25.4 mm.

Ci = Continuous insulation. NR = No requirement.

a. When using *R*-value compliance method, a thermal spacer block is required, otherwise use the *U*-factor compliance method. [see Tables 502.1.2 and 502.2(2)].

b. Assembly descriptions can be found in Table 502.2(2).

c. When heated slabs are placed below grade, below-grade walls must meet the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.

502.2.2.1 Above-grade walls. Above-grade walls are those walls covered by Section 502.2.3 on the exterior of the building and completely above grade or walls that are more than 15 percent above grade.

502.2.2.2 Below-grade walls. Below-grade walls covered by Section 502.2.4 are basement or first-story walls associated with the exterior of the building that are at least 85 percent below grade.

502.2.3 Above-grade walls. The minimum thermal resistance (*R*-value) of the insulating material(s) installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table 502.2(1), based on framing type and construction materials used in the wall assembly. The *R*-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table 502.2(1). "Mass walls" shall include walls weighing at least (1) 35 pounds per square foot (170 kg/m2) of wall surface area or (2) 25 pounds per square foot (120 kg/m^2) of wall surface area if the material weight is not more than 120 pounds per cubic foot (1900 kg/m_3).

502.2.4 Below-grade walls. The minimum thermal resistance (*R*-value) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table 502.2(1), and shall extend to a depth of 10 feet (3048mm) below the outside finished ground level, or to the level of the floor, whichever is less.

502.2.5 Floors over outdoor air or unconditioned space. The minimum thermal resistance (*R*-value) of the insulating material installed either between the floor framing or con-tinuously on the floor assembly shall be as specified in Table 502.2(1), based on construction materials used in the floor assembly.

"Mass floors" shall include floors weighing at least (1)35 pounds per square foot (170 kg/m^2) of floor surface area or (2) 25 pounds per square foot (120 kg/m^2) of floor surface area if the material weight is not more than 120 pounds per cubic foot (1,900 kg/m^3).

502.2.6 Slabs on grade. The minimum thermal resistance (*R*-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors shall be as specified in Table 502.2(1). The insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table.

502.2.7 Opaque doors. Opaque doors (doors having less than 50 percent glass area) shall meet the applicable requirements for doors as specified in Table 502.2(1) and be considered as part of the gross area of above-grade walls that are part of the building envelope.

502.3 Fenestration (Prescriptive). Fenestration shall comply with Table 502.3.

TABLE 502.2(2)
BUILDING ENVELOPE REQUIREMENTS-OPAQUE ASSEMBLIES

ROOFS	DESCRIPTION	REFERENCE
R-19	Standing seam roof with single fiberglass insulation layer. This construction is R-19 faced fiberglass insulation batts draped perpendicular over the purlins. A minimum R-3.5 thermal spacer block is placed above the purlin/batt, and the roof deck is secured to the purlins.	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
R-13 + R-13 R-13 + R-19	Standing seam roof with two fiberglass insulation layers. The first *R*-value is for faced fiberglass insulation batts draped over purlins. The second *R*-value is for unfaced fiberglass insulation batts installed parallel to the purlins. A minimum R-3.5 thermal spacer block is placed above the purlin/batt, and the roof deck is secured to the purlins.	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
R-11 + R-19 FC	Filled cavity fiberglass insulation. A continuous vapor barrier is installed below the purlins and uninterrupted by framing members. Both layers of uncompressed, unfaced fiberglass insulation rest on top of the vapor barrier and are installed parallel, between the purlins. A minimum R-3.5 thermal spacer block is placed above the purlin/batt, and the roof deck is secured to the purlins.	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
WALLS		
R-16, R-19	Single fiberglass insulation layer. The construction is faced fiberglass insulation batts installed vertically and compressed between the metal wall panels and the steel framing.	ASHRAE/IESNA 90.1 Table A3.2 including Addendum "G"
R-13 + R-5.6ci R-19 + R-5.6ci	The first *R*-value is for faced fiberglass insulation batts installed perpendicular and compressed between the metal wall panels and the steel framing. The second rated *R*-value is for continuous rigid insulation installed between the metal wall panel and steel framing, or on the interior of the steel framing.	ASHRAE/IESNA 90.1 Table A3.2 including Addendum "G"

TABLE 502.3
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

CLIMATE ZONE	5 AND MARINE 4
Vertical fenestration (30% maximum of above-grade wall)	
Framing materials other than metal with or without metal reinforcement or cladding	
U-factor	0.35
Metal framing with or without thermal break	
Curtain wall/storefront *U*-factor	0.45
Entrance door *U*-factor	0.80
All other *U*-factor[a]	0.46
SHGC-all frame types	0.40
Skylights (3% maximum)	
U-factor	0.60
SHGC	0.40

NR = No requirement.
PF = Projection factor (see Section 502.3.2).
a. All others includes operable windows, fixed windows and nonentrance doors.

502.3.1 Maximum area. The vertical fenestration area (not including opaque doors) shall not exceed the percentage of the gross wall area specified in Table 502.3. The skylight area shall not exceed the percentage of the gross roof area specified in Table 502.3.

502.3.2 Maximum *U*-factor and SHGC. For vertical fenestration and skylights, the maximum *U*-factor and solar heat gain coefficient (SHGC) shall be as specified in Table 502.3.

502.4 Air leakage (Mandatory).

502.4.1 Window and door assemblies. The air leakage of window and sliding or swinging door assemblies that are part of the building envelope shall be determined in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, or NFRC 400 by an accredited, independent laboratory, and *labeled* and certified by the manufacturer and shall not exceed the values in Section 502.4.2.

Exception: Site-constructed windows and doors that are weatherstripped or sealed in accordance with Section 502.4.3.

502.4.2 Curtain wall, storefront glazing and commercial entrance doors. Curtain wall, *storefront* glazing and commercial-glazed swinging entrance doors and revolving

doors shall be tested for air leakage at 1.57 pounds per square foot (psf) (75 Pa) in accordance with ASTM E 283. For curtain walls and *storefront* glazing, the maximum air leakage rate shall be 0.3 cubic foot per minute per square foot (cfm/ft^2) (5.5 m^3/h × m^2) of fenestration area. For commercial glazed swinging entrance doors and revolving doors, the maximum air leakage rate shall be 1.00 cfm/ft^2 (18.3 m^3/h × m^2) of door area when tested in accordance with ASTM E 283.

502.4.3 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems com-patible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

502.4.4 Outdoor air intakes and exhaust openings. Stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage-rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s · C m^2) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D.

Stair and shaft vent dampers shall be capable of being automatically closed during normal building operation and interlocked to open as required by fire and smoke detection systems.

502.4.5 Loading dock weatherseals. Cargo doors and loading dock doors shall be equipped with weatherseals to restrict infiltration when vehicles are parked in the doorway.

502.4.6 Vestibules. A door that separates conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time.

Exceptions:

1. Doors not intended to be used as a building *entrance door*, such as doors to mechanical or electrical equipment rooms.
2. Doors opening directly from a *sleeping unit* or dwelling unit.
3. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area.
4. Revolving doors.
5. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

502.4.7 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and *labeled* as meeting ASTM E 283 when tested at 1.57 psf (75 Pa) pressure differential with no more than 2.0 cfm (0.944 L/s) of air movement from the *conditioned space* to the ceiling cavity. All recessed luminaires shall be sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

SECTION 503
BUILDING MECHANICAL SYSTEMS

503.1 General. Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Section 503.2 (referred to as the mandatory provisions) and either:

1. Section 503.3 (Simple systems), or
2. Section 503.4 (Complex systems).

503.2 Provisions applicable to all mechanical systems (Mandatory).

503.2.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with the procedures described in the ASHRAE/ACCA Standard 183. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook*. Alternatively, design loads shall be determined by an *approved* equivalent computation procedure, using the design parameters specified in Chapter 3.

503.2.1.1 Packaged electric equipment. Forced air unit and packaged electric equipment with a total heating capacity greater than 20,000 Btu/h (5862W) shall have a heat pump as the primary heating source.

Exception: Unstaffed equipment shelters or cabinets used solely for personal wireless service facilities.

503.2.2 Equipment and system sizing. Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with Section 503.2.1. A single piece of equipment providing both heating and cooling must satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.

503.2.3 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 503.2.3(1), 503.2.3(2), 503.2.3(3), 503.2.3(4), 503.2.3(5), 503.2.3(6), 503.2.3(7) and 503.2.3(8) when tested and rated in accordance with the applicable test procedure. The efficiency shall be verified through certification under an *approved* certification program or, if no certification program exists, the equipment

efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

Exception: Water-cooled centrifugal water-chilling packages listed in Table 503.2.3(7) not designed for operation at ARHI Standard 550/590 test conditions of 44°F (7°C) leaving chilled water temperature and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 I/s.kW) condenser water flow shall have maximum full load and NPLV ratings adjusted using the following equations:

Adjusted maximum full load kW/ton rating = [full load kW/ton from Table 503.2.3(7)]/K_{adj}

Adjusted maximum NPLV rating = [IPLV from Table 503.2.3(7)]/K_{adj}

where:

K_{adj} = $6.174722 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$

X = DT_{std} + LIFT

DT_{std} = {24+[full load kW/ton from Table 503.2.3(7)] × 6.83}/Flow

Flow = Condenser water flow (GPM)/Cooling Full Load Capacity (tons)

LIFT = CEWT - CLWT (°F)

CEWT = Full Load Condenser Entering Water Temperature (°F)

CLWT = Full Load Leaving Chilled Water Temperature (°F)

The adjusted full load and NPLV values are only applicable over the following full-load design ranges:

Minimum Leaving Chilled Water Temperature: 38°F (3.3°C)

Maximum Condenser Entering Water Temperature: 102°F (38.9°C)

Condensing Water Flow: 1 to 6 gpm/ton 0.018 to 0.1076 1/s kW) and X > 39 and <60

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of 27°F (-2.8°C) or lower for freeze protection are not covered by this code.

503.2.4 HVAC system controls. Each heating and cooling system shall be provided with thermostatic controls as required in Section 503.2.4.1, 503.2.4.2, 503.2.4.3, 503.2.4.4, 503.4.1, 503.4.2, 503.4.3 or 503.4.4.

503.2.4.1 Thermostatic controls. The supply of heating and cooling energy to each zone shall be controlled by individual thermostatic controls that respond to temperature within the zone.

Exception: Independent perimeter systems that are designed to offset only building envelope heat losses or gains or both serving one or more perimeter zones also served by an interior system provided:

1. The perimeter system includes at least one ther-mostatic control zone for each building expo-sure having exterior walls facing only one orientation (within +/-45 degrees) (0.8 rad) for more than 50 contiguous feet (15.2 m); and
2. The perimeter system heating and cooling sup-ply is controlled by a thermostat(s) located within the zone(s) served by the system.

503.2.4.1.1 Heat pump supplementary heat. Heat pumps having supplementary electric resistance heat shall have controls that, except during defrost, prevent supplementary heat operation when the heat pump can meet the heating load.

503.2.4.2 Set point overlap restriction. Where used to control both heating and cooling, *zone* thermostatic controls shall provide a temperature range or deadband of at least 5°F (2.8°C) within which the supply of heating and cooling energy to the zone is capable of being shut off or reduced to a minimum.

Exception: Thermostats requiring manual change over between heating and cooling modes.

503.2.4.3 Optimum start controls. Each HVAC system shall have controls that vary the start-up time of the system to just meet the temperature set point at time of occupancy.

503.2.4.4 Off-hour controls. Each zone shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

Exceptions:

1. Zones that will be operated continuously.
2. Zones with a full HVAC load demand not exceeding 6,800 Btu/h (2 kW) and having a readily accessible manual shutoff switch.

503.2.4.4.1 Thermostatic setback capabilities. Thermostatic setback controls shall set back or temporarily operate the system to maintain zone temperatures down to 55°F (13°C) or up to 85°F (29°C).

TABLE 503.2.3(1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air conditioners, Air cooled	< 65,000 Btu/h[d]	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.2 EER[c] 11.4 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.0 EER[c] 11.2 IEER	AHRI 340/360
	≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	10.0 EER[c] 10.1 IEER	
	≥ 760,000 Btu/h	Split system and single package	9.7 EER[c] 9.8 IEER	
Through-the-wall, Air cooled	< 30,000 Btu/h[d]	Split system	12.0 SEER	AHRI 210/240
		Single package	12.0 SEER	
Air conditioners, Water and evaporatively cooled	< 65,000 Btu/h	Split system and single package	12.1 EER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.5 EER[c] 11.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.0 EER[c] 11.2 IEER	AHRI 340/360
	≥ 240,000 Btu/h	Split system and single package	11.5 EER[c] 11.1 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. IPLVs are only applicable to equipment with capacity modulation.

c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

d. Single-phase air-cooled air conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

TABLE 503.2.3(2)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air cooled, (Cooling mode)	< 65,000 Btu/h[d]	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.0 EER[c] 11.2 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	10.6 EER[c] 10.7 IEER	AHRI 340/360
	≥ 240,000 Btu/h	Split system and single package	9.5 EER[c] 9.6 IPLV	
Through-the-Wall (Air cooled, cooling mode)	< 30,000 Btu/hd	Split system	12.0 SEER	AHRI 210/240
		Single package	12.0 SEER	
Water Source (Cooling mode)	< 17,000 Btu/h	86ºF entering water	11.2 EER	AHRI/ASHRAE 13256-1
	≥ 17,000 Btu/h and < 135,000 Btu/h	86ºF entering water	12.0 EER	AHRIASHRAE 13256-1
Groundwater Source (Cooling mode)	< 135,000 Btu/h	59ºF entering water	16.2 EER	AHRI/ASHRAE 13256-1
Ground source (Cooling mode)	< 135,000 Btu/h	77ºF entering water	13.4 EER	AHRI/ASHRAE 13256-1
Air cooled (Heating mode)	< 65,000 Btu/h[d] (Cooling capacity)	Split system	7.7 HSPF	AHRI 210/240
		Single package	7.7 HSPF	
	≥ 65,000 Btu/h and < 135,000 Btu/h (Cooling capacity)	47ºF db/43ºF wb Outdoor air	3.3 COP	
	≥ 135,000 Btu/h (Cooling capacity)	47ºF db/43ºF wb Outdoor air	3.2 COP	AHRI 340/360
Through-the-wall (Air cooled heating mode)	<30,000 Btu/h	Split System	7.4 HSPF	AHRI 210/240
		Single package	7.4 HSPF	
Water source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	68°F entering water	4.2 COP	AHRI/ASHRAE 13256-1
Groundwater source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	50°F entering water	3.6 COP	AHRI/ASHRAE 13256-1
Ground source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	32°F entering water	3.1 COP	AHRI/ASHRAE 13256-1

For SI: °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W.
db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.
a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
d. Single-phase air-cooled heat pumps < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA), SEER and HSPF values are those set by NAECA.

TABLE 503.2.3(3)
PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
PTAC (Cooling mode) Standard size	All capacities	95°F db outdoor air	12.5 - (0.213 · Cap/1000) EER	AHRI 310/380
PTAC (Cooling mode) Nonstandard size	All capacities	95°F db outdoor air	10.9 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) Standard size	All capacities	95°F db outdoor air	12.3 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) Nonstandard size	All capacities	95°F db outdoor air	10.8 - (0.213 · Cap/1000) EER	
PTHP (Heating mode) New construction	All capacities	—	3.2 - (0.026 · Cap/1000) COP	
PTHP (Heating mode) Replacements[c]	All capacities	—	2.9 - (0.026 · Cap/1000) COP	
SPVAC, (Cooling mode)	< 65,000 Btu/h	95ºF db/75ºF wb Outdoor air	9.0 EER	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	95ºF db/75ºF wb Outdoor air	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95ºF db/75ºF wb Outdoor air	8.6 EER	
SPVHP, (Cooling mode)	< 65,000 Btu/h	95ºF db/75ºF wb Outdoor air	9.0 EER	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	95ºF db/75ºF wb Outdoor air	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95ºF db/75ºF wb Outdoor air	8.6 EER	
SPVAC, (Heating mode)	< 65,000 Btu/h	47ºF db/43ºF wb Outdoor air	3.0 COP	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	47ºF db/43ºF wb Outdoor air	3.0 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	47ºF db/43ºF wb Outdoor air	2.9 COP	

For SI: °C - [(°F) - 32]/1.8, 1 British thermal unit per hour - 0.2931 W.
db = dry-bulb temperature, °F.
wb = wet-bulb temperature, °F.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
c. Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) high and less than 42 inches (1067 mm) wide.

TABLE 503.2.3(4)
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY [d, e]	TEST PROCEDURE[a]
Warm air furnaces, gas fired	< 225,000 Btu/h	—	78% AFUE or 80% E_t[c]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80% E_t[f]	ANSI Z21.47
Warm air furnaces, oil fired	< 225,000 Btu/h	—	78% AFUE or 80% E_t[c]	DOE 10 CFR Part 430 or UL 727
	≥ 225,000 Btu/h	Maximum capacity[b]	81% E_t[g]	UL 727
Warm air duct furnaces, gas fired	All capacities	Maximum capacity[b]	80% E_c	ANSI Z83.8
Warm air unit heaters, gas fired	All capacities	Maximum capacity[b]	80% E_c	ANSI Z83.8
Warm air unit heaters, oil fired	All capacities	Maximum capacity[b]	80% E_c	UL 731

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. Minimum and maximum ratings as provided for and allowed by the unit's controls.

c. Combination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.

d. E_t = Thermal efficiency. See test procedure for detailed discussion.

e. E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.

f. E_c = Combustion efficiency. Units must also include an IID, have jackets not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

g. E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

TABLE 503.2.3(5)
BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE[f]	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE
Boilers, Gas-fired	< 300,000 Btu/h	Hot water	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	
	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	Minimum capacity[b]	80% E_c (See Note c, d)	DOE 10 CFR Part 431
	> 2,500,000 Btu/h[f]	Hot water	82% E_c (See Note c, d)	
		Steam	77% E_t (See Note c, d)	
Boilers, Oil-fired	< 300,000 Btu/h	—	80% AFUE	DOE 10 CFR Part 430
	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	Minimum capacity[b]	82% E_t (See Note c, d)	DOE 10 CFR Part 431
	> 2,500,000 Btu/h[a]	Hot water	84% E_c (See Note c, d)	
		Steam	81% E_t (See Note c, d)	
Boilers, Oil-fired (Residual)	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h	Minimum capacity[b]	78% E_t and 83% E_c (See Note c, d)	DOE 10 CFR Part 431
	> 2,500,000 Btu/h[a]	Hot water	83% E_c (See Note c, d)	
		Steam	83% E_c (See Note c, d)	

For SI: 1 British thermal unit per hour = 0.2931 W.
a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Minimum ratings as provided for and allowed by the unit's controls.
c. Ec = Combustion efficiency (100 percent less flue losses). See reference document for detailed information.
d. Et = Thermal efficiency. See reference document for detailed information.
e. Alternative test procedures used at the manufacturer's option are ASME PTC-4.1 for units greater than 5,000,000 Btu/h input, or ANSI Z21.13 for units greater than or equal to 300,000 Btu/h and less than or equal to 2,500,000 Btu/h input.
f. These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

TABLE 503.2.3(6)
CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Condensing units, air cooled	≥ 135,000 Btu/h	10.1 EER 11.2 IPLV	AHRI 365
Condensing units, water or evaporatively cooled	≥ 135,000 Btu/h	13.1 EER 13.1 IPLV	

For SI: 1 British thermal unit per hour = 0.2931 W.
a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. IPLVs are only applicable to equipment with capacity modulation.

TABLE 503.2.3(7)
WATER CHILLING PACKAGES, EFFICIENCY REQUIREMENTS[a]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	AS OF 1/1/2010c				TEST PROCEDURE[b]
			PATH A		PATH B		
			FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-cooled chillers	< 150 tons	EER	≥ 9.562	≥ 12.500	NA[d]	NA[d]	AHRI 550/590
	≥ 150 tons	EER	≥ 9.562	≥ 12.750	NA[d]	NA[d]	
Air cooled without condenser, electrical operated	All capacities	EER	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water cooled, electrically operated, reciprocating	All capacities	kW/ton	Reciprocating units must comply with water cooled positive displacement efficiency requirements				
Water cooled, electrically operated, positive displacement	< 75 tons	kW/ton	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	
	≥ 75 tons and < 150 tons	kW/ton	≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	≥ 300 tons	kW/ton	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	
Water cooled, electrically operated, centrifugal	< 150 tons	kW/ton	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
	≥ 150 tons and < 300 tons	kW/ton					
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	≥ 600 tons	kW/ton	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR[e]	NA[d]	NA[d]	AHRI 560
Water-cooled, absorption single effect	All capacities	COP	≥ 0.700	NR[e]	NA[d]	NA[d]	
Absorption double effect, indirect-fired	All capacities	COP	≥ 1.000	≥ 1.050	NA[d]	NA[d]	
Absorption double effect, direct fired	All capacities	COP	≥ 1.000	≥ 1.000	NA[d]	NA[d]	

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W.

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is < 40°F.

b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or B.

d. NA means that this requirement is not applicable and cannot be used for compliance.

e. NR means that there are no minimum requirements for this category.

TABLE 503.2.3(8)
HEAT REJECTION EQUIPMENT–MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a,b,c]	TEST PROCEDURE[c,d,e]
Propeller or Axial Fan Open-Circuit Cooling Towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal Fan Open-Circuit Cooling Towers	< 1,100 gpm[f]	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Low Profile Centrifugal Fan Open-Circuit Cooling Towers[g]	≥ 1,100 gpm[f]	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 30.0 gpm/hp	CTI ATC-105 and CTI STD-201
Propeller or Axial Fan Closed-Circuit Cooling Towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ 14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal Closed-Circuit Cooling Towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201
Air-Cooled Condensers	All	125°F Condensing Temperature R-22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering db	≥ 176,000 Btu/h·hp	ARI 460

For SI: °C = [(°F) - 32]/1.8

a. For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of tower at thermal rating conditions listed in this table divided by the fan motor nameplate power.
b. For purposes of this table, closed-circuit cooling tower performance is defined as the process water flow rating of the tower at the thermal rating condition listed in this table divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate horsepower.
c. For purposes of this table, air-cooled condenser performance is defined as heat rejected from refrigerant divided by the fan motor nameplate power.
d. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
e. The efficiencies and test procedures for both open- and closed circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections.
f. Open circuit cooling towers 1,100 gpm or larger that are ducted (inlet or discharge) or have external sound attenuation that require external static pressure capability may meet the requirements of towers smaller than 1,100 gpm.
g. Low profile cooling towers, where required by local planning department, must meet the performance as specified in this table.

503.2.4.4.2 Automatic setback and shutdown capabilities. Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours. Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer capable of being adjusted to operate the system for up to 2 hours; or an occupancy sensor.

503.2.4.5 Shutoff damper controls. Both outdoor air supply and exhaust shall be equipped with not less than Class I motorized dampers with a maximum leakage rate of 4 cfm per square foot (6.8 L/s · C m^2) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D, that will automatically shut when the systems or spaces served are not in use.

Exception: Gravity dampers shall be permitted for outside air intake or exhaust airflows of 300 cfm (0.14 m^3/s) or less.

503.2.4.6 Freeze protection and snow melt system controls. Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls capable of shutting off the systems when *outdoor air* temperatures are above 40°F (4°C) or when the conditions of the protected fluid will prevent freezing. Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F (10°C) and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible.

503.2.4.7 Zone isolation controls. A system serving multiple occupancies or floors in the same building shall be independently zoned and equipped with isolation devices capable of automatically shutting off the supply of conditioned air and outside air to and from each isolated area. Each isolated area shall be controlled independently and satisfy temperature setback (see Section 503.2.4.4.1) and optimum start control requirements

(see Section 503.2.4.3). The central fan system air volume shall be reduced through fan speed reduction.

Exception: A cooling system less than 240,000 Btu/h (70 kW) or a heating system with less than 300,000 Btu/h (88 kW) total capacity.

503.2.4.8 Separate air distribution systems. Zones with special process temperature requirements and/or humidity requirements shall be served by separate air distribution systems from those serving zones requiring only comfort conditions; or shall include supplementary control provisions so that the primary systems may be specifically controlled for comfort purposes only.

Exceptions: Zones requiring only comfort heating or comfort cooling that are served by a system primarily used for process temperature and humidity control provided that:

1. The total supply air to those comfort zones is no more than 25 percent of the total system supply air, or
2. The total conditioned floor area of the zones is less than 1,000 square feet (90 m^2).

503.2.4.9 Humidity control. If a system is equipped with a means to add or remove moisture to maintain specific humidity levels in a zone or zones, a humidity control device shall be provided.

503.2.4.9.1 The humidity control device shall be set to prevent the use of fossil fuel or electricity to produce relative humidity in excess of 30 percent. Where a humidity control device is used for dehumidification, it shall be set to prevent the use of fossil fuel or electricity to reduce relative humidity below 60 percent.

Exception: Hospitals, process needs, archives, museums, critical equipment, and other noncomfort situations with specific humidity requirements outside this range.

503.2.4.9.2 Humidity controls shall maintain a deadband of at least 10 percent relative humidity where no active humidification or dehumidification takes place.

Exception: Heating for dehumidification is provided with heat recovery or heat pumping and the mechanical cooling system efficiency is 10 percent higher than required in Section 503.2.3, HVAC equipment performance requirements.

503.2.5 Ventilation. Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *Mechanical Code*. Where mechanical ventila-tion is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 4 of the *Mechanical Code*.

503.2.5.1 Demand controlled ventilation. Demand control ventilation (DCV) is required for spaces larger than 500 ft^2 (46.5 m^2) for simple systems and spaces larger than 150 ft^2 (13.9 m^2) for multiple zone systems and with an average occupant load of 25 people or more per 1000 ft^2 (93 m^2) of floor area (as established in Table 403.3 of the *Mechanical Code*) and served by systems with one or more of the following:

1. An air-side economizer;
2. Automatic modulating control of the outdoor air damper; or
3. A design outdoor airflow greater than 3,000 cfm (1400 L/s).

Exceptions:

1. Systems with energy recovery complying with Section 503.2.6.
2. Spaces less than 750 ft^2 (69.7 m^2) where an occupancy sensor turns the fan off, closes the ventilation damper, or closes the zone damper when the space is unoccupied.

503.2.5.2 Kitchen hoods. Kitchen makeup air shall be provided as required by the *Mechanical Code*. For each kitchen with a total exhaust capacity greater than 5,000 cfm (2360 L/s), 50 percent of the required makeup air shall be (a) unheated or heated to no more than 60°F (15.55°C); and (b) uncooled or evaporatively cooled.

Each kitchen with a total exhaust capacity greater than 5,000 cfm (2360 L/s) shall be equipped with a demand ventilation system on at least 75 percent of the exhaust and makeup air. Such systems shall be equipped with automatic controls that reduce airflow in response to cooking appliance operation.

Exceptions:

1. Where hoods are used to exhaust ventilation air that would otherwise be exhausted by other fan systems. Air transferred from spaces served by other fan systems may not be used if those systems are required to meet either Sections 503.2.5.1 or 503.2.6. Occupancy schedule of HVAC system supplying transfer air shall be similar to kitchen exhaust hood operating schedule.
2. Kitchen exhaust systems that include exhaust air energy recovery complying with Section 503.2.6.

503.2.5.3 Enclosed parking garage ventilation controls. In Group S-2, enclosed parking garages used for storing or handling automobiles operating under their own power having ventilation exhaust rates 30,000 cfm (14 157 L/s) and greater shall employ automatic carbon monoxide sensing devices. These devices shall modulate the ventilation system to maintain a maximum average concentration of carbon monoxide of 50 parts per million during any 8-hour period, with a maximum concentration not greater than 200 parts per million for a period not exceeding 1 hour. The system shall be capable of producing a ventilation rate of 1.5 cfm per square foot ($0.0076 m^3/s \cdot m^2$) of floor area. Failure of such devices shall cause the exhaust fans to operate in the ON position.

503.2.6 Energy recovery ventilation systems. Individual fan systems that have both a design supply air capacity of 5,000 cfm (2.36 m^3/s) or greater and a minimum outside air supply of 70 percent or greater of the design supply air quantity shall have an energy recovery system that provides a change in the enthalpy of the outdoor air supply of 50 percent or more of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the energy recovery system to permit cooling with outdoor air where cooling with outdoor air is required. Where a single room or space is supplied by multiple units, the aggregate supply (cfm) of those units shall be used in applying this requirement.

Exception: An energy recovery ventilation system shall not be required in any of the following conditions:

1. Where energy recovery systems are prohibited by the *Mechanical Code*.
2. Laboratory fume hood systems that include at least one of the following features:
   - 2.1. Variable-air-volume hood exhaust and room supply systems that reduce exhaust and makeup air volume to 50 percent or less of design values during periods of reduced occupancy or system demand.
   - 2.2. Variable-air-volume hood exhaust and room supply systems that reduce exhaust and makeup air volume and/or incorporate a heat recovery system to precondition makeup air from laboratory exhaust shall meet the following:

     A + B*(E/M) = 50%

     where:

     A = Percentage that the exhaust and makeup airflow rates will be reduced from design conditions.

     B = Percentage sensible heat recovery effectiveness.

     E = Exhaust airflow rate through the heat recovery device at design conditions

     M= Makeup air flow rate of the system at design conditions
   - 2.3. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (1.1°C) below room setpoint, cooled to no cooler than 3°F (1.7°C) above room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
3. Systems serving spaces that are not cooled and are heated to less than 60°F (15.5°C).
4. here more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
5. Type 1 kitchen exhaust hoods.
6. Cooling systems in climates with a 1-percent cooling design wet-bulb temperature less than 64°F (18°C).
7. Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil when the evaporative coil is located upstream of the exhaust air stream.
8. Systems exhausting toxic, flammable, paint exhaust, corrosive fumes or dust.

503.2.7 Duct and plenum insulation and sealing. All supply and return air ducts and plenums shall be insulated with a minimum of R-5 insulation when located in unconditioned spaces and a minimum of R-8 insulation when located outside the building. When located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-8 insulation.

Exceptions:

1. When located within equipment.
2. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C).

All ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the *Mechanical Code*.

503.2.7.1 Duct construction. Ductwork shall be constructed and erected in accordance with the *Mechanical Code.*

503.2.7.1.1 Low-pressure duct systems. All longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches w.g. (500 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *Mechanical Code.*

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.

503.2.7.1.2 Medium-pressure duct systems. All ducts and plenums designed to operate at a static pressure greater than 2 inches w.g. (500 Pa) but less than 3 inches w.g. (750 Pa) shall be insulated and sealed in accordance with Section 503.2.7. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *Mechanical Code.*

503.2.7.1.3 High-pressure duct systems. Ducts designed to operate at static pressures in excess of 3 inches w.g. (746 Pa) shall be insulated and sealed in accordance with Section 503.2.7. In addition, ducts and plenums shall be leak-tested in accordance with

the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage (CL) less than or equal to 6.0 as determined in accordance with Equation 5-2.

$$CL = F \times P^{0.65} \quad \textbf{(Equation 5-2)}$$

where:

F = The measured leakage rate in cfm per 100 square feet of duct surface.

P = The static pressure of the test.

Documentation shall be furnished by the designer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

503.2.8 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 503.2.8.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 60°F (14°C) and 105°F (41°C).
4. Runout piping not exceeding 4 feet (1219 mm) in length and 1 inch (25 mm) in diameter between the control valve and HVAC coil.

TABLE 503.2.8
MINIMUM PIPE INSULATION
(thickness in inches)

FLUID	NOMINAL PIPE DIAMETER	
	≤ 1.5″	> 1.5″
Steam	$1^1/_2$	3
Hot water	$1^1/_2$	2
Chilled water, brine or refrigerant	$1^1/_2$	$1^1/_2$

For SI: 1 inch = 25.4 mm.

a. Based on insulation having a conductivity (k) not exceeding 0.27 Btu per inch/h · ft^2 · °F.

b. For insulation with a thermal conductivity not equal to 0.27 Btu · inch/h · ft^2 · °F at a mean temperature of 75°F, the minimum required pipe thickness is adjusted using the following equation;

$T = r[(1+t/r)^{K/k}-1]$

where:

T = Adjusted insulation thickness (in).

r = Actual pipe radius (in).

t = Insulation thickness from applicable cell in table (in).

K = New thermal conductivity at 75°F (Btu · in/hr · ft^2 · °F).

k = 0.27 Btu · in/hr · ft^2 · °F.

503.2.9 HVAC system completion.

503.2.9.1 Air system balancing. Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *Mechanical Code*. Discharge dampers intended to modulate airflow are prohibited on constant volume fans and variable volume fans with motors 10 horsepower (hp) (7.5 kW) and larger.

503.2.9.2 Hydronic system balancing. Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections.

503.2.9.3 Manuals. The construction documents shall require that an operating and maintenance manual be provided to the building owner by the mechanical contractor. The manual shall include, at least, the following:

1. Equipment capacity (input and output) and required maintenance actions.
2. HVAC system control maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-determined setpoints shall be permanently recorded on control drawings, at control devices or, for digital control systems, in programming comments.
3. A complete written narrative of how each system is intended to operate.

503.2.10 Air system design and control. Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) (3.7 kW) shall meet the provisions of Sections 503.2.10.1 through 503.2.10.2.

503.2.10.1 Allowable fan floor horsepower. Each HVAC system at fan system design conditions shall not exceed the allowable fan system motor nameplate hp (Option 1) or fan system bhp (Option 2) as shown in Table 503.2.10.1(1). This includes supply fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability.

Exceptions:

1. Hospital and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.
2. Individual exhaust fans with motor nameplate horsepower of 1 hp (0.7 kW) or less.

503.2.10.2 Motor nameplate horsepower. For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp). The fan brake horsepower (bhp) shall be indicated on the design documents to allow for compliance verification by the *code official*.

Exceptions:

1. For fans less than 6 bhp, where the first available motor larger than the brake horsepower has a nameplate rating within 50 percent of the bhp, selection of the next larger nameplate motor size is allowed.

503.2.11 Heating outside a building. Systems installed to provide heat outside a building shall be radiant systems. Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically deenergized when no occupants are present.

503.2.12 Hot gas bypass limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table 503.2.12.

Exception: Unitary packaged systems with cooling capacities not greater than 90,000 Btu/h (26 379 W).

TABLE 503.2.12
MAXIMUM HOT GAS BYPASS CAPACITY

RATED CAPACITY	MAXIMUM HOT GAS BYPASS CAPACITY (% of total capacity)
< 240,000 Btu/h	50%
> 240,000 Btu/h	25%

For SI: 1 Btu/h = 0.2931 watts.

503.3 Simple HVAC systems and equipment (Prescriptive). This section applies to buildings served by unitary or packaged HVAC equipment listed in Tables 503.2.3(1) through 503.2.3(5), each serving one zone and controlled by a single thermostat in the zone served. It also applies to two-pipe heating systems serving one or more zones, where no cooling system is installed.

This section does not apply to fan systems serving multiple zones, nonunitary or nonpackaged HVAC equipment and systems or hydronic or steam heating and hydronic cooling equipment and distribution systems that provide cooling or cooling and heating which are covered by Section 503.4.

> **503.3.1 Economizers.** Supply air economizers shall be provided on each cooling system and shall be capable of providing 100-percent outdoor air, even if additional mechanical cooling is required to meet the cooling load of the building. Systems shall provide a means to relieve excess outdoor air during economizer operation to prevent overpressurizing the building. The relief air outlet shall be located to avoid recirculation into the building. Where a single room or space is supplied by multiple air systems, the aggregate capacity of those systems shall be used in applying this requirement.

> **Exceptions:**

1. Cooling equipment less than 54,000 Btu/h (15 827 W) total cooling capacity. The total capacity of all such units without economizers shall not exceed 240,000 Btu/h (70 342 W) per building area served by one utility meter or service, or 10 percent of its total installed cooling capacity, whichever is greater. That portion of the equipment serving dwelling units and guest rooms is not included in determining the total capacity of units without economizers.
2. Economizer cooling is not required for new cooling systems serving an existing dedicated computer server room, electronic equipment room or telecom switch room in existing buildings up to a total of 600,000 Btu/h (17 586 W) of new cooling equipment.
3. Economizer cooling is not required for new cooling systems serving a new dedicated computer server room, electronic equipment room or telecom switch room in existing buildings up to a total of 240,000 Btu/h (70 344 W) of new cooling equipment.

503.3.2 Hydronic system controls. Hydronic systems of at least 300,000 Btu/h (87 930W) design output capacity supplying heated and chilled water to comfort conditioning systems shall include controls that meet the requirements of Section 503.4.3. <

503.4 Complex HVAC systems and equipment. (Prescritive). This section applies to buildings served by HVAC equipment and systems not covered in Section 503.3.

503.4.1 Economizers. Supply air economizers shall be provided on each cooling system and shall be capable of operating at 100 percent outside air, even if additional mechanical cooling is required to meet the cooling load of the building. <

Exceptions:

1. Systems utilizing water economizers that are capable of cooling supply air by direct or indirect evaporation or both and providing 100 percent of the expected system cooling load at outside air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and below.
2. Cooling equipment less than 54,000 Btu/h (15 827 W) total cooling capacity. The total capacity of all such units without economizers shall not exceed 240,000 Btu/h (70 342 W) per building area served by one utility meter or service, or 10 percent of its total installed cooling capacity, whichever is greater. That portion of the equipment serving dwelling units and guest rooms is not included in determining the total capacity of units without economizers.
3. Ground-coupled heat pumps with cooling capacity of 54,000 Btu/h (15 827 W) or less.
4. Systems where internal/external zone heat recovery is used.
5. Systems used to cool any dedicated computer server room, electronic equipment room or telecom switch room having a water economizer system capable of cooling air by direct and/or indirect evaporation and providing 100 percent of the expected systems cooling load at outside air temperatures of 45ºF (7°C) dry bulb and 40°F (8°C) wet bulb and below.
6. Economizer cooling is not required for new cooling systems serving an existing dedicated computer server room, electronic equipment room or telecom switch room in existing buildings up to a

total of 600,000 Btu/h (17 586 W) of new cooling equipment.

7. Economizer cooling is not required for new cooling systems serving a new dedicated computer server room, electronic equipment room or telecom switch room in existing buildings up to a total of 240,000 Btu/h (70 344 W) of new cooling equipment.
8. Systems using condenser heat recovery, up to the cooling capacity used to provide condenser heat recovery.

503.4.2 Variable air volume (VAV) fan control. Individual VAV fans with motors of 10 horsepower (7.5 kW) or greater shall be:

1. Driven by a mechanical or electrical variable speed drive; or
2. The fan motor shall have controls or devices that will result in fan motor demand of no more than 30 percent of their design wattage at 50 percent of design airflow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

For systems with direct digital control of individual zone boxes reporting to the central control panel, the static pressure set point shall be reset based on the zone requiring the most pressure, i.e., the set point is reset lower until one zone damper is nearly wide open.

503.4.3 Hydronic systems controls. The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections 503.4.3.1 through 503.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls capable of sequencing operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h input design capacity shall include either a multistaged or modulating burner.

503.4.3.1 Three-pipe system. Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

503.4.3.2 Two-pipe changeover system. Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a dead band between changeover from one mode to the other of at least 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for at least 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F (16.7°C) apart.

503.4.3.3 Hydronic (water loop) heat pump systems. Hydronic heat pump systems shall comply with Sections 503.4.3.3.1 through 503.4.3.3.3.

503.4.3.3.1 Temperature dead band. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature dead band of at least 20°F (11.1°C) between initiation of heat rejection and heat addition by the central devices.

Exception: Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on realtime conditions of demand and capacity, dead bands of less than 20°F (11°C) shall be permitted.

503.4.3.3.2 Heat rejection. Heat rejection equipment shall comply with this section.

1. If a closed-circuit cooling tower is used directly in the heat pump loop, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower, or lower leakage positive closure dampers shall be provided.
2. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower.
3. If an open- or closed-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the cooling tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

Exception: Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.

503.4.3.3.3 Two position valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 horsepower (hp) (7.5 kW) shall have an automatic two-position valve or be served by a dedicated pump with check valve for each heat pump.

503.4.3.4 Part load controls. Hydronic systems greater than or equal to 300,000 Btu/h (87 930W) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that:

1. Automatically reset the supply-water tempera-tures using zone-return water temperature, building-return water temperature, or outside air temperature as an indicator of building heating or cooling demand. The temperature shall be capable of being reset by at least 25 percent of the design supply-to-return water temperature difference; or
2. For pumping systems less than 5hp (4 kW) reduce system pump flow by at least 50 percent of design flow rate utilizing adjustable speed drive(s) on pump(s), or multiple-staged pumps where at least one-half of the total pump horsepower is capable of being automatically turned

off and control valves designed to modulate or step down, and close, as a function of load, or other *approved* means.

3. For pumping systems greater than 5hp (4 kW) reduce system pump flow by at least 50 percent of design flow rate utilizing adjustable speed drive(s) on pump(s) and control valves designed to modulate or step down, and close, as a function of load, or other *approved* means.

Exception: Dedicated equipment circulation pumps designed to meet minimum flow requirements established by the manufacturer, such as boiler or chiller auxiliary circulation pumps.

503.4.3.5 Pump isolation. Chilled water plants including more than one chiller shall have the capability to reduce flow automatically through the chiller plant when a chiller is shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

Boiler plants including more than one boiler shall have the capability to reduce flow automatically through the boiler plant when a boiler is shut down.

503.4.3.6 Heating and cooling water pump control. Water circulation systems serving heating coil(s) or cooling coil(s) shall have controls that lock out pump operation when there is no demand. The pumps shall shut off based on the following outside air lock out temperatures: hot water pump whenever outside air temperature is 70°F (21°C) or higher, cooling water pump when outside air temperature is 55°F (13°C) or lower.

Exceptions:

1. Industrial process and humidity control process,
2. Hot water reheat for terminal units,
3. Hot water circulation systems used to provide multiple functions (e.g., space heating, service water heating - DHW) as an integrated system.
4. Pumps serving water side economizer functions, systems.

503.4.3.7 Tower flow turndown. Open cooling towers configured with multiple condenser water pumps shall be designed so that all cells can be run in parallel with a turndown flow that is the larger of (1) the flow produced by the smallest pump or (2) 50 percent of the design flow for the cell.

503.4.4 Heat rejection equipment fan speed control. Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exception: Factory-installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables 503.2.3(6) and 503.2.3(7).

503.4.5 Requirements for complex mechanical systems serving multiple zones. Sections 503.4.5.1 through 503.4.5.3 shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be VAV systems which, during periods of occupancy, are designed controlled to comply with all of the following:

1. Reduce primary air supply to each zone to one of the following when the zone temperature is in a 5°F (3°C) zone temperature dead band after cooling is no longer required and before reheating, recooling or mixing takes place:
   - 1.1 Twenty percent of the maximum supply air to each zone.
   - 1.2 Three hundred cfm (142 L/s) or less where the maximum flow rate is less than 10 percent of the total fan system supply airflow rate.
   - 1.3 The minimum ventilation requirements of Chapter 4 of the *Mechanical Code* unless increasing the volume to critical zones (zones with the highest ratio of outside air to total supply air) beyond the minimum ventilation requirements results in a decrease in overall outside air required by the HVAC system. An increase beyond minimum ventilation rates shall not be applied to more than 20 percent of the zones with reheat.
2. The volume of air that is reheated, recooled, or mixed in peak heating demand shall be less than 50 percent of the *zone* design peak supply rate
3. Airflow between *dead band* and full heating or full cooling shall be modulated.

Exception: The following define when individual zones or when entire air distribution systems are exempted from the requirement for VAV control:

1. Zones where special pressurization relationships or cross-contamination requirements are such that VAV systems are impractical.
2. Zones or supply air systems where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. Zones where special humidity levels are required to satisfy process needs.
4. Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.

5. Zones where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *Mechanical Code*.
6. Zones or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the zone(s) and prevent reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

503.4.5.1 Single duct variable air volume (VAV) systems, terminal devices. Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place.

503.4.5.2 Dual duct and mixing VAV systems, terminal devices. Systems that have one warm air duct and one cool air duct shall use terminal devices which reduce the flow from one duct to a minimum before mixing of air from the other duct takes place.

503.4.5.3 Supply-air temperature reset controls. HVAC systems serving multiple zones, including dedicated outside air systems shall include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be capable of resetting the supply air temperature at least 35 percent of the difference between the design supply-air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity control requirements are allowed. Zones which are expected to experience relatively constant loads, such as electronic equipment rooms or interior zones without reheat, shall be designed for the fully reset supply temperature.

Exceptions:

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. 75 percent of the energy for reheating is from site-recovered or site solar energy sources.

503.4.5.4 Heat recovery for reheat and service water heating. Where the total installed heat rejection capacity of water-cooled chillers exceeds 6,000,000 Btu/h (1 758 600 W) and the combined design reheat, dual duct heating, and service water heating load exceeds 1,000,000 Btu/h (293 100W), all the following shall apply:

1. Condenser heat recovery shall be installed for heating or preheating of service hot water, heating water for reheat, or dual-duct system heating.
2. Reheat coils and dual duct heating coils shall be hydronic; except VAV zones with design airflow less than 500 cfm (236 L/s) may have electric reheat.
3. The required heat recovery system shall have the capacity to provide the smaller of:
   3.1. 30 percent of the peak heat rejection load at design conditions; or
   3.2. The preheating required to raise the peak service hot water draw to 85°F (29°C) plus 10 percent of the design reheat or dual-duct heating load.

Exception: Facilities that provide 25 percent of their combined design service water heating, reheat, and Dual Duct heating from site solar or site recovered energy, such as geothermal heat recovery or combined heat and power.

503.4.6 Limited use of air cooled chillers. Chilled water plants with more than 300 tons (304 814 kg) total capacity shall not have more than 100 tons (101 605 kg) provided by air-cooled chillers.

Exception: Air-cooled chillers with minimum efficiencies equal to or greater than approved water-cooled equipment.

SECTION 504
SERVICE WATER HEATING
(Mandatory)

504.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

504.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table 504.2. The efficiency shall be verified through data furnished by the manufacturer or through certification under an *approved* certification program.

504.3 Temperature controls. Service water-heating equipment shall be provided with controls to allow a setpoint of 110°F (43°C) for equipment serving dwelling units and 90°F (32°C) for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to 110°F (43°C).

504.4 Heat traps. Water-heating equipment not supplied with integral heat traps and serving noncirculating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

504.5 Pipe insulation. For automatic-circulating hot water and externally heated (such as heat trace or impedance heating) systems, piping shall be insulated with 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h $ft^2 \times °F$ (1.53 W per 25 $mm/m^2 \times K$). The first 8 feet (2438 mm) of piping in noncirculating systems served by equipment without integral heat traps shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h $\times$ $ft^2 \times °F$ (1.53 W per 25 $mm/m^2 \times K$).

TABLE 504.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Water heaters, Electric	≤ 12 kW	Resistance ≥ 20 gal	0.97 - 0.00132V, EF	DOE 10 CFR Part 430
	> 12 kW	Resistance ≥ 20 gal	1.73V + 155 SL, Btu/h	Section G.2 of ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00132V, EF	DOE 10 CFR Part 430
Storage water heaters, Gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019V, EF	DOE 10 CFR Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E^t $\left(Q / 800 + 110\sqrt{V}\right)$ SL, Btu/h	Sections G.1 and G.2 of ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E^t $\left(Q / 800 + 110\sqrt{V}\right)$ SL, Btu/h	
Instantaneous water heaters, Gas	> 50,000 Btu/h and < 200,000 Btu/hc	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.0019V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E^t	Sections G.1 and G.2 of ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E^t $\left(Q / 800 + 110\sqrt{V}\right)$ SL, Btu/h	
Storage water heaters, Oil	≤ 105,000 Btu/h	≥ 20 gal	0.59 - 0.0019V, EF	DOE 10 CFR Part 430
	> 105,000 Btu/h	< 4,000 Btu/h/gal	78% E^t $\left(Q / 800 + 110\sqrt{V}\right)$ SL, Btu/h	Sections G.1 and G.2 of ANSI Z21.10.3
Instantaneous water heaters, Oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	DOE 10 CFR Part 430
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E^t	Sections G.1 and G.2 of ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E^t $\left(Q / 800 + 110\sqrt{V}\right)$ SL, Btu/h	
Hot water supply boilers, Gas and Oil	≥ 300,000 Btu/h and <12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E^t	Sections G.1 and G.2 of ANSI Z21.10.3
Hot water supply boilers, Gas	≥ 300,000 Btu/h and <12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E^t $\left(Q / 800 + 110\sqrt{V}\right)$ SL, Btu/h	
Hot water supply boilers, Oil	> 300,000 Btu/h and <12,500,000 Btu/h	> 4,000 Btu/h/gal and > 10 gal	78% E^t $\left(Q / 800 + 110\sqrt{V}\right)$ SL, Btu/h	
Pool heaters, Gas and Oil	All	—	78% E^t	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 (h · ft² · °F)/Btu	(none)

For SI: °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

a. Energy factor (EF) and thermal efficiency (Et) are minimum requirements. In the EF equation, V is the rated volume in gallons.

b. Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.

c. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

504.6 Hot water system controls. Systems designed to maintain usage temperatures in hot water pipes, such as hot water recirculating systems or heat trace, shall be turned off automatically when the hot water system is not operational and shall have demand sensing controls (flow switch in cold water make-up pipe, return water aquastat temperature sensor) that turn off the system when there is no demand when the system is operational. A check valve or similar device shall be located between the circulator pump and the water heating equipment to prevent water from flowing backwards though the recirculation loop.

Exceptions:

1. Where public health standards require 24 hours per day operation of pumps for uses such as swimming pools, spas and hospitals.
2. Service water heating systems used to provide multiple functions (e.g., space heating and DHW) as part of an integrated system.
3. Where coupled with water heating capacity less than 100,000 Btu/h (29 kW).

504.7 Pools, spas and hottubs. Pools, spas and hottubs shall be provided with energy conserving measures in accordance with Sections 504.7.1 through 504.7.3.

504.7.1 Heaters. All heaters shall be equipped with a readily *accessible* on-off switch to allow shutting off the heater without adjusting the thermostat setting. Heaters fired by natural gas or LPG shall not have continuously burning pilot lights.

504.7.2 Time switches. Time switches that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on heaters and pumps.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Where pumps are required to operate solar-and waste-heat-recovery heating systems.

504.7.3 Covers. Heated pools, spas and hottubs shall be equipped with a vapor retardant cover on or at the water surface. Pools, spas and hottubs heated to more than 90°F (32°C) shall have a cover with a minimum insulation value of R-12.

Exception: Pools, spas and hottubs deriving over 60 percent of the energy for heating from site-recovered energy or solar energy source.

504.7.4 Heat recovery. Heated indoor swimming pools, spas, or hot tubs with water surface area greater than 200 square feet (19 m²) shall provide for energy conservation by an exhaust air heat recovery system that heats ventilation air, pool water, or domestic hot water. The heat recovery system shall be capable of decreasing the exhaust air temperature at design heating conditions by 28°F (15.5°C).

Exception: Pools, spas, or hot tubs that include system(s) that provide equivalent recovered energy on an annual basis through one of the following methods:

1. Heated by renewable energy,
2. Dehumidification heat recovery when the evaporative coil is located upstream of the exhaust air stream,
3. Waste heat recovery, or
4. A combination of these system(s) sources capable of providing at least 70 percent of the heating energy required over an operating season.

SECTION 505
ELECTRICAL POWER AND LIGHTING SYSTEMS (Mandatory)

505.1 General (Mandatory). This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior applications and minimum acceptable lighting equipment for exterior applications.

Exception: Lighting within dwelling units where 50 percent or more of the permanently installed interior light fixtures are fitted with high-efficacy lamps.

505.2 Lighting controls (Mandatory). Lighting systems shall be provided with controls as required in Sections 505.2.1, 505.2.2, 505.2.3 and 505.2.4.

505.2.1 Interior lighting controls. At least one local shut-off lighting control shall be provided for every 2,000 square feet (185.8 m²) of lit floor area and each area enclosed by walls or floor-to-ceiling partitions. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status.

Exceptions:

1. Lighting systems serving areas designated as security or emergency areas that must be continuously lighted.
2. Lighting in public areas such as concourses, stairways or corridors that are elements of the means of egress with switches that are accessible only to authorized personnel.
3. Lighting for warehouses, parking garages or spaces using less than 0.5 watts per square foot (5.4 W/m²).
4. Lighting for contiguous, single-tenant retail spaces.

505.2.1.1 Egress lighting. Egress illumination shall be controlled by a combination of listed emergency relay and occupancy sensors to shut off during periods that the building space served by the means of egress is unoccupied.

Exception: Building exits as defined in Section 1002 of the *Building Code.*

505.2.2 Additional controls. Each area that is required to have a manual control shall have additional controls that meet the requirements of Sections 505.2.2.1 and 505.2.2.2.

505.2.2.1 Light reduction controls. Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a rea-

sonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other *approved* method:

1. Controlling all lamps or luminaires (dimming or multi-level switching);
2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps;
3. Switching the middle lamp luminaires independently of the outer lamps; or
4. Switching each luminaire or each lamp.

Exceptions:

1. Areas that have only one luminaire.
2. Areas that are controlled by an occupant-sensing device.
3. Corridors, storerooms, restrooms or public lobbies.
4. *Sleeping unit* (see Section 505.2.3).
5. Spaces that use less than 0.6 watts per square foot (6.5 W/m^2).
6. Electrical and mechanical rooms.

505.2.2.2 Automatic lighting shutoff. Buildings larger than 2,000 square feet (186 m^2) shall be equipped with an automatic control device to shut off lighting in those areas. This automatic control device shall function on either:

1. A scheduled basis, using time-of-day, with an independent program schedule that controls the interior lighting in areas that do not exceed 10,000 square feet (929 m^2) and are not more than one floor; or
2. An occupant sensor that shall turn lighting off within 30 minutes of an occupant leaving a space; or
3. A signal from another control or alarm system that indicates the area is unoccupied.

Occupancy sensors in rooms that include daylight zones are required to have Manual ON activation,

An occupant sensor control device shall be installed that automatically turns lighting off within 30 minutes of all occupants leaving a space, except spaces with multi-scene control, in:

1. Classrooms and lecture halls
2. Conference, meeting and training rooms.
3. Employee lunch and break rooms.
4. Rooms used for document copying and printing.
5. Office spaces up to 300 square feet (29 m^2).
6. Restrooms.
7. Dressing, fitting and locker rooms.

An occupant sensor control device that automatically turns lighting off within 30 minutes of all occupants leaving a space or a locally activated switch that automatically turns lighting off within 30 minutes of being activated shall be installed in all storage and supply rooms up to 1000 square feet (93 m^2).

Exception: The following shall not require an auto matic control device:

1. *Sleeping unit* (see Section 505.2.3)
2. Lighting in spaces where patient care is directly provided.
3. Spaces where an automatic shutoff would endanger occupant safety or security.

505.2.2.2.1 Occupant override. Where an automatic time switch control device is installed to comply with Section 505.2.2.2, Item 1, it shall incorporate an override switching device that:

1. Is readily *accessible*.
2. Is located so that a person using the device can see the lights or the area controlled by that switch, or so that the area being lit is annunciated.
3. Is manually operated.
4. Allows the lighting to remain on for no more than 2 hours when an override is initiated.
5. Controls an area not exceeding 2,000 square feet (185.8 m^2).

Exceptions:

1. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, where captive-key override is utilized, override time shall be permitted to exceed 2 hours.
2. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, the area controlled shall not exceed 20,000 square feet (1860 m^2).

505.2.2.2.2 Holiday scheduling. If an automatic time switch control device is installed in accordance with Section 505.2.2.2, Item 1, it shall incorporate an automatic holiday scheduling feature that turns off all loads for at least 24 hours, then resumes the normally scheduled operation.

Exceptions:

1. Retail stores and associated malls, restaurants, grocery stores, places of religious worship, theaters and exterior lighting zones.
2. Single zone electronic time control devices and self-contained wall box preset lighting controls.

505.2.2.3 Daylight zone control. All daylight zones, as defined by this code, shall be provided with individual controls that control the lights independent of general area lighting in the nondaylight zone. In all individual daylight zones larger than 350 square feet (33 m^2), automatic daylight controls shall be provided.

Automatic daylight sensing controls shall reduce the light output of the controlled luminaires within the daylighted area by at least 50 percent, and provide an automatic OFF control, while maintaining a uniform level of illumination.

Contiguous daylight zones adjacent to vertical fenestration are allowed to be controlled by a single controlling device provided that they do not include zones facing more than two adjacent cardinal orientations (i.e., north, east, south, west). Daylight zones under skylights shall be controlled separately from daylight zones adjacent to vertical fenestration.

Exceptions:

1. Retail spaces adjacent to vertical glazing (retail spaces under overhead glazing are not exempt).
2. Display, exhibition and specialty lighting.
3. HID lamps 150 watts or less.
4. Spaces required to have occupancy sensors.

505.2.3 Sleeping unit controls. *Sleeping units* in hotels, motels, boarding houses or similar buildings shall have at least one master switch at the main entry door that controls all permanently wired luminaires and switched receptacles, except those in the bathroom(s). Suites shall have a control meeting these requirements at the entry to each room or at the primary entry to the suite.

505.2.4 Exterior lighting controls. Lighting not designated for dusk-to-dawn operation shall be controlled by either a combination of a photosensor and a time switch, or an astronomical time switch. Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. All time switches shall retain programming and the time setting during loss of power for a period of at least 10 hours. Lighting designated to operate more than 2000 hours per year for uncovered parking areas shall be equipped with motion sensors that will reduce the luminaire power by 33 percent or turn off one-third the luminaires when no activity is detected.

505.3 Tandem wiring (Mandatory). The following luminaires located within the same area shall be tandem wired:

1. Fluorescent luminaires equipped with one, three or odd-numbered lamp configurations, that are recess-mounted within 10 feet (3048 mm) center-to-center of each other.
2. Fluorescent luminaires equipped with one, three or any odd-numbered lamp configuration, that are pendant- or surface-mounted within 1 foot (305 mm) edge-to-edge of each other.

Exceptions:

1. Where electronic high-frequency ballasts are used.
2. Luminaires on emergency circuits.
3. Luminaires with no available pair in the same area.

505.4 Exit signs (Mandatory). Internally illuminated exit signs shall not exceed 5 watts per side.

505.5 Interior lighting power requirements (Prescriptive). A building complies with this section if its total connected lighting power calculated under Section 505.5.1 is no greater than the interior lighting power calculated under Section 505.5.2 or 505.5.2.1.

505.5.1 Total connected interior lighting power. The total connected interior lighting power (watts) shall be the sum of the watts of all interior lighting equipment as determined in accordance with Sections 505.5.1.1 through 505.5.1.4.

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
   1.1. *Sleeping unit* lighting in hotels, motels, boarding houses or similar buildings.
   1.2. Emergency lighting automatically off during normal building operation.
   1.3. Lighting in spaces specifically designed for use by occupants with special lighting needs including the visually impaired visual impairment and other medical and age-related issues.
   1.4. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
   1.5 Casino gaming areas.
2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:
   2.1. Task lighting for medical and dental purposes.
   2.2. Display lighting for exhibits in galleries, museums and monuments.
3. Lighting for theatrical purposes, including performance, stage, film production and video production.
4. Lighting for photographic processes.
5. Lighting integral to equipment or instrumentation and is installed by the manufacturer.
6. Task lighting for plant growth or maintenance.
7. Advertising signage or directional signage.
8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
9. Lighting equipment that is for sale.
10. Lighting demonstration equipment in lighting education facilities.
11. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.

12. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
13. Furniture mounted supplemental task lighting that is controlled by automatic shutoff.

505.5.1.1 Screw lamp holders. The wattage shall be the maximum *labeled* wattage of the luminaire.

505.5.1.2 Low-voltage lighting. The wattage shall be the specified wattage of the transformer supplying the system.

505.5.1.3 Other luminaires. The wattage of all other lighting equipment shall be the wattage of the lighting equipment verified through data furnished by the manufacturer or other *approved* sources.

505.5.1.4 Line-voltage lighting track and plug-in busway. The wattage shall be:

1. The specified wattage of the luminaires included in the system with a minimum of 50W/lin ft. (98 W/lin. m);
2. The wattage limit of the system's circuit breaker; or
3. The wattage limit of other permanent current limiting device(s) on the system.

505.5.2 Interior lighting power method. The total interior lighting power (watts) is the sum of all interior lighting powers for all areas in the building covered in this permit. The interior lighting power is the floor area for each building area type listed in Table 505.5.2(a) times the value from Table 505.5.2(a) for that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single building area type as listed in Table 505.5.2(a). When this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area.

505.5.2.1 Space-by-space method. The total interior connected lighting power shall not exceed the maximum power allowance calculated by multiplying the lighting power density from Table 505.5.2(b) for each space by the floor area of that space. Parking garages and exterior canopies shall be treated separately from the building for the purposes of calculating interior connected lighting power.

505.5.2.1.1 Additional lighting power for retail displays. For lighting equipment installed in retail sales area that is specifically designed and directed to highlight merchandise, one of the following may apply:

1. 0.6 watts per square foot of sales floor area not listed in 2 or 3 below; or
2. 1.4 watts per square foot of furniture, clothing, cosmetics or artwork floor area; or
3. 2.5 watts per square foot of jewelry, crystal; or china floor area.

The specified floor area for 1, 2, and 3 above, and the adjoining circulation paths shall be identified and specified on building plans. Calculate the additional power allowance by multiplying the above LPDs by the sales floor area for each department excluding major circulation paths. The total additional lighting power allowance is the sum of allowances sales categories, 1, 2, or 3. This additional lighting power shall only be used for retail display lighting in the applicable space, and shall not be used to increase lighting power allowance with other spaces or general lighting system within the space and shall be controlled separately from the space general lighting system.

TABLE 505.5.2(a)
INTERIOR LIGHTING POWER ALLOWANCES

LIGHTING POWER DENSITY	
Building Area Type[a]	(W/ft^2)
Automotive Facility	0.79
Convention Center	1.16
Court House	1.08
Dining: Bar Lounge/Leisure	1.19
Dining: Cafeteria/Fast Food	1.34
Dining: Family	1.5
Dormitory	1.0
Exercise Center	0.92
Gymnasium	1.07
Healthcare—clinic	0.89
Hospital	1.08
Hotel	1.0
Library	1.17
Manufacturing Facility	1.24
Motel	1.0
Motion Picture Theater	1.18
Multifamily	0.58
Museum	1.04
Office	0.91
Parking Garage	0.26
Penitentiary	1.0
Performing Arts Theater	1.46
Police	0.89
Fire Station	0.74
Post Office	0.98
Religious Building	1.18
Retail[b]	1.32
School/University	1.01
Sports Arena	1.03
Town Hall	0.94
Transportation	0.85
Warehouse	0.73
Workshop	1.2

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m^2.

TABLE 505.5.2(b)
SPACE-BY-SPACE METHOD MAXIMUM ALLOWABLE LIGHTING POWER DENSITY (LPD)

COMMON SPACE TYPES	LPD (W/ft²)[1]
Office-enclosed[2]	0.97
Office-open plan[2]	0.93
Conference/Meeting/Multipurpose[3]	1.11
Classroom/Lecture/Training	1.23
Lobby	1.28
For Hotel	1.1
For Performing Arts Theater	3.24
For Motion Picture Theater	1.01
Audience/Seating Area	0.84
For Gymnasium	0.4
For Exercise Center	0.27
For Convention Center	0.7
For Religious Buildings	1.60
For Sports Complex	0.4
For Performing Arts Theater	2.52
For Motion Picture Theater	1.11
For Transportation	0.46
Atrium-first three floors	0.6
Atrium-each additional floors	0.16
Lounge/Recreation	1.16
For Hospital	0.71
Dining Area[2]	—
For Hotel/Motel	1.23
For Bar Lounge/Leisure Dining	1.4
For Family Dining	2.1
Food Preparation	1.07
Laboratory	1.4
Restrooms	0.82
Dressing/Locker Room	0.52
Corridor/Transition	0.41
For Hospital	0.94
For Manufacturing Facility	0.41
Stairs-active	0.49
Active Storage	0.66
For Hospitals	0.79
Inactive Storage	0.26
For Museum	0.66
Electrical/Mechanical	1.24
Workshop[4]	1.64
BUILDING SPECIFIC SPACE TYPES	
Courthouse/Police Station	—
Courtroom	1.78
Judges Chambers	1.18
Gymnasium/Exercise Center	—
Playing Area	1.35
Exercise Area	0.76
Fire Stations	—
Fire Station Engine Room	0.64
Sleeping Quarters	0.27
Post Office - Sorting Area	1.01
Convention Center - Exhibit Space[3]	1.09
Library[2]	—
Card File and Cataloging	0.96
Stacks	1.47
Reading Area	1.07
Hospital	—
Emergency	2.34
Recovery	0.74
Nurse Station	0.85
Exam/Treatment Room	1.26
Pharmacy	0.99
Patient Room	0.59
Operating Room	1.92
Nursery	0.48
Medical Supply	1.23
Physical Therapy	0.80
Radiology	0.35
Laundry-Washing	0.52
Automotive - Service/Repair	0.63
Museum	—
General Exhibition	1.0
Restoration	1.58
Bank/Office - Banking Activity Area	1.31
Religious Buildings	—
Worship-pulpit, choir	2.29
Fellowship Hall	0.81
Retail	1.5
Mall Concourse	1.5
Fitting Room	1.06
Sports Arena Complex	—
Ring Sports Area	2.7
Court Sports Area	2.0
Indoor Playing Field Area	1.35
Warehouse	—
Fine Material Storage	1.24
Medium/Bulky Material Storage	0.81
Parking Garage - Garage Area	0.2
Transportation	—
Airport - Concourse	0.57
Air/Train/Bus - Baggage Area	0.89
Terminal - Ticket Counter	1.31

For SI: 1 foot = 304.8 mm, 1 square foot = 0.929 m^2, $W/m^2 = W/ft^2 \times 10.764$

1. The watts per square foot may be increased by 2 percent per foot of ceiling height above 20 feet unless specified differently by another footnote.
2. The watts per square foot of room may be increased by 2 percent per foot of ceiling height above 9 feet.
3. Hotel banquet room, conference rooms, or exhibit hall watt per square foot of room may be increased by 2 percent per foot of ceiling height above 12 feet.
4. Spaces used specifically for manufacturing are exempt.

505.6 Exterior lighting. (Mandatory). When the power for exterior lighting is supplied through the energy service to the building, all exterior lighting, other than low-voltage landscape lighting, shall comply with Sections 505.6.1 and 505.6.2.

Exception: Where *approved* because of historical, safety, signage or emergency considerations.

505.6.1 Exterior building grounds lighting. No incandescent or mercury vapor lighting sources shall be used for exterior building lighting.

Exceptions:

1. Incandescent lighting used in or around swimming pools, water features, or other locations subject to the requirements of Article 680 of the *Electrical Code*.
2. Incandescent luminaires controlled by motion sensors with total power less than 150 watts.

505.6.2 Exterior building lighting power. The total exte-rior lighting power allowance for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated and are permitted in Table 505.6.2(2) for the applicable lighting zone. Tradeoffs are allowed only among exterior lighting applications listed in Table 505.6.2(2), Tradable Surfaces section. The lighting zone for the building exterior is determined from Table 505.6.2(1) unless otherwise specified by the local jurisdiction. Exterior lighting for all applications (except those included in the exceptions to Section 505.6.2) shall comply with the requirements of Section 505.6.1.

Exceptions: Lighting used for the following exterior applications is exempt when equipped with a control device independent of the control of the nonexempt lighting:

1. Specialized signal, directional and marker lighting associated with transportation;
2. Advertising signage or directional signage;
3. Integral to equipment or instrumentation and is installed by its manufacturer;
4. Theatrical purposes, including performance, stage, film production and video production;
5. Athletic playing areas;
6. Temporary lighting;
7. Industrial production, material handling, transportation sites and associated storage areas;
8. Theme elements in theme/amusement parks; and
9. Used to highlight features of public monuments and registered historic landmark structures or buildings.

TABLE 505.6.2(1)
EXTERIOR LIGHTING ZONES

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

Tables 505.6.2(3) and Tables 505.6.2(4). Deleted.

505.7 Electrical energy consumption. (Mandatory). In buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.

SECTION 506
WHOLE BUILDING APPROACH

506.1 Whole Building Approach (WBA). Applicants shall demonstrate that the whole building annual energy consumption will not exceed that used by a similar building using similar forms of energy design in accordance with the prescriptive requirements of this code. Compliance under this section allows tradeoffs between building components using an 8,760 - hour annual building simulation. Information and criteria for demonstrating compliance using the WBA is available at http://www.bcd.oregon.gov.

SECTION 507
OTHER EQUIPMENT

507.1 Distribution transformers.

507.1.1 Energy efficiency. All distribution transformers shall meet the minimum efficiency levels specified in Tables 507.1 and 507.2. All other terms and provisions of National Electrical Manufacturers Association (NEMA) Standard TP 1-1996, *Guide for Determining Energy Efficiency for Distribution Transformers*, shall apply to distribution transformers. These requirements shall apply to transformers within the scope of TP 1-1996.

Exceptions:

1. Liquid-filled transformers below 10 kVA.
2. Dry-type transformers below 15 kVA.
3. Drive transformers designed only to operate electronic variable speed AC and DC drives.

4. Rectifier transformers designed only to power rectifier circuits that have nameplate ratings for fundamental frequency and RMS.
5. High harmonic transformers with a *K*-rating of K-4 or greater that are designed to supply loads with higher than normal harmonic current levels. A licensed engineer shall submit verification of need for harmonic current control.
6. Autotransformers in which the primary and secondary windings are not electrically isolated, and in which secondary voltage is derived from at least a portion of the primary winding as specified by a licensed engineer.
7. Nondistribution transformers, such as those designed as an integral part of an uninterruptible power system (UPS).
8. Transformers with special impedance outside the following ranges: 1.5 percent to 7.0 percent for 15 kVA - 150 kVA units, 3.0 percent to 8.0 percent for 167 kVA - 500 kVA units, and 5.0 percent to 8.0 percent for 667 kVA -2500 kVA units.
9. Voltage regulating transformers with load tap changing gear.
10. Sealed transformers that are designed to remain hermetically sealed and nonventilated transformers designed to prevent airflow through the transformer.
11. Replacement of an existing transformer where a qualified TP-1 transformer will not fit in the space provided.
12. Transformers feeding circuits dedicated to machine tools and/or welders.
13. Transformers with tap ranges greater than 15 percent or with frequencies other than 50 to 60 Hz.
14. Grounding transformers that only provide a system ground reference point, or testing transformers that are part of, or supply power to electrical test equipment.

507.1.2 Testing. All distribution transformers shall be tested in accordance with National Electrical Manufacturers Association (NEMA) TP 2-1998, *Standard Test Method for measuring the Energy Consumption of Distribution Transformers*.

507.1.3 Labeling. All distribution transformers shall be labeled in accordance with National Electrical Manufacturers Association (NEMA) TP 3-2000, *Standard for the Labeling of Distribution Transformer Efficiency.*

507.1.4 Alterations. Replacement of existing equipment shall meet the requirements of this section.

Note: Tables 505.6.1(1), 505.6.6.1(3)-4 were deleted.

TABLE 505.6.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.)		500 W	600 W	750 W	1300 W
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**Uncovered Parking Areas**				
	Parking areas and drives	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.2 W/ft^2
	Stairways	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
	Pedestrian tunnels	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2
	Building Entrances and Exits				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
	Sales Canopies				
	Free-standing and attached	0.6 W/ft^2	0.6 W/ft^2	0.8 W/ft^2	1.0 W/ft^2
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ft^2	0.25 W/ft^2	0.5 W/ft^2	0.7 W/ft^2
	Street frontage for vehicle sales lots in addition to “open area” allowance	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the “Tradable Surfaces” section of this table.)	Building facades	No allowance	0.1 W/ft^2 for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length	0.15 W/ft^2 for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length	0.2 W/ft^2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area
	Drive-up windows/doors	400 W per drive-through	400 W per drive-through	400 W per drive-through	400 W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m^2.

TABLE 507.1
NEMA CLASS 1 EFFICIENCY LEVELS FOR LIQUID-FILLED DISTRIBUTION TRANSFORMERS[1]

SINGLE PHASE		THREE PHASE	
kVa	**Efficiency**	**kVa**	**Efficiency**
10	98.3%	15	98.0%
15	98.5%	30	98.3%
25	98.7%	45	98.5%
37.5	98.8%	75	98.7%
50	98.9%	112.5	98.8%
75	99.0%	150	98.9%
100	99.0%	225	99.0%
167	99.1%	300	99.0%
250	99.2%	500	99.1%
333	99.2%	750	99.2%
500	99.3%	1,000	99.2%
667	99.4%	1,500	99.3%
833	99.4%	2,000	99.4%
		2,500	99.4%

1. Efficiency is calculated per conditions stated in NEMA Standard TP 1-1996.

TABLE 507.2
NEMA CLASS 1 EFFICIENCY LEVELS FOR DRY-TYPE DISTRIBUTION TRANSFORMERS[1]

SINGLE PHASE EFFICIENCY			THREE PHASE EFFICIENCY		
kVa	**Low Voltage**	**Medium Voltage**	**kVa**	**Low Voltage**	**Medium Voltage**
15	97.7%	97.6%	15	97.0%	96.8%
25	98.0%	97.9%	30	97.5%	97.3%
37.5	98.2%	98.1%	45	97.7%	97.6%
50	98.3%	98.2%	75	98.0%	97.9%
75	98.5%	98.4%	112.5	98.2%	98.1%
100	98.6%	98.5%	150	98.3%	98.2%
167	98.7%	98.7%	225	98.5%	98.4%
250	98.8%	98.8%	300	98.6%	98.5%
333	98.9%	98.9%	500	98.7%	98.7%
500	—	99.0%	750	98.8%	98.8%
667	—	99.0%	1,000	98.9%	98.9%
833	—	99.1%	1,500	—	99.0%
			2,000	—	99.0%
			2,500	—	99.1%

1. Efficiency is calculated per conditions stated in NEMA Standard TP 1-1996.

CHAPTER 6
REFERENCED STANDARDS

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 107.

AAMA

American Architectural Manufacturers Association
1827 Walden Office Square
Suite 550
Schaumburg, IL 60173-4268

Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A c440—05	Specifications for Windows, Doors and Unit Skylights	402.4.4, 502.4.1

AHRI

Air Conditioning, Heating, and Refrigeration Institute
4100 North Fairfax Drive
Suite 200
Arlington, VA 22203

Standard reference number	Title	Referenced in code section number
210/240—03	Unitary Air-Conditioning and Air-Source Heat Pump Equipment	Table 503.2.3(1), Table 503.2.3(2)
310/380—93	Standard for Packaged Terminal Air-conditioners and Heat Pumps	Table 503.2.3(3)
340/360—2000	Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment	Table 503.2.3(1), Table 503.2.3(2)
365—02	Commercial and Industrial Unitary Air-conditioning Condensing Units	Table 503.2.3(6)
440—05	Room Fan-coil	503.2.8
550/590—98	Water Chilling Packages Using the Vapor Compression Cycle—with Addenda	Table 503.2.3(7)
560—00	Absorption Water Chilling and Water Heating Packages	Table 503.2.3(7)
840—1998	Unit Ventilators	503.2.8
13256-1 (2004)	Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps	Table 503.2.3(2)
1160—2004	Performance Rating of Heat Pump Pool Heaters	Table 504.2

AMCA

Air Movement and Control Association International
30 West University Drive
Arlington Heights, IL 60004-1806

Standard reference number	Title	Referenced in code section number
500D—07	Laboratory Methods for Testing Dampers for Rating	502.4.5

ANSI

American National Standards Institute
25 West 43rd Street
Fourth Floor
New York, NY 10036

Standard reference number	Title	Referenced in code section number
Z21.10.3—01	Gas Water Heaters, Volume III - Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous—with Addenda Z21.10.3a-2003 and Z21.10.3b-2004	Table 504.2
Z21.13—04	Gas-fired Low Pressure Steam and Hot Water Boilers	Table 503.2.3(5)
Z21.47—03	Gas-fired Central Furnaces	Table 503.2.3(4)
Z83.8—02	Gas Unit Heaters and Gas-Fired Duct Furnaces—with Addendum Z83.8a-2003	Table 503.2.3(4)

ASHRAE

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle, NE
Atlanta, GA 30329-2305

Standard reference number	Title	Referenced in code section number
119—88 (RA 2004)	Air Leakage Performance for Detached Single-family Residential Buildings	Table 405.5.2(1)
140—2007	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs	506.6.1
146—1998	Testing and Rating Pool Heaters	Table 504.2
ANSI/ASHRAE/ACCA Standard 183—2007	Peak Cooling and Heating Load Calculations in Buildings Except Low-rise Residential Buildings	503.2.1
13256-1 (2005)	Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps (ANSI/ASHRAE/IESNA 90.1-2004)	Table 503.2.3(2)
90.1—2007	Energy Standard for Buildings Except Low-rise Residential Buildings (ANSI/ASHRAE/IESNA 90.1-2007)	501.1, 501.2, 502.1.1, Table 502.2(2)
ASHRAE—2005	ASHRAE Handbook of Fundamentals	402.1.4, Table 405.5.2(1)
ASHRAE—2004	ASHRAE HVAC Systems and Equipment Handbook-2004	503.2.1

ASME

American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990

Standard reference number	Title	Referenced in code section number
PTC 4.1 - 1964 (Reaffirmed 1991)	Steam Generating Units	Table 503.2.3(5)

ASTM

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2859

Standard reference number	Title	Referenced in code section number
C 90—06b	Specification for Load-bearing Concrete Masonry Units	Table 502.2(1)
E 283—04	Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen	402.4.5, 502.4.2, 502.4.8

CSA

Canadian Standards Association
5060 Spectrum Way
Mississauga, Ontario, Canada L4W 5N6

Standard reference number	Title	Referenced in code section number
101/I.S.2/A440—08	Specifications for Windows, Doors and Unit Skylights	402.4.4, 502.4.1

DOE

U.S. Department of Energy
c/o Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402-9325

Standard reference number	Title	Referenced in code section number
10 CFR Part 430, Subpart B, Appendix E (1998)	Uniform Test Method for Measuring the Energy Consumption of Water Heaters	Table 504.2
10 CFR Part 430, Subpart B, Appendix N (1998)	Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers	Table 503.2.3(4), Table 503.2.3(5)

DOE—continued

10 CFR Part 431, Subpart E 2004	Test Procedures and Efficiency Standards for Commercial Packaged Boilers	Table 503.2.3(6)
DOE/EIA—0376 (Current Edition)	State Energy Prices and Expenditure Report	405.3, 506.2

ICC

International Code Council, Inc.
500 New Jersey Avenue, NW
6th Floor
Washington, DC 20001

Standard reference number	Title	Referenced in code section number
IBC—09	International Building Code®	201.3, 303.2, 402.2.9
IFC—09	International Fire Code®	201.3
IFGC—09	International Fuel Gas Code®	201.3
IMC—09	International Mechanical Code®	503.2.5, 503.2.6, 503.2.7.1, 503.2.7.1.1, 503.2.7.1.2, 503.2.9.1, 503.3.1, 503.4.5
IPC—09	International Plumbing Code®	201.3
IRC—09	International Residential Code®	201.3, 403.2.2, 403.6, 405.6.1, Table 405.5.2(1)

IESNA

Illuminating Engineering Society of North America
120 Wall Street, 17th Floor
New York, NY 10005-4001

Standard reference number	Title	Referenced in code section number
90.1—2007	Energy Standard for Buildings Except Low-rise Residential Buildings	501.1, 501.2, 502.1.1, Table 502.2(2)

NFRC

National Fenestration Rating Council, Inc.
6305 Ivy Lane, Suite 140
Greenbelt, MD 20770

Standard reference number	Title	Referenced in code section number
100—04	Procedure for Determining Fenestration Product U-factors—Second Edition	303.1.3
200—04	Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence—Second Edition	303.1.3
400—04	Procedure for Determining Fenestration Product Air Leakage—Second Edition	402.4.2, 502.4.1

SMACNA

Sheet Metal and Air Conditioning Contractors National Association, Inc.
4021 Lafayette Center Drive
Chantilly, VA 20151-1209

Standard reference number	Title	Referenced in code section number
SMACNA—85	HVAC Air Duct Leakage Test Manual	503.2.7.1.3

UL

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062-2096

Standard reference number	Title	Referenced in code section number
727—06	Oil-fired Central Furnaces	Table 503.2.3(4)
731—95	Oil-fired Unit Heaters—with Revisions through February 2006	Table 503.2.3(4)

US—FTC

United States - Federal Trade Commission
600 Pennsylvania Avenue NW
Washington, DC 20580

Standard reference number	Title	Referenced in code section number
CFR Title 16	R-value Rule	303.1.4

WDMA

Window and Door Manufacturers Association
1400 East Touhy Avenue, Suite 470
Des Plaines, IL 60018

Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A440—08	Specifications for Windows, Doors and Unit Skylights	402.4.4, 502.4.1

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