

Appendix 120.AA ‘Stretch’ Energy Code

This ‘stretch’ code appendix is based on the 2009 International Energy Conservation Code (IECC 2009) which will be adopted by the Commonwealth of Massachusetts as the ‘base’ code by Jan 2010. Proposed changes to the IECC 2009 are shown in ~~strikeout~~ (deleted text or numeric) or red font (added text or numeric).

CHAPTER 1 - ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION 101 SCOPE AND GENERAL REQUIREMENTS

101.1 Title. This ~~appendix to the Massachusetts building code~~ shall be known as the ~~International Energy Conservation Code of [NAME OF JURISDICTION],~~ **Massachusetts Stretch Energy Code appendix** and shall be cited as such. It is referred to herein as “this **appendix.**”

101.2 Scope. This ~~appendix~~ applies to residential and commercial buildings. ~~Buildings not included in this scope shall comply with 780 CMR 13, 34, 61, or 93, as applicable.~~

101.3 Purpose and Intent.

~~The purpose of 780 CMR 120.AA is to provide a more energy efficient alternative to the base energy code applicable to the relevant sections of the building code for both new construction and existing buildings. A municipality seeking to ensure that construction within its boundaries is designed and built above the energy efficiency requirements of 780 CMR may mandate adherence to this appendix.~~

~~This appendix may be adopted by any municipality in the commonwealth, by decision of its governing body. In a city having a Plan D or Plan E charter the governing body shall be the city manager and the city council, and in any other city the mayor and city council. In towns the governing body shall be the board of selectmen. In order to be adopted, the appendix must be considered at an appropriate municipal public hearing, subject to the municipality’s existing public notice provisions. If adopted by a municipality this appendix rather than 780 CMR 13, 34, 61, or 93, as applicable, shall govern.~~

~~This ~~appendix~~ shall regulate the design and construction of buildings for the effective use of energy. This ~~appendix~~ is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve the effective use of energy. This ~~appendix~~ 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 ~~appendix~~ specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

101.4.1 Existing buildings. Except as specified in this chapter, this ~~code~~**appendix** 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~~**appendix.**

101.4.2 Historic buildings. Any building or structure that is listed in the State or National Register of Historic Places; designated as a historic property under local or state designation law or survey; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the National or State Registers of Historic Places either individually or as a contributing building to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, are exempt from this **appendix**.

101.4.3 Residential: New Construction. New low-rise (three stories or less) residential buildings including townhouses shall require a HERS (Home Energy Rating System) index rating as verified by a RESNET (Residential Energy Services Network) certified HERS rater.

- For units greater than 3,000 sq ft in conditioned floor space, a HERS rating of 65 or less is required.
- For units less than 3,000 sq ft, a HERS rating of 70 or less is required.
- In addition, all new construction shall demonstrate compliance with the Energy Star Qualified Homes Thermal Bypass Inspection Checklist¹.

101.4.4 Residential additions.

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

101.4.4.1 Prescriptive option for Residential additions:

Compliance with the most recent Energy Star for Homes Prescriptive Builders Option Package (BOP), except for heating and cooling equipment and appliances, and

- Compliance with the Energy Star Qualified Homes Thermal Bypass Inspection Checklist¹.
- Envelope insulation requirements that meet or exceed IECC 2009 requirements for climate zone 5 (Residential Chapter 4, Section 402)

101.4.4.2 Performance option for residential additions.

The performance approach and HERS ratings of 101.4.3 may be followed in lieu of the prescriptive requirements of 101.4.4.1

101.4.5 Residential alterations, renovations or repairs.

Alterations, renovations or repairs to an existing building, building system or portion thereof shall conform to the provisions of this ~~code~~**appendix** as they relate to new construction, without requiring the unaltered portion(s) of the existing building, or building system to comply with this ~~code~~**appendix**. Alterations, renovations or repairs shall not create an unsafe or hazardous condition or overload existing building systems.

101.4.5.1 Prescriptive option for alterations, renovations or repairs.

Alterations, renovations or repairs that involve accessing the building envelope shall require the affected portion of the envelope to comply with 101.4.4.1. Envelope insulation shall meet or exceed IECC 2009 requirements for climate zone 5, or fully fill existing cavities with insulating material which meets or exceeds an R value of R 3.7/inch.

¹ http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Thermal_Bypass_Inspection_Checklist.pdf

101.4.5.2 Performance option for alternations, renovations or repairs.

In all cases of alternations, renovations or repairs the performance approach of 101.4.3 may be followed in lieu of the prescriptive requirements of 101.4.5 with the following HERS rating requirements:

- For units greater than 2,000 sq ft in conditioned floor space, a HERS rating of 80 or less is required.
- For units less than 2,000 sq ft, a HERS rating of 85 or less is required.
- Compliance with the Energy Star Qualified Homes Thermal Bypass Inspection Checklist¹.

101.4.5.3 Exceptions

1. Storm windows installed over existing fenestration.
2. Glass only replacements in an **Repairs** to an existing sash and frame.
3. Existing ceiling, wall or floor cavities, **of the building envelope**, exposed **or accessible** during construction provided that **any empty cavities are filled with insulation that meets or exceeds an R value of R 3.7/inch.**
4. ~~Construction where the existing roof, wall or floor cavity is not exposed.~~
5. Reroofing or residing over uninsulated roofs or walls ~~for roofs where neither the sheathing is not exposed. Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either in the cavity or above the sheathing. Walls without insulation in the cavity and where the sheathing or insulation is exposed during residing shall be insulated in either in the cavity with~~
6. 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,
7. Alterations that replace less than 50 percent of the luminaires in a space, provided that such alterations do not increase the installed interior lighting power.
8. Alterations that replace only the bulb and ballast within the existing luminaires in a space provided that the alteration does not increase the installed interior lighting power.

101.4.6 Commercial: New Construction.

- Buildings from 5,000 to 100,000 sq. ft. and additions to such buildings greater than or equal to 30% of the existing conditioned floor area with their own heating system, shall comply with Chapter 5, or may elect to comply with requirements for new construction of buildings greater than 100,000 sq. ft.
- Buildings greater than 100,000 sq. ft., and additions to such buildings greater than or equal to 30% of the existing conditioned floor area, shall be designed to achieve energy use per square foot equal to at least 20% below the energy requirements of ASHRAE 90.1-2007, measured by industry-accepted energy modeling.
- Buildings greater than 40,000 sq. ft. in area, and additions to such buildings greater than or equal to 30% of the existing conditioned floor area with these uses:
 - Supermarkets
 - Warehouses
 - Laboratories

shall be designed to achieve energy use per square foot equal to at least 20% below the energy requirements of ASHRAE 90.1-2007, measured by industry-accepted energy modeling.

Exceptions:

1. Commercial buildings less than 5,000 sq. ft.
2. Commercial buildings from 5,000 to 40,000 sq. ft. in area with these uses:
 - Supermarkets
 - Warehouses
 - Laboratories
 - A building of specialized use by variance to this appendix through appeal to the BBS.

101.4.47 Change in occupancy or use. Spaces undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this ~~code~~ **appendix**. Where the use in a space changes from one use in Table 505.5.2 to another use in Table 505.5.2, the installed lighting wattage shall comply with Section 505.5.

101.4.58 Change in space conditioning. Any non-conditioned space that is altered to become conditioned space shall be required to be brought into full compliance with this ~~code~~ **appendix**.

101.4.69 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~~ **section 101.4** for residential and **sections 101.4 and/or** Chapter 5 for commercial.

101.5 Compliance. Residential buildings shall meet the **applicable** provisions of ~~Chapter 4~~ **section 101.4**. Commercial buildings shall meet the **applicable** provisions of **sections 101.4 and** Chapter 5.

101.5.1 Compliance materials. The code official shall be permitted to approve specific computer software, worksheets, compliance manuals and other similar materials that meet the intent of this ~~code~~ **appendix**.

101.5.2 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~~ **appendix**, shall be exempt from the building thermal envelope provisions of this ~~code~~ **appendix**:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h•ft² (10.7 W/m²) or 1.0 watt/ft² (10.7 W/m²) 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~~ **appendix** 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~~ **appendix**.

102.1.1 Above code programs. The code official or other authority having jurisdiction shall be permitted to deem a national, state or local energy efficiency program to exceed the energy efficiency required by this ~~code~~ **appendix**. Buildings approved in writing by such an energy efficiency program shall be considered in compliance with this ~~code~~ **appendix**. The requirements identified as “mandatory” in ~~Chapters 4 and~~ **Sections 101.4 and Chapter 5** of this ~~code~~ **appendix**, as applicable, shall be met.

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION 103 CONSTRUCTION DOCUMENTS

103.1 General. Construction documents and other supporting data shall be submitted in one or more sets with each application for a permit. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the code official is authorized to require necessary construction documents to be prepared by a registered design professional. Exception: The code official is authorized to waive the requirements for construction documents or other supporting data if the code official determines they are not necessary to confirm compliance with this ~~code~~ **appendix**.

103.2 Information on construction documents. Construction documents shall be drawn to scale upon suitable material. Electronic media documents are permitted to be submitted when approved by the code official. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and shown sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, as applicable, insulation materials and their R-values; fenestration U-factors and SHGCs; area-weighted U-factor and SHGC calculations; mechanical system design criteria; mechanical and service water heating system and equipment types, sizes and efficiencies; economizer description; equipment and systems controls; fan motor horsepower (hp) and controls; duct sealing, duct and pipe insulation and location; lighting fixture schedule with wattage and control narrative; and air sealing details.

103.3 Examination of documents. The code official shall examine or cause to be examined the accompanying construction documents and shall ascertain whether the construction indicated and described is in accordance with the requirements of this ~~code~~ **appendix** and other pertinent laws or ordinances.

103.3.1 Approval of construction documents. When the code official issues a permit where construction documents are required, the construction documents shall be endorsed in writing and stamped “Reviewed for Code Compliance.” Such approved construction documents shall not be changed, modified or altered without authorization from the code official. Work shall be done in accordance with the approved construction documents. One set of construction documents so reviewed shall be retained by the code official. The other set shall be returned to the applicant, kept at the site of work and shall be open to inspection by the code official or a duly authorized representative.

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

103.3.3 Phased approval. The code official shall have the authority to issue a permit for the construction of part of an energy conservation system before the construction documents for the entire system have been submitted or approved, provided adequate information and detailed statements have been filed complying with all pertinent requirements of this ~~code~~ **appendix**. The holders of such permit shall proceed at their own risk without assurance that the permit for the entire energy conservation system will be granted.

103.4 Amended construction documents. Changes made during construction that are not in compliance with the approved construction documents shall be resubmitted for approval as an amended set of construction documents.

103.5 Retention of construction documents. One set of approved construction documents shall be retained by the code official for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.

SECTION 104 INSPECTIONS

104.1 General. Construction or work for which a permit is required shall be subject to inspection by the code official **or approved inspection agencies.**

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

104.3 Final inspection. The building shall have a final inspection and not be occupied until approved.

104.4 Reinspection. A building shall be reinspected when determined necessary by the code official.

104.5 Approved inspection agencies. The code official is authorized to **require or** accept reports of approved inspection agencies, provided such agencies satisfy the requirements as to qualifications and reliability.

104.6 Inspection requests. It shall be the duty of the holder of the permit or their duly authorized agent to notify the code official when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this **code appendix.**

104.7 Reinspection and testing. Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made so as to achieve compliance with this code. The work or installation shall then be resubmitted to the code official for inspection and testing.

104.8 Approval. After the prescribed tests and inspections indicate that the work complies in all respects with this **code appendix,** a notice of approval shall be issued by the code official.

104.8.1 Revocation. The code official is authorized to, in writing, suspend or revoke a notice of approval issued under the provisions of this **code appendix** wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the building or structure, premise, or portion thereof is in violation of any ordinance or regulation or any of the provisions of this **code appendix.**

SECTION 105 VALIDITY

105.1 General. If a portion of this **code appendix** is held to be illegal or void, such a decision shall not affect the validity of the remainder of this **code appendix.**

SECTION 106 REFERENCED STANDARDS

106.1 General. The codes and standards referenced in this **code appendix** shall be those listed in Chapter 6, and such codes and standards shall be considered as part of the requirements of this **code appendix** to the prescribed extent of each such reference.

106.2 Conflicting requirements. Where the provisions of this **code appendix** and the referenced standards conflict, the provisions of this **code appendix** shall take precedence.

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

106.4 Other laws. The provisions of this code ~~appendix~~ shall not be deemed to nullify any provisions of local, state or federal law.

SECTION ~~107~~ FEES

~~107.1 Fees.~~ A permit shall not be issued until the fees prescribed in Section ~~107.2~~ have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

~~107.2 Schedule of permit fees.~~ A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

~~107.3 Work commencing before permit issuance.~~ Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the code official, which shall be in addition to the required permit fees.

~~107.4 Related fees.~~ The payment of the fee for the construction, alteration, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

~~107.5 Refunds.~~ The code official is authorized to establish a refund policy.

SECTION ~~108~~ STOP WORK ORDER

~~108.1 Authority.~~ Whenever the code official finds any work regulated by this code being performed in a manner either contrary to the provisions of this code or dangerous or unsafe, the code official is authorized to issue a stop work order.

~~108.2 Issuance.~~ The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner's agent, or to the person doing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order, and the conditions under which the cited work will be permitted to resume.

~~108.3 Emergencies.~~ Where an emergency exists, the code official shall not be required to give a written notice prior to stopping the work.

~~108.4 Failure to comply.~~ Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be liable to a fine of not less than [AMOUNT] dollars or more than [AMOUNT] dollars.

SECTION ~~109~~ BOARD OF APPEALS

~~109.1 General.~~ In order to hear and decide appeals of orders, decisions or determinations made by the code official relative to the application and interpretation of this code, there shall be and is hereby created a board of appeals. The code official shall be an ex officio member of said board but shall have no vote on any matter before the board. The board of appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business, and shall render all decisions and findings in writing to the appellant with a duplicate copy to the code official.

~~109.2 Limitations on authority.~~ An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The board shall have no authority to waive requirements of this code.

~~109.3 Qualifications.~~ The board of appeals shall consist of members who are qualified by experience and training and are not employees of the jurisdiction.

CHAPTER 2 - DEFINITIONS

SECTION 201 GENERAL

201.1 Scope. Unless stated otherwise, the following words and terms in this ~~code~~ **appendix** 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~~ **appendix** but are defined in the International Building Code, International Fire Code, International Fuel Gas Code, International Mechanical Code, International Plumbing Code or the International 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.

SECTION 202 GENERAL DEFINITIONS

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

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

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

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

ALTERATION. Any construction 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”).

BASEMENTWALL. A wall 50 percent or more below grade and enclosing conditioned space.

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

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 ft² × °F) [W/(m² × K)].

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

COMMERCIAL BUILDING. For this ~~code~~ **appendix**, 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 horizontal dimension, in each direction, is equal to the skylight dimension in that direction plus either 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 and unless more detailed analysis is provided, the daylight zone depth is assumed to extend into the space a distance of 15 feet (4572 mm) 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 CONTROL 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.

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

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

DWELLING UNIT. A single unit providing complete independent 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.

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 [appendix](#), 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.

EXTERIORWALL. 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 ($\text{Btu/h} \times \text{ft} \times ^\circ\text{F}$) [$\text{W}/(\text{m} \times \text{K})$].

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.

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

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.

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

NAMEPLATE HORSEPOWER. The nominal motor horsepower rating stamped on the motor nameplate.

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

PROPOSED DESIGN. A description of the proposed building used to estimate annual energy use for determining compliance 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 appendix, includes R-3 buildings, as well as R-2 and R-4 buildings three stories or less in height above grade.

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 ($h \cdot ft^2 \cdot ^\circ F/Btu$) [$(m^2 \cdot K)/W$].

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

SERVICEWATER 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 appendix 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 mullied 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 dwelling with a glazing area in excess of 40 percent of the gross area of the structure’s exterior walls and roof.

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

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

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

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.

Delete Chapters 3 and 4 of IECC 2009

Modify Chapter 5 of IECC 2009 as shown herein.

CHAPTER 5

ADVANCED 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 with total square footage less than 100,000 square feet. Commercial buildings of 100,000 square feet or more shall meet the requirements of ASHRAE/IESNA Standard 90.1-2007, Energy Standard for Buildings Except for Low-Rise Residential Buildings, and shall based on industry-accepted modeling practices, be projected to use at least 20% less energy per square foot than a building built to the requirements of 90.1-2007.

~~These commercial buildings shall meet either the requirements of ASHRAE/IESNA Standard 90.1, Energy Standard for Buildings Except for Low-Rise Residential Buildings, or 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), 505 (Electrical power and lighting systems), and 507 (Advanced Prescriptive Options) in its entirety.

Compliance with section 507 requires complying with any ONE of the following prescriptive options:

- a. 507.2.1 Efficient Mechanical Equipment
- b. 507.2.2 Reduced Lighting Power Density
- c. 507.2.3 On-Site Supply of Renewable Energy

Compliance with section 507 does not remove the requirement to comply with any other mandatory requirements in this appendix.

~~As an alternative the commercial building project shall comply with the requirements of ASHRAE/IESNA 90.1 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 IECC climate zone for Massachusetts: Climate Zone 5A 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 the building envelope provisions of ASHRAE/IESNA 90.1.~~

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.

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.

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/m²) of wall surface area if the material weight is not more than 120 pounds per cubic foot (1900 kg/m³).

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 (3048 mm) 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 continuously 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/m²) of floor surface area or (2) 25 pounds per square foot (120 kg/m²) of floor surface area if the material weight is not more than 12 pounds per cubic foot (1,900 kg/m³).

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

CLIMATE ZONE	4		2		3		4		5 AND MARINE 4		6		7		8			
	All other	Group-R	All other	Group-R	All other	Group-R	All other	Group-R	All other	Group-R	All other	Group-R	All other	Group-R	All other	Group-R		
Roofs																		
Insulation entirely above deck	U-0.063	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	
Metal buildings	U-0.065	U-0.065	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.055	U-0.049	U-0.049	U-0.049	U-0.049	U-0.035	U-0.035	
Attic and other	U-0.034	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	
Walls, Above Grade																		
Mass	U-0.058	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.071	U-0.071	U-0.052	
Metal building	U-0.093	U-0.093	U-0.093	U-0.093	U-0.084	U-0.084	U-0.084	U-0.084	U-0.069	U-0.069	U-0.069	U-0.069	U-0.069	U-0.057	U-0.057	U-0.057	U-0.057	
Metal framed	U-0.124	U-0.124	U-0.124	U-0.064	U-0.084	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.064	U-0.037	
Wood framed and other	U-0.089	U-0.089	U-0.089	U-0.089	U-0.089	U-0.089	U-0.089	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036	
Walls, Below Grade																		
Below-grade wall ^a	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.119	C-1.119	C-1.119	C-1.119	C-1.119	C-1.119	C-1.119	C-1.119	C-0.092	C-1.119	C-0.075
Floors																		
Mass	U-0.322	U-0.322	U-0.107	U-0.087	U-0.107	U-0.087	U-0.087	U-0.074	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.064	U-0.051	U-0.057	U-0.051	
Joist/Framing	U-0.282	U-0.282	U-0.052	U-0.052	—	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033
Slab-on-Grade Floors																		
Unheated slabs	F-0.730	F-0.730	F-0.730	F-0.730	F-0.730	F-0.730	F-0.730	F-0.540	F-0.730	F-0.540	F-0.540	F-0.540	F-0.520	F-0.520	F-0.520	F-0.520	F-0.510	
Heated slabs	F-1.020	F-1.020	F-1.020	F-1.020	F-0.900	F-0.900	—	F-0.860	F-0.860	F-0.860	F-0.860	F-0.860	F-0.688	F-0.830	F-0.688	F-0.688	F-0.688	

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.

**TABLE 502.2(1)
BUILDING ENVELOPE REQUIREMENTS – OPAQUE ASSEMBLIES**

CLIMATE ZONE	1		2		3		4		5-AND MARINE 4		6		7		8	
	All-other	Group-R	All-other	Group-R	All-other	Group-R	All-other	Group-R	All-other	Group-R	All-other	Group-R	All-other	Group-R	All-other	Group-R
Roofs																
Insulation entirely above deck	R-15ei	R-20ei	R-20ei	R-20ei	R-20ei	R-20ei	R-20ei	R-20ei	R-20ei	R-20ei	R-20ei	R-20ei	R-25ei	R-25ei	R-25ei	R-25ei
Metal buildings (with R-5 thermal blocks ^{a,b})	R-19	R-19	R-13+ R-13	R-13+ R-13	R-13+ R-13	R-13+ R-13	R-19	R-13+ R-13	R-19	R-13+ R-13	R-19	R-13+ R-19	R-13+ R-19	R-19+ R-10	R-11+ R-19	R-19+ R-10
Attic and other	R-30	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49
Walls, Above-Grade																
Mass	NR	R-5.7ei	R-5.7ei	R-7.6ei	R-7.6ei	R-9.5ei	R-7.6ei ^c	R-11.4ei	R-11.4ei	R-13.3ei	R-13.3ei	R-15.2ei	R-15.2ei	R-15.2ei	R-25ei	R-25ei
Metal building ^a	R-16	R-16	R-16	R-16	R-19	R-19	R-19	R-19	R-13+ R-5.6ei	R-13+ R-5.6ei	R-13+ R-5.6ei	R-13+ R-5.6ei	R-19+ R-5.6ei	R-19+ R-5.6ei	R-19+ R-5.6ei	R-19+ R-5.6ei
Metal-framed	R-13	R-13	R-13	R-13+ R-7.5ei	R-13+ R-3.8ei	R-13+ R-7.5ei	R-13+ R-7.5	R-13+ R-7.5ei	R-13+ R-7.5ei	R-13+ R-7.5ei	R-13+ R-7.5ei	R-13+ R-7.5ei	R-13+ R-7.5ei	R-13+ R-15.6ei	R-13+ R-7.5ei	R-13+ R-18.8ei
Wood framed and other	R-13	R-13	R-13	R-13	R-13	R-13	R-13	R-13+ R-3.8ei	R-13+ R-3.8ei	R-13+ R-3.8	R-13+ R-7.5	R-13+ R-7.5	R-13+ R-7.5ei	R-13+ R-7.5ei	R-13+ R-15.6ei	R-13+ R-15.6ei
Walls, Below-Grade																
Below-grade wall ^d	NR	NR	NR	NR	NR	NR	NR	R-7.5ei	R-7.5ei	R-7.5ei	NR R-7.5ei	R-7.5ei	R-7.5ei	R-10ei	R-7.5ei	R-12.5ei
Floors																
Mass	NR	NR	R-6.3ei	R-8.3ei	R-6.3ei	R-8.3ei	R-10ei	R-10.4ei	R-10ei	R-12.5ei	R-12.5ei	R-14.6ei	R-15ei	R-16.7ei	R-15ei	R-16.7ei
Joist/Framing	NR	NR	R-19	R-30	R-19	R-30	R-30	R-30	R-30	R-30	R-30	R-30 ^e	R-30	R-30 ^e	R-30 ^e	R-30 ^e
Slab-on-Grade Floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	NR	R-10 for-12 in. below	NR	R-10 for-12 in. below	R-10 for-12 in. below	R-15 for-24 in. below	R-15 for-24 in. below	R-15 for-24 in. below	R-15 for-24 in. below	R-15 for-24 in. below
Heated slabs	R-7.5 for-12 in. below	R-7.5 for-12 in. below	R-7.5 for-12 in. below	R-7.5 for-12 in. below	R-10 for-24 in. below	R-10 for-24 in. below	R-15 for-24 in. below	R-15 for-24 in. below	R-15 for-24 in. below	R-15 for-24 in. below	R-15 for-24 in. below	R-20 for-48 in. below	R-20 for-24 in. below	R-20 for-48 in. below	R-20 for-48 in. below	R-20 for-48 in. below
Opaque Doors																
Swinging	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.70	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50
Roll-up or sliding	U-1.45	U-1.45	U-1.45	U-1.45	U-1.45	U-1.45	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50	U-0.50

For SI: 1 inch = 25.4 mm.

ei = 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. R-5.7 ei is allowed to be substituted with concrete block walls complying with ASTM C-90, ungrouted or partially-grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu-in./h-ft²-F.

d. 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.

e. Steel floor joist systems shall to be R-38.

**TABLE 502.2(2)
BUILDING ENVELOPE REQUIREMENTS—OPAQUE ASSEMBLIES**

ROOFS	DESCRIPTION	REFERENCE
R-19	<p>Standing seam roof with single fiberglass insulation layer.</p> <p>This construction is R-19 faced fiberglass insulation batts draped perpendicular over the purlins. A minimum of R-3.5 thermal spacer blocks is placed above the purlin/batt, and the roof deck is secured to the purlins.</p>	ASHRAE/IESNA 90.1 Table A2.3 including addendum "G"
R-13 + R-13 R-13 + R-19	<p>Standing seam roof with two fiberglass insulation layers.</p> <p>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.</p>	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
R-11 + R-19 FC	<p>Filled cavity fiberglass insulation.</p> <p>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.</p>	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
Walls		
R-16, R-19	<p>Single fiberglass insulation layer.</p> <p>The construction is faced fiberglass insulation batts installed vertically and compressed between the metal wall panels and the steel framing.</p>	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"
R-13 + R-5.6 ei R-19 + R-5.6 ei	<p>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.</p>	ASHRAE/IESNA 90.1 Table A2.3 including Addendum "G"

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

Roofs	All Other	Group R
Insulation entirely above deck	U - 0.039	U - 0.039
Metal buildings (with R-5 thermal blocks)	U - 0.049	U - 0.049
Attic and other	U - 0.027	U - 0.027
Walls, Above Grade		
Mass, exterior insulation	U- 0.080	U- 0.071
Mass, interior insulation	U- 0.085	U- 0.085
Metal building ^c	U- 0.061	U- 0.061
Metal framed	U- 0.064	U- 0.057
Wood framed and other	U- 0.051	U- 0.051
Walls, Below Grade		
Mass, exterior insulation	C- 0.119	C- 0.119
Mass, interior insulation	C- 0.063	C- 0.063
Floors		
Mass	U- 0.074	U- 0.064
Metal Joist	U- 0.033	U- 0.033
Wood Joist/Framing	U- 0.033	U- 0.033
Slab-on-Grade Floors		
Unheated slabs	F- 0.540	F- 0.520
Heated slabs	F- 0.580	F- 0.580
Opaque Doors		
Swinging	U- 0.37	U- 0.37
Roll-up or sliding	U- 0.50	U- 0.50

For SI: 1 inch = 25.4 mm.

ci – Continuous Insulation

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.

**TABLE 502.2(1)
BUILDING ENVELOPE REQUIREMENTS - OPAQUE ASSEMBLIES**

Roofs	All Other	Group R	Note: IECC 2009 equivalent
Insulation entirely above deck	R-25 ci	R-25 ci	Zone 7
Metal buildings (with R-5 thermal blocks ^a) ^b	R-13 + R-19	R-19 + R-10	Zone 7
Attic and other	R-38	R-38	Zone 2-7
Walls, Above Grade			
Mass, exterior insulation	R-11.4ci	R-13.3ci	Zone 5
Mass, interior insulation	R-13	R-13	N/A
Metal buildings	R-13 + R-5.6ci	R-13 + R-5.6ci	Zone 5-6
Metal framed	R-13 + R-7.5ci	R-13 + R-7.5 ci	Zone 5-6
Wood framed and other	R-13 + R-7.5	R-13 + R-7.5	Zone 6
Walls, Below Grade^a			
Mass, exterior insulation	R-7.5 ci	R-7.5 ci	Zone 5-6
Mass, interior insulation	R-19	R-19	N/A
Floors			
Mass	R-10 ci	R-12.5ci	Zone 5
Metal Joist	R-30	R-30	Zone 4-8
Wood Joist/Framing	R-30	R-30	Zone 4-8
Slab-on-Grade Floors			
Unheated slabs	R-10 for 24 in. below	R-15 for 24 in. below	Zone 6
Heated slabs	R-15 for 36 in. + R-5ci below	R-15 for 36 in. + R-5ci below	NBI Core Performance Values
Opaque Doors			
Swinging	U – 0.37	U – 0.37	
Roll-up or sliding	R – 4.75	R – 4.75	

For SI: 1 inch = 25.4 mm.
ci – Continuous Insulation
NR – No Requirement

- a. Thermal blocks are a minimum R-5 of rigid insulation, which extends 1-inch beyond the width of the purlin on each side, perpendicular to the purlin.
- b. 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. Reference: ASHRAE/IESNA 90.1 Table A2.3 including Addendum “G”
- c. 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 of insulation* is for insulation installed from the inside, covering the girts. Reference: ASHRAE/IESNA 90.1 Table A2.3 including Addendum “G”
- d. 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.

502.2.6 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.

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, the maximum U-factor and solar heat gain coefficient (SHGC) shall be as specified in Table 502.3, based on the window projection factor which is uniformly set at 0.40. For skylights, the limit is set at 3% of roof area, but can be expanded to 5% of roof area in conjunction with automatic daylighting controls. In all cases, the maximum U-factor and solar heat gain coefficient (SHGC) shall be as specified in Table 502.3.

The window projection factor shall be determined in accordance with Equation 5-1:

$$PF = A/B \quad \text{(Equation 5-1)}$$

where:

PF = Projection factor (decimal).

A = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or permanently attached shading device to the vertical surface of the glazing.

B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.

Where different windows or glass doors have different PF values, they shall each be evaluated separately, or an area weighted PF value shall be calculated and used for all windows and glass doors.

**TABLE 502.3
BUILDING ENVELOPE REQUIREMENTS:
FENESTRATION**

	All
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	0.42
Entrance Door U-Factor	0.80
All Other U-Factor a	0.45
SHGC-All Frame Types	
SHGC	0.40
Skylights (3% maximum, or 5% maximum with automatic daylighting controls b)	
U-Factor	0.45
SHGC	0.40

a. All others includes operable windows, fixed windows and doors other than entrance doors.

b. Automatic daylighting controls shall meet the requirements of Section 505.2.2.2.3

502.4 Air leakage (Mandatory).

502.4.1 Air Barriers. The building envelope shall be designed and constructed with a continuous air barrier to control air leakage into, or out of the conditioned space. An air barrier system shall also be provided for interior separations between conditioned space and space designed to maintain temperature or humidity levels which differ from those in the conditioned space by more than 50% of the difference between the conditioned space and design ambient conditions.

The air barrier shall have the following characteristics:

1. It must be continuous, with all joints made airtight.
2. Materials used for the air barrier system shall have an air permeability not to exceed 0.004 cfm/ft² under a pressure differential of 0.3 in. water (1.57psf) (0.02 L/s.m² @ 75 Pa) when tested in accordance with ASTM E 2178. Air barrier materials shall be taped or sealed in accordance with the manufacturer's instructions.
3. It shall be capable of withstanding positive and negative combined design wind, fan and stack pressures on the envelope without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.
4. Air barrier materials shall be maintainable, or, if inaccessible, shall meet the durability requirements for the service life of the envelope assembly.
4. The air barrier material of an envelope assembly shall be joined and sealed in a flexible manner to the air barrier material of adjacent assemblies, allowing for the relative movement of assemblies due to thermal and moisture variations and creep. Connections shall be made between:

- a. joints around fenestration and door frames
- b. junctions between walls and foundations, between walls at building corners, between walls and structural floors or roofs, and between walls and roof or wall panels
- c. openings at penetrations of utility services through roofs, walls, and floors
- d. site-built fenestration and doors
- e. building assemblies used as ducts or plenums
- f. joints, seams, and penetrations of vapor retarders
- g. all other openings in the building envelope

502.4.2 Air Barrier Penetrations. All penetrations of the air barrier and paths of air infiltration/exfiltration shall be made air tight.

502.4.13 Window and door assemblies. The air leakage of window, skylight 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 402.4.2. Window and skylight air leakage shall not exceed 0.2 cfm/ft² at 1.57 pounds per square foot (psf) (75Pa), or 0.3 cfm/ft² at 6.24 psf (300 Pa). Door assembly air leakage shall not exceed 0.3 cfm/ft² for all other products at 1.57 psf (75Pa).

Exceptions:

- a. Site-constructed windows and doors that are weatherstripped or sealed in accordance with Section 502.4.38.
- b. Commercial entrance doors covered by section 502.4
- c. Garage doors shall be permitted to use air leakage determined by test at standard test conditions in accordance with ANSI/DASMA 105.

502.4.4 Doors and Access Openings to Shafts, Chutes, Stairwells, and Elevator Lobbies: These doors and access openings shall either meet the requirements of 502.4.3 or shall be equipped with weather seals.

Exception: Weatherseals on elevator lobby doors are not required when a smoke control system is installed.

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. Building entrances that separate 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. Interior and exterior doors shall have a minimum distance between them of not less than 7 ft when in the closed position. The exterior envelope of conditioned vestibules shall comply with the requirements for a conditioned space. The interior and exterior envelope of unconditioned vestibules

shall comply with the requirements for a semi heated space.

Exceptions:

- a. Building entrances with revolving doors.
- b. Doors not intended to be used as a building entrance.
- c. Doors opening directly from a dwelling unit.
- d. Doors that open directly from a space that is less than 3000 ft² in area and is separate from the building entrance.
- e. doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

502.4.7 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 0.06 cubic foot per minute per square foot (cfm/ft²) (5.5 1.1 m³/h × m²) of fenestration area. For commercial glazed swinging entrance doors and revolving doors, the maximum air leakage rate shall be 1.00 cfm/ft² (18.3 m³/h × m²) of door area when tested in accordance with ASTM E 283.

502.4.8 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible 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.

502.4.9 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 502.4.4.

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

**TABLE 502.4.4
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 = 0.29 watts.

502.4.10 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 m²) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D. **These air tight, operable dampers shall be installed when the air barrier is penetrated by:**

- 1 Fixed open louvers such as in elevator shafts and machine rooms.
2. Mechanical system components which allow infiltration or exfiltration of air when the systems are inactive, such as atrium smoke exhaust systems, elevator shaft smoke relief openings, and other similar elements.

Such dampers shall be set in the closed position and automatically open upon:

1. the activation of any fire alarm initiating device of the building's fire alarm system;
2. the interruption of power to the damper.

Exception: Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height above grade.

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

502.4.11 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.

**TABLE 502.3
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION**

CLIMATE ZONE	1	2	3	4 except Marine	5 and Marine 4	6	7	8
Vertical Fenestration (40% maximum of above-grade wall)								
U-Factor								
Framing materials other than metal with or without metal reinforcement or cladding								
U-Factor	1.20	0.75	0.65	0.40	0.35	0.35	0.35	0.35
Metal framing with or without thermal break								
Curtain Wall/Storefront U-Factor	1.20	0.70	0.60	0.50	0.45	0.45	0.40	0.40
Entrance Door U-Factor	1.20	1.10	0.90	0.85	0.80	0.80	0.80	0.80
All Other U-Factor ^a	1.20	0.75	0.65	0.55	0.55	0.55	0.45	0.45
SHGC- All Frame Types								
SHGC: PF < 0.25	0.25	0.25	0.25	0.40	0.40	0.40	0.45	0.45
SHGC: 0.25 ≤ PF < 0.5	0.33	0.33	0.33	NR	NR	NR	NR	NR
SHGC: PF ≥ 0.5	0.40	0.40	0.40	NR	NR	NR	NR	NR
Skylights (3% maximum)								
U-Factor	0.75	0.75	0.65	0.60	0.60	0.60	0.60	0.60
SHGC	0.35	0.35	0.35	0.40	0.40	0.40	NR	NR

NR = No requirement.

PF = Projection factor (see Section 502.3.2).

a. All others includes operable windows, fixed windows and nonentrance doors.

502.4.7 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. Buildings in climate Zones 1 and 2 as indicated in Figure 301.1 and Table 301.1.

- 2. Doors not intended to be used as a building *entrance door*, such as doors to mechanical or electrical equipment rooms.
- 3. Doors opening directly from a *sleeping unit* or dwelling unit.
- 4. Doors that open directly from a space less than 3,000 square feet (298 m²) in area.
- 5. Revolving doors.
- 6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

502.4.8 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.

502.5 Vapor retarders. Class I or II vapor retarders are required on the interior side of walls in Zones 5, 6, 7, 8 and Marine 4.

Exceptions:

- 1. Basement walls.
- 2. Below grade portion of any wall.
- 3. Construction where moisture or its freezing will not damage the materials.

502.5.1 Class III Vapor retarders. Class III vapor retarders shall be permitted where any one of the conditions in Table 502.5.1 are met.

**TABLE 502.5.1
CLASS III VAPOR RETARDERS**

Zone	Class III vapor retarders permitted for:
5	Vented cladding over OSB Vented cladding over Plywood Vented cladding over Fiberboard Vented cladding over Gypsum Insulated sheathing with R-value \geq R5 over 2x4 wall Insulated sheathing with R-value \geq R7.5 over 2x6 wall
6	Vented cladding over Fiberboard Vented cladding over Gypsum Insulated sheathing with R-value \geq R7.5 over 2x4 wall Insulated sheathing with R-value \geq R11.25 over 2x6 wall
7 and 8	Insulated sheathing with R-value \geq R10 over 2x4 wall Insulated sheathing with R-value \geq R15 over 2x6 wall

502.5.2 Material vapor retarder class. The vapor retarder class shall be based on the manufacturer's certified testing or a tested assembly. The following shall be deemed to meet the class specified:

- Class I: Sheet polyethylene, non-perforated aluminum foil
- Class II: Kraft faced fiberglass batts or low perm paint (paint with $0.1 < \text{perm} \leq 1.0$)
- Class III: Latex or enamel paint

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).

NOTE: Compliance path a. (Efficient Mechanical Equipment) in section 507 is not available for equipment installed according to the minimum performance values outlined in section 503.2.3. In this case, compliance can be met with one of the following paths:

- b. 507.2.2 Reduced Lighting Power Density
- c. 507.2.3 On-Site Supply of Renewable Energy

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. **The design loads shall include an accurate representation of the building envelope, lighting, ventilation and occupancy loads based on the specific design characteristics of the project.** 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 **IECC 2009** Chapter 3.

503.2.2 Equipment and system sizing. 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) and 503.2.3(7) 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 l/skW) 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:

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

$$X = DT_{std} + LIFT$$

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

$$\text{Flow} = \text{Condenser water flow (GPM)} / \text{Cooling Full Load Capacity (tons)}$$

$$LIFT = CEWT - CLWT \text{ (}_\text{F)}$$

$$CEWT = \text{Full Load Condenser Entering Water Temperature (}_\text{F)}$$

$$CLWT = \text{Full Load Leaving Chilled Water Temperature (}_\text{F)}$$

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 l/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 appendix .

**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 ^a	Split system	13.0 SEER	AHRI 210/240
		Single package	13 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	10.3 EER ^c (before Jan 1, 2010) 11.2 EER ^c (as of Jan 1, 2010)	AHRI 340/360
			9.7 EER ^c (before Jan 1, 2010) 11.0 EER ^c (as of Jan 1, 2010)	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.5 EER ^c 9.7 IPLV ^c (before Jan 1, 2010) 10.0 EER ^c 9.7 IPLV ^g (as of Jan 1, 2010)	AHRI 340/360
≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	9.2 EER ^c 9.4 IPLV ^c (before Jan 1, 2010) 9.7 EER ^c 9.4 IPLV ^c (as of Jan 1, 2010)		
Through-the-wall, Air cooled	< 30,000 Btu/h ^a	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
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	AHRI 340/360
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.0 EER ^c	
	≥ 240,000 Btu/h	Split system and single package	11.5 EER ^c	

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 _a	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	10.3 EER _c (before Jan 1, 2010) 11.2 EER _c (as of Jan 1, 2010)	AHRI 340/360
		Split system and single package	9.3 EER _c (before Jan 1, 2010) 10.6 EER _c (as of Jan 1, 2010)	
≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.0 EER _c 9.2 IPLV _c (before Jan 1, 2010) 9.5 EER _c 9.2 IPLV _c (as of Jan 1, 2010)	AHRI 340/360	
	Split system and single package	9.0 EER _c 9.2 IPLV _c (before Jan 1, 2010) 9.5 EER _c 9.2 IPLV _c (as of Jan 1, 2010)		
Through-the-Wall (Air cooled, cooling mode)	< 30,000 Btu/h _a	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
Water source (Cooling mode)	< 17,000 Btu/h	86°F entering water	11.2 EER	AHRI/ASHRAE-13256-1
	≥ 17,000 Btu/h and < 135,000 Btu/h	86°F entering water	12.0 EER	AHRI/ASHRAE-13256-1
Groundwater source (Cooling mode)	< 135,000 Btu/h	59°F entering water	16.2 EER	AHRI/ASHRAE-13256-1
Ground source (Cooling mode)	< 135,000 Btu/h	77°F entering water	13.4 EER	AHRI/ASHRAE 13256-1
Air cooled (Heating mode)	< 65,000 Btu/h _a (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)	47°F db/43°F wb outdoor air	3.2 COP (before Jan 1, 2010) 3.3 COP (as of Jan 1, 2010)	AHRI 340/360
		47°F db/43°F wb outdoor air	3.1 COP (before Jan 1, 2010) 3.2 COP (as of Jan 1, 2010)	
Through-the-wall (Air cooled, heating mode)	< 30,000 Btu/h	Split system	7.1 HSPE (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010)	AHRI 210/240
		Single package	7.0 HSPF (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010)	

(continued)

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

Water source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	68°F entering water	4.2 COP	ARI/ASHRAE-13256-1
Groundwater source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	50°F entering water	3.6 COP	ARI/ASHRAE-13256-1
Ground Source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	32°F entering water	3.1 COP	ARI/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) New construction	All capacities	95°F db outdoor air	12.5 - (0.213 · Cap/1000) EER	ARI 310/380
PTAC (Cooling mode) Replacements ^c	All capacities	95°F db outdoor air	10.9 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) New construction	All capacities	95°F db outdoor air	12.3 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) Replacements ^c	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	

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 ^{a, e}	TEST PROCEDURE ^a
Warm air furnaces, gas fired	< 225,000 Btu/h	—	78% AFUE or 80% E_{tc}	DOE 10 CFR Part 430 or ANSI Z21.47
	\geq 225,000 Btu/h	Maximum capacity ^c	80% E_{tf}	ANSI Z21.47
Warm air furnaces, oil fired	< 225,000 Btu/h	—	78% AFUE or 80% E_t	DOE 10 CFR Part 430 or UL 727
	\geq 225,000 Btu/h	Maximum capacity ^b	81% E_{tg}	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 ^r	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY ^{c, d, e}	TEST PROCEDURE ^a
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	75% E_t and 80% E_c (See Note c, d)	DOE 10 CFR Part 431
		> 2,500,000 Btu/hr	Hot water	
		Steam	80% E_c (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	78% E_t and 83% E_c (See Note c, d)	DOE 10 CFR Part 431
		> 2,500,000 Btu/hr	Hot water	
			Steam	83% E_c (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/hr	Hot water	
		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. E_c = Combustion efficiency (100 percent less flue losses). See reference document for detailed information.
- d. E_t = 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	ARI 365
		11.2 IPLV	
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	BEFORE 1/1/2010		AS OF 1/1/2010 ^c				TEST PROCEDURE ^b
			FULL LOAD	IPLV	PATH A		PATH B		
					FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-Cooled Chillers	<150 tons	EER	≥9.562	≥10.416	≥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	≥10.586	≥11.782	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	≤0.837	≤0.696	Reciprocating units must comply with water cooled positive displacement efficiency requirements				
Water Cooled Electrically Operated, Positive Displacement	<75 tons	kW/ton	≤0.790	≤0.676	≤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	≤0.717	≤0.627	≤0.680	≤0.580	≤0.718	≤0.540	
	≥300 tons	kW/ton	≤0.639	≤0.571	≤0.620	≤0.540	≤0.639	≤0.490	
Water Cooled Electrically Operated, Centrifugal	<150 tons	kW/ton	≤0.703	≤0.669	≤0.634	≤0.596	≤0.639	≤0.450	
	≥150 tons and < 300 tons	kW/ton	≤0.634	≤0.596					
	≥300 tons and < 600 tons	kW/ton	≤0.576	≤0.549	≤0.576	≤0.549	≤0.600	≤0.400	
	≥600 tons	kW/ton	≤0.576	≤0.549	≤0.570	≤0.539	ARI 560	≤0.400	
Air Cooled Absorption Single Effect	All Capacities	COP	≥0.600	NR ^e	≥0.600	NR ^e	NA ^d	NA ^d	
Water-Cooled Absorption Single Effect	All Capacities	COP	≥0.700	NR ^e	≥0.700	NR ^e	NA ^d	NA ^d	
Absorption Double Effect Indirect-Fired	All Capacities	COP	≥1.000	≥1.050	≥1.000	≥1.050	NA ^d	NA ^d	
Absorption Double Effect Direct Fired	All Capacities	COP	≥1.000	≥1.000	≥1.000	≥1.000	NA ^d	NA ^d	

For SI: 1 ton = 907 kg, 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 $\leq 40^{\circ}\text{F}$.

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.

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 capable of responding to temperature within the zone. Where humidification or dehumidification or both is provided, at least one humidity control device shall be provided for each humidity control system.

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 thermostatic control zone for each building exposure 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 supply 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 changeover between heating and cooling modes.

503.2.4.3 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.

503.2.4.3.1 Thermostatic setback capabilities.

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

503.2.4.3.2 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.

503.2.4.4 Shutoff damper controls. Both outdoor air supply and exhaust ducts shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use.

Exceptions:

1. Gravity dampers shall be permitted in buildings less than three stories in height.
2. Gravity dampers shall be permitted for buildings of any height located in Climate Zones 1, 2 and 3.
3. Gravity dampers shall be permitted for outside air intake or exhaust airflows of 300 cfm (0.14

m³/s) or less.

503.2.4.5 Snow melt system controls. 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.

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

503.2.5.1 Demand controlled ventilation.

Demand control ventilation (DCV) is required for spaces larger than 500 ft² (50m²) and with an average occupant load of 40 people per 1000 ft² (93 m²) of floor area (as established in Table 403.3 of the *International 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. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
3. System with a design outdoor airflow less than 1,200 cfm (600 L/s).
4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (600 L/s).
5. Building spaces where CO₂ Sensors are inappropriate measures for ventilation needs because of ventilation needs other than occupant requirements.
6. Building spaces where the primary ventilation needs are for process loads.

503.2.6 Energy recovery ventilation systems.

Individual fan systems that have both a design supply air capacity of 5,000 cfm (2.36 m³/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.

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 *International 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 capable of reducing exhaust and makeup air volume to 50 percent or less of design values.
 - 2.2. 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. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
5. Heating systems in climates with less than 3,600 HDD.
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.

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 *International Mechanical Code*.

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

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

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 appendix .
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 55°F (13°C) and 105°F (41°C).
4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
5. 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 · ft² · °F.

b. For insulation with a thermal conductivity not equal to 0.27 Btu · inch/h · ft² · °F at a mean temperature of 75°F, the minimum required pipe thickness is adjusted using the following equation:

$$T = r[(1 + t/r)k - 1]$$

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 · ft² · °F).

k = 0.27 Btu · in/hr · ft² · °F.

503.2.9 HVAC system completion. Prior to the issuance of a certificate of occupancy, the design professional shall provide evidence of system completion in accordance with Sections 503.2.9.1 through 503.2.9.3.

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 *International Mechanical Code*. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 horsepower (hp) (7.4 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. Equipment operation and maintenance manuals.
3. 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.
4. A complete written narrative of how each system is intended to operate.

503.2.9 Mechanical systems commissioning and completion requirements.

503.2.9.1 System commissioning.

Commissioning is a process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner’s project requirements and construction documents. Drawing notes shall require commissioning and completion requirements in accordance with this section. Drawing notes may refer to specifications for further requirements. Copies of all documentation shall be given to the owner. The building official may request commissioning documentation for review purposes. At the time of plan submittal, the building jurisdiction shall be provided, by the submittal authority, a letter of intent to commission the building in accordance with this appendix to the code.

503.2.9.1.1 Commissioning plan. A commissioning plan shall include as a minimum the following items:

1. A detailed explanation of the original owner’s project requirements,
2. A narrative describing the activities that will be accomplished during each phase of commissioning, including guidance on who accomplishes the activities and how they are completed,

3. Equipment and systems to be tested, including the extent of tests,
4. Functions to be tested (for example calibration, economizer control, etc.),
5. Conditions under which the test shall be performed (for example winter and summer design conditions, full outside air, etc.), and
6. Measurable criteria for acceptable performance.

503.2.9.1.2 Systems adjusting and balancing.

All HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within 10% of design rates. Test and balance activities shall include as a minimum the following items:

1. Air systems 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 International Mechanical Code. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp, fan speed shall be adjusted to meet design flow conditions.

Exception: Fan with fan motors of 1 hp or less.

2. Hydronic systems balancing: Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the ability to measure pressure across the pump, or test ports at each side of each pump.

Exceptions:

1. Pumps with pump motors of 5 hp or less.
2. When throttling results in no greater than 5% of the nameplate horsepower draw above that required if the impeller were trimmed.

503.2.9.1.3 Functional performance testing

503.2.9.1.3.1 Equipment functional performance testing. Equipment functional performance testing shall demonstrate the correct installation and operation of components, systems, and system-to-system interfacing relationships in accordance with

approved plans and specifications. This demonstration is to prove the operation, function, and maintenance serviceability for each of the Commissioned systems. Testing shall include all modes of operation, including:

1. All modes as described in the Sequence of Operation,
2. Redundant or automatic back-up mode,
3. Performance of alarms, and
4. Mode of operation upon a loss of power and restored power.

Exception: Unitary or packaged HVAC equipment listed in Tables 503.2.3 (1) through (3) that do not require supply air economizers.

503.2.9.1.3.2 Controls functional performance testing. HVAC control systems shall be tested to document that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with approved plans and specifications.

503.2.9.1.4 Preliminary commissioning report. A preliminary report of commissioning test procedures and results shall be completed and provided to the Owner. The report shall be identified as “Preliminary Commissioning Report” and shall identify:

1. Itemization of deficiencies found during testing required by this section which have not been corrected at the time of report preparation and the anticipated date of correction.
2. Deferred tests which cannot be performed at the time of report preparation due to climatic conditions.
3. Climatic conditions required for performance of the deferred tests, and the anticipated date of each deferred test.

503.2.9.2 Acceptance. Buildings, or portions thereof, required by this appendix to comply with this section shall not be issued a final certificate of occupancy allowing public or owner occupation until such time that the building official has received a letter of transmittal from the building owner that states they have received the Preliminary Commissioning Report as required by Section 503.2.9.1.4. At the request of the building official, a copy of the Preliminary Commissioning Report shall be made available for review.

503.2.9.3 Completion requirements. The construction documents shall require that within 90

days after the date of final certificate of occupancy, the documents described in this section be provided to the building owner.

503.2.9.3.1 Drawings. Construction documents shall include as a minimum the location and performance data on each piece of equipment.

503.2.9.3.2 Manuals. An operating manual and a maintenance manual shall be in accordance with industry-accepted standards and shall include, at a minimum, the following:

1. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.
2. Manufacturer's operation manuals and maintenance manuals for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
3. Names and addresses of at least one service agency.
4. HVAC controls system 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.
5. A complete narrative of how each system is intended to operate, including suggested setpoints.

503.2.9.3.3 System balancing report. A written report describing the activities and measurements completed in accordance with Section 503.2.9.1.2

503.2.9.3.4 Final Commissioning Report. A complete report of test procedures and results identified as "Final Commissioning Report" shall include:

1. Results of all Functional Performance Tests.

2. Disposition of all deficiencies found during testing, including details of corrective measures used or proposed.

3. All Functional Performance Test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.

Exception: Deferred tests which cannot be performed at the time of report preparation due to climatic conditions.

503.2.10 Air system design and control. Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) 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 or less.
3. Fans exhausting air from fume hoods. (Note: If this exception is taken, no related exhaust side credits shall be taken from Table 503.2.10.1(2) and the Fume Exhaust Exception Deduction must be taken from Table 503.2.10.1(2).

**TABLE 503.2.10.1(1)
FAN POWER LIMITATION**

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
Option 1: Fan system motor nameplate	Allowable nameplate motor	$hp \leq CFMs * 0.0011$	$hp \leq CFMs * 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \leq CFMs * 0.00094 + A$	$bhp \leq CFMs * 0.0013 + A$

where:

CFMs = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.

hp = The maximum combined motor nameplate horsepower.

Bhp = The maximum combined fan brake horsepower.

$A = \text{Sum of } [PD_CFM_b / 4131]$.

where:

PD = Each applicable pressure drop adjustment from Table 503.2.10.1(2) in. w.c.

**TABLE 503.2.10.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT**

DEVICE	ADJUSTMENT
Credits	
Fully ducted return and/or exhaust air systems	0.5 in w.c.
Return and/or exhaust air flow control devices	0.5 in w.c.
Exhaust filters, scrubbers, or other exhaust treatment.	The pressure drop of device calculated at fan system design condition.
Particulate Filtration Credit: MERV 9 thru 12	0.5 in w.c.
Particulate Filtration Credit: MERV 13 thru 15	0.9 in w.c.
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.
Carbon and Other gas-phase air cleaners	Clean filter pressure drop at fan system design condition.
Heat Recovery Device	Pressure drop of device at fan system design condition.
Evaporative Humidifier/Cooler in series with another cooling coil	Pressure drop of device at fan system design conditions
Sound Attenuation Section	0.15 in w.c.
Deductions	
Fume Hood Exhaust Exception (required if 503.2.10.1.1 Exception 3 is taken)	-1.0 in w.c.

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.
2. For fans 6 bhp and larger, where the first available motor larger than the bhp has a nameplate rating within 30 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 de-energized when no occupants are present.

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, non-unitary or non-packaged 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 as shown in Table 503.3.1(1).

Economizers 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 over-pressurizing 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. Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(1) or 503.2.3(2) and meets or exceeds the minimum cooling efficiency requirement (EER) by the percentages shown in Table 503.3.1(2).

2. Systems with air or evaporatively cooled condensers and which serve spaces with open case refrigeration or that require filtration equipment in order to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.

**TABLE 503.3.1(1)
ECONOMIZER REQUIREMENTS**

CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B, 2A, 7, 8	No requirement
2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B	Economizers on all cooling systems \geq 54,000 Btu/ha

For SI: 1 British thermal unit per hour = 0.293 W.

a. The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater.

**TABLE 503.3.1(2)
EQUIPMENT EFFICIENCY PERFORMANCE
EXCEPTION FOR ECONOMIZERS**

CLIMATE ZONES	COOLING EQUIPMENT PERFORMANCE IMPROVEMENT (EER OR IPLV)
2B	10% Efficiency Improvement
3B	15% Efficiency Improvement
4B	20% Efficiency Improvement

503.3.2 Hydronic system controls. Hydronic systems of at least 300,000 Btu/h (87,930 W) 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. (Prescriptive). 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 according to Table 503.3.1(1). Economizers 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. Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(1), 503.2.3(2), or 503.2.3(6) and meets or exceeds the minimum EER by the percentages shown in Table 503.3.1(2)

3. Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(7) and meets or exceeds the minimum integrated part load value (IPLV) by the percentages shown in Table 503.3.1(2).

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 Sections 503.4.3.3.2.1 and 503.4.3.3.2.2.

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

503.4.3.3.2.1 Climate Zones 3 and 4. For Climate Zones 3 and 4 as indicated in Figure 301.1 and Table 301.1:

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.~~

503.4.3.3.2.2 Climate Zones 5 through 8. For climate Zones 5 through 8 as indicated in Figure 301.1 and Table 301.1, if an open- or closed-circuit cooling tower is used, then a separate heat exchanger shall be required to isolate the cooling tower from the heat pump loop, and heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop and providing an automatic valve to stop the flow of fluid.

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) (7.5kW) shall have a two-position valve.

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

1. Automatically reset the supply-water temperatures 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. 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 or control valves designed to modulate or step down, and close, as a function of load, or other *approved* means.

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.

503.4.4 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 and capable of being controlled to reduce primary air supply to each *zone* to one of the following before reheating, recooling or mixing takes place:

1. Thirty percent of the maximum supply air to each *zone*.
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.
3. The minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.

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, re-cooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *International 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 which are capable of preventing 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 are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.

503.4.5.3 Single fan dual duct and mixing VAV systems, economizers. Individual dual duct or mixing heating and cooling systems with a single fan and with total capacities greater than 90,000 Btu/h [(26 375 W) 7.5 tons] shall not be equipped with air economizers.

503.4.5.4 Supply-air temperature reset controls. Multiple *zone* HVAC 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 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Exceptions:

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. Seventy five percent of the energy for reheating is from site-recovered or site solar energy sources.
3. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

503.4.6 Heat recovery for service water heating.

Condenser heat recovery shall be installed for heating or reheating of service hot water provided the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 6,000,000 Btu/hr of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h.

The required heat recovery system shall have the capacity to provide the smaller of:

1. Sixty percent of the peak heat rejection load at design conditions; or
2. The preheating required to raise the peak service hot water draw to 85°F (29°C).

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.

Exceptions:

1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.

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.

**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	0.97 - 0.00132V, EF	DOE 10 CFR Part 430
	> 12 kW	Resistance	1.73V + 155 SL, Btu/h	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 $(Q / 800 + 110\sqrt{V})SL$, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q / 800 + 110\sqrt{V})SL$, Btu/h	
Instantaneous water heaters, Gas	> 50,000 Btu/h and < 200,000 Btu/h ^c	≥ 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	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q / 800 + 110\sqrt{V})SL$, 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 $(Q / 800 + 110\sqrt{V})SL$, Btu/h	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	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E_t $(Q / 800 + 110\sqrt{V})SL$, 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	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 $(Q / 800 + 110\sqrt{V})SL$, 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 $(Q / 800 + 110\sqrt{V})SL$, Btu/h	
Pool heaters, Gas and Oil	All	—	78% E_t	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	ARI 1160
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 (h- ft- 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 (E_t) are minimum requirements. In the EF equation, V is the rated volume in gallons.

(continued)

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.

504.5 Pipe insulation. For automatic-circulating hot water systems, piping shall be insulated with 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h x ft² x °F (1.53 W per 25 mm/m² x 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 x ft² x °F (1.53 W per 25 mm/m² x K).

504.6 Hot water system controls. Automatic-circulating hot water system pumps or heat trace shall be arranged to be conveniently turned off automatically or manually when the hot water system is not in operation.

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

504.7.1 Pool heaters. All pool heaters shall be equipped with a readily *accessible* on-off switch to allow shutting off the heater without adjusting the thermostat setting. Pool 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 swimming pool 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 pool heating systems.

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

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

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. Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area. 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. Areas designated as security or emergency areas that must be continuously lighted.
2. Lighting in stairways or corridors that are elements of the means of egress.

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 reasonably 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;
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/m²).

505.2.2.2 Automatic lighting shutoff. Buildings larger than 5,000 square feet (465m²) 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 25,000 square feet (2323 m²) 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.

Exception: The following shall not require an automatic 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 5,000 square feet (465 m²).

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 m²).

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.

Exception: Retail stores and associated malls, restaurants, grocery stores, places of religious worship and theaters.

505.2.2.3 Daylight Zone Control. Daylight zones, as defined by this code **appendix**, shall be provided with individual controls that control the lights independent of general area lighting. 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 more than 15 feet from the perimeter shall be controlled separately from daylight zones adjacent to vertical fenestration.

Exception: Daylight spaces enclosed by walls or ceiling height partitions and containing two or fewer light fixtures are not required to have a separate switch for general area lighting.

505.2.2.2 Automatic lighting controls. All commercial buildings shall be equipped with automatic control devices to shut off lighting in compliance with one of the following automatic control technologies:

1. Section 505.2.2.2.1 Occupancy Sensors
2. Section 505.2.2.2.2 Time Clock Controls
3. Section 505.2.2.2.3 Automatic Daylighting Controls

505.2.2.2.1 Occupancy sensors. Occupancy sensors shall be installed in all classrooms,

conference/meeting rooms, employee lunch and break rooms, private offices, restrooms, storage rooms and janitorial closets, and other spaces 300 sf. or less enclosed by ceiling height partitions. These automatic control devices shall be installed to automatically turn off lights within 30 minutes of all occupants leaving the space, except spaces with multi-scene control.

505.2.2.2.2 Time Clock Controls In areas not controlled by occupancy sensors, automatic time switch control devices shall be used. 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 4 hours when an override is initiated.
5. Controls an area not exceeding 5,000 square feet (465 m²).

Exceptions:

1. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, where captive-key override is utilized, override time may exceed 2 hours.
2. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, the area controlled may not exceed 20,000 square feet (1860 m²).

505.2.2.2.3 Automatic daylighting controls. Automatic controls installed in daylight zones shall control lights in the daylight areas separately from the non-daylit areas. Controls for calibration adjustments to the lighting control device shall be readily accessible to authorized personnel. Each daylight control zone shall not exceed 2,500 square feet. Automatic daylighting controls must incorporate an automatic shut-off ability based on time or occupancy in addition to lighting power reduction controls.

Controls will automatically reduce lighting power in response to available daylight by either one of the following methods:

- 1. Continuous dimming** using dimming ballasts and daylight-sensing automatic controls that are capable of reducing the power of general lighting in the daylight zone continuously to less than 35% of rated power at maximum light output.
- 2. Stepped Dimming** using multi-level switching and daylight-sensing controls that are capable of reducing

lighting power automatically. The system should provide a minimum of two control channels per zone and be installed in a manner such that at least one control step shall reduce power of general lighting in the daylight zone by 30% to 50% of rated power and another control step that reduces lighting power by 65% to 100%. Stepped dimming control is not allowed in continuously occupied areas with ceiling heights of 14 feet or lower

Exception: Daylight spaces enclosed by walls or ceiling height partitions and containing 2 or fewer luminaire are not required to have a separate switch for general area lighting.

505.2.3 Additional Controls

- a. Display/Accent Lighting—display or accent lighting shall have a separate control device.
- b. Case Lighting—lighting in cases used for display purposes shall have a separate control device.
- c. Hotel and Motel Guest Room Lighting—hotel and motel guest rooms and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.
- d. Task Lighting—supplemental task lighting, including permanently installed undershelf or undercabinet lighting, shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device is readily accessible and located so that the occupant can see the controlled lighting.
- e. Nonvisual Lighting—lighting for nonvisual applications, such as plant growth and food warming, shall have a separate control device.
- f. Demonstration Lighting—lighting equipment that is for sale or for demonstrations in lighting education shall have a separate control device.

Exceptions:

- a., b. and d. Where LED lighting is used no additional control is required.

~~**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 be capable of retaining programming and the time setting during loss of power for a period of at least 10 hours.

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.

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. Professional sports arena playing field lighting.
 - 1.2. *Sleeping unit* lighting in hotels, motels, boarding houses or similar buildings.
 - 1.3. Emergency lighting automatically off during normal building operation.
 - 1.4. 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.
 - 1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
 - 1.6. 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 *approved* because of safety or emergency considerations, inclusive of exit lights.
12. Lighting integral to both open and glass enclosed refrigerator and freezer cases.
13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
14. 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 30 W/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. 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 times the value from Table 505.5.2 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. 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.

NOTE: Compliance path b. (Reduced Lighting Power Density) in section 507 is not available for lighting installed according to the values in table 505.5.2. In this case, compliance can be met with one of the following paths:

- a. 507.2.1 Efficient Mechanical Equipment
- c. 507.2.3 On-Site Supply of Renewable Energy

**TABLE 505.5.2
INTERIOR LIGHTING POWER ALLOWANCES
LIGHTING POWER DENSITY**

Building Area Type _a	(W/ft ²)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Healthcare Clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.2
Multi Family	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

**TABLE 505.5.2
INTERIOR LIGHTING POWER ALLOWANCES
LIGHTING POWER DENSITY**

Building Area Type _a	Whole Building	Space by Space
	(W/ft ²)	
Active Storage		0.8
Atrium – First Three Floors		0.6
Atrium – Each Additional Floor		0.2
AUTOMOTIVE FACILITY	0.9	
Classroom/lecture/training		1.3
Conference/Meeting/Multipurpose		1.1
Corridor/Transition		0.5
Electrical/Mechanical		1.1
Food Preparation		1.2
Inactive Storage		0.2
Lobby		1.1
Restroom		0.8
Stairway		0.6
CONVENTION CENTER	1.2	
Exhibit Space		1.3
Audience/Seating Area		0.9
COURTHOUSE	1.2	
Audience/Seating Area		0.9
Courtroom		1.9
Confinement Cells		0.9
Judges Chambers		1.3
Dressing/Locker/Fitting Room		0.6
DINING: BAR LOUNGE/LEISURE	1.3	
Lounge/Leisure Dining		1.4
DINING: CAFETERIA/FAST FOOD	1.4	
DINING: FAMILY	1.6	
Dining		1.4
Kitchen		1.2
DORMITORY	1	
Living Quarters		1.1
Bedroom		0.5
Study Hall		1.4
EXERCISE CENTER	1	
Dressing/Locker/Fitting Room		0.6
Audience/Seating Area		0.3
Exercise Area		0.9
Exercise Area/Gymnasium		0.9
RETAIL: SUPERMARKET GYMNASIUM	1.3	
Dressing/Locker/Fitting Room		0.6
Audience/Seating Area		0.4
Playing Area		1.4
Exercise Area		0.9
HEALTHCARE CLINIC	1	
Corridors w/patient waiting, exam		1
Exam/Treatment		1.5
Emergency		2.7
Public & Staff Lounge		0.8
Hospital/Medical supplies		1.4
Hospital - Nursery		0.6
Nurse station		1
Physical therapy		0.9
Patient Room		0.7
Pharmacy		1.2
Hospital/Radiology		0.4
Operating Room		2.2

Recovery		0.8
Active storage		0.9
Laundry-Washing		0.6
HOTEL	1	
Dining Area		1.3
Guest quarters		1.1
Reception/Waiting		2.5
Lobby		1.1
LIBRARY	1.3	
Library-Audio Visual		0.7
Stacks		1.7
Card File & Cataloguing		1.1
Reading Area		1.2
MANUFACTURING FACILITY	1.3	
MOTEL	1	
Dining Area		1.2
Guest quarters		1.1
Reception/Waiting		2.1
MOTION PICTURE THEATER	1.2	
Audience/Seating Area		1.2
Lobby		1
MUSEUM	1.1	
Active Storage		0.8
General exhibition		1
Restoration		1.7
MULTI FAMILY	0.7	
OFFICE	0.9	
Enclosed		1
Open Plan		1
PARKING GARAGE	0.3	
PENITENTIARY	1.0	
PERFORMING ARTS THEATER	1.6	
Audience/Seating Area		2.6
Lobby		3.3
Dressing/Locker/Fitting Room		1.1
POLICE STATIONS	1	
FIRE STATIONS	0.8	
Fire Station Engine Room		0.8
Sleeping Quarters		0.3
Audience/Seating Area		0.8
Police Station Laboratory		1.4
POST OFFICETS/SF	1.1	
Sorting Area		1.2
Lobby		1
RELIGIOUS BUILDINGS	1.3	
Lobby		0.6
Worship/Pulpit/Choir		2.4
RETAIL	1.3	
Department Store Sales Area		1.3
Specialty Store Sales Area		1.8
Fine Merchandise Sales Area		2.9
Supermarket Sales Area		1.3
Personal Services Sales Area		1.3
Mass Merchandising Sales Area		1.3
Mall Concourse		1.7
SCHOOL/UNIVERSITY	1.2	
Classroom		1.3
Audience		0.7
Dining		1.1

Office		1.1
Corridor		0.5
Storage		0.5
Laboratory		1.1
RETAIL	1.5	
RETAIL: SPECIALTY	1.6	
SPORTS ARENA	1.1	
TOWN HALL	1.1	
TRANSPORTATION	1	
Dining Area		2.1
Baggage Area		1
Airport - Concourse		0.6
Terminal - Ticket Counter		1.5
Reception/Waiting		0.5
WAREHOUSE	0.6	
Fine Material		1.4
Medium/Bulky Material		0.6
WORKSHOP	1.4	

Note: The lighting power densities contained in this table include allowances for video-display terminals, decorative lighting and display lighting. Additional lighting power is not allowed for these uses. Task lighting is not included in these connected LPD limits.

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

- In cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.
- Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

Calculate the additional lighting power as follows:
 Additional Interior Lighting Power Allowance = 1000watts +
 (Retail Area 1 × 0.6 W/ft²) + (Retail Area 2 × 0.6W/ft²) + (Retail Area 3 × 1.4 W/ft²) + (Retail Area 4 × 2.5 W/ft²).

where:
 Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.

Retail Area 2 = The floor area used for the sale of vehicles, sporting goods and small electronics.

Retail Area 3 = The floor area used for the sale of furniture, clothing, cosmetics and artwork.

Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.

Exception: Other merchandise categories are permitted to be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is *approved* by the authority having jurisdiction.

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. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lumens per watt unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section 505.6.2.

505.6.2 Exterior building lighting power. The total exterior 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

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.

**TABLE 505.6.2
LIGHTING POWER DENSITIES FOR BUILDING EXTERIORS**

APPLICATIONS	LIGHTING POWER DENSITIES
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 Lots and drives	0.15 W/ft ²
Building Grounds	
Walkways less than 10 feet wide	1.0 watts/linear foot
Walkways 10 feet wide or greater, plaza areas and special feature areas	0.2 W/ft ²
Stairways	1.0 W/ft ²
Building Entrances and Exits	
Main entries	30 watts/linear foot of door width
Other doors	20 watts/linear foot of door width
Canopies and Overhangs	
Canopies (free standing & attached and overhangs)	1.25 W/ft ²
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft ²
Street frontage for vehicle sales lots in addition to "open area" allowance	20 watts/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	0.2 W/ft ² for each illuminated wall or surface or 5.0 Watts/linear foot for each illuminated wall or surface length
Automated teller machines and night depositories	270 watts per location plus 90 watts per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft ² of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft ² of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)
Drive-up windows at fast food restaurants	400 watts per drive-through
Parking near 24-hour retail entrances	800 watts per main entry

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

**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
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and can-not 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 drivethrough	400 W per drivethrough	400 W per drivethrough	400 W per drivethrough
	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 m².

SECTION 506 – TOTAL BUILDING PERFORMANCE

As referenced in section 101.4.6 and section 501, buildings establishing compliance with this appendix through total building performance shall meet the requirements of ASHRAE/IESNA Standard 90.1-2007, Energy Standard for Buildings Except for Low-Rise Residential Buildings, and shall be designed to achieve energy use per square foot equal to at least 20% below the energy requirements of ASHRAE 90.1-2007, measured by industry accepted energy modeling.

**SECTION 507
ALTERNATIVE PRESCRIPTIVE
COMPLIANCE PACKAGES**

507.1 Requirements. Buildings are required to comply with any one of the following sections:

- a. 507.2.1 Efficient Mechanical Equipment
- b. 507.2.2 Reduced Lighting Power Density
- c. 507.2.3 On-Site Supply of Renewable Energy

507.2.1 Efficient Mechanical Equipment

This mechanical alternative compliance option is intended to allow the builder to meet the requirements of section 507 by choosing to install efficient mechanical equipment. This section in no way replaces requirements in section 503, but is one of several optional compliance packages.

Mechanical equipment choices that fulfill requirements for section 507.2.1 shall comply with the following:

- a. Package unitary equipment shall meet the minimum efficiency requirements in Tables 507.2.1(1) and 507.2.1(2)
- b. Package Terminal Air Conditioners and Heat Pumps shall meet the minimum efficiency requirements in Table 507.2.1(3)
- c. Warm air furnaces and combination warm air furnaces / air conditioning units shall meet the minimum efficiency requirements in Table 507.2.1(4)
- d. Boilers shall meet the minimum efficiency requirements in Table 507.2.1(5)
- e. Electric chillers shall meet the energy efficiency requirements in Table 507.2.1(6)
- f. Absorption chillers shall meet the minimum efficiency requirements in Table 507.2.1(7)

**TABLE 507.2.1(1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS,
ELECTRICALLY OPERATED, EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	REQUIRED EFFICIENCY^a
Air conditioners, Air cooled	< 65,000 Btu/h	Split system	15.0 SEER 12.5 EER
		Single package	15.0 SEER 12.0 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.5 EER _b 11.9 IPLV _b
		Split system and single package	11.5 EER _b 11.9 IPLV _b
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	10.5 EER _b 10.9 IPLV _b
		Split system and single package	10.5 EER _b 10.9 IPLV _b
≥ 240,000 Btu/h and < 760,000 Btu/h		9.7 EER _b 11.0 IPLV _b	
≥ 760,000 Btu/h		9.7 EER _b 11.0 IPLV _b	
Air conditioners, Water and evaporatively cooled		Split system and single package	14.0 EER

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

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

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

**TABLE 507.2.1(2)
UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY
OPERATED, EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	REQUIRED EFFICIENCY_a
Air cooled (Cooling mode)	< 65,000 Btu/h _a	Split system	15.0 SEER 12.5 EER
		Single package	15.0 SEER 12.0 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.5 EER _b 11.9 IPLV _b
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.5 EER _b 11.9 IPLV _b
	≥ 240,000 Btu/h	Split system and single package	10.5 EER _b 10.9 IPLV _b
Water source (Cooling mode)	< 135,000 Btu/h	85°F entering water	14.0 EER
Air cooled (Heating mode)	< 65,000 Btu/h _a (Cooling capacity)	Split system	8.5 HSPF
		Single package	8.0 HSPF
	≥ 65,000 Btu/h and < 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb outdoor air	3.4 COP
		77°F db/15°F wb outdoor air	2.4 COP
	≥ 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb outdoor air	3.1 COP
		77°F db/15°F wb outdoor air	2.1 COP
Water source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	70°F entering water	4.6 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. IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.

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

**TABLE 507.2.1(3)
PACKAGED TERMINAL AIR CONDITIONERS AND
PACKAGED TERMINAL HEAT PUMPS**

EQUIPMENT TYPE	SIZE CATEGORY	REQUIRED EFFICIENCY_b
Air conditioners	< 7,000 Btu / h	11.9 EER
& Heat Pumps (Cooling Mode)	7,000 Btu / h and < 10,000 Btu / h	11.3 EER
	10,000 Btu / h and < 13,000 Btu / h	10.7 EER
	> 13,000 Btu / h	9.5 EER

a. 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 507.2.1(4)
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS,
WARM AIR DUCT FURNACES AND UNIT HEATERS, EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING OR CONDITION	REQUIRED EFFICIENCY	TEST PROCEDURE
Warm air furnaces, gas fired	< 225,000 Btu/h	-	90 AFUE or 90 <i>Et</i>	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity	90% <i>Ec</i> , note 1.	ANSI Z21.47
Warm air furnaces, oil fired	< 225,000 Btu/h	-	85 AFUE or 85 <i>Et</i>	DOE 10 CFR Part 430 or <u>UL727</u>
	≥ 225,000 Btu/h	Maximum capacity	85 % <i>Et</i> , note 1	<u>UL 727</u>
Warm air duct furnaces, gas fired	All capacities	Maximum capacity	90% <i>Ec</i>	ANSI Z83.8
Warm air unit heaters, gas fired	All capacities	Maximum capacity	90% <i>Ec</i>	ANSI Z83.8
Warm air unit heaters, oil fired	All capacities	Maximum capacity	90% <i>Ec</i>	UL 731

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

1. Units must also include an IID (intermittent ignition device), 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.

Where there are two ratings, 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.

Et = Thermal efficiency

Ec = Combustion efficiency (100% less flue losses)

Efficient furnace fan: All fossil fuel furnaces in zones 3 to 8 shall have a furnace electricity ratio not greater than 2% and shall include a manufacturer's designation of the furnace electricity ratio.

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**TABLE 507.2.1(5)
BOILER, EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	REQUIRED EFFICIENCY
Gas Hot Water	< 300,000 Btu / h	90% <i>Et</i>
	> 300,000 Btu / h and > 2.5 mBtu/h	89% <i>Et</i>
Gas Steam	< 300,000 Btu / h	89% <i>Et</i>
	> 300,000 Btu / h	89% <i>Et</i>
Oil	< 300,000 Btu / h	90% <i>Et</i>
	> 300,000 Btu / h	89% <i>Et</i>
<p><i>Et</i> = thermal efficiency</p> <p>* Systems must be designed with lower operating hot water temperatures (<150°F) and use hot water reset to take advantage of the much higher efficiencies of condensing boilers.</p>		

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**TABLE 507.2.1(5)
CHILLERS - EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	SIZE CATEGORY	REQUIRED EFFICIENCY- CHILLERS		OPTIONAL COMPLIANCE PATH - REQUIRED EFFICIENCY - CHILLERS WITH VSD	
		Full Load (KW /TON)	IPLV (KW /TON)	Full Load (KW /TON)	IPLV (KW /TON)
Air Cooled w/ Condenser	All	1.2	1.0	N/A	N/A
Air Cooled w/o Condenser	All	1.08	1.08	N/A	N/A
Water Cooled, Reciprocating	All	0.840	0.630	N/A	N/A
Water Cooled, Rotary Screw and Scroll	< 90 tons	0.780	0.600	N/A	N/A
	³ 90 tons and < 150 tons	0.730	0.550	N/A	N/A
	³ 150 tons and < 300 tons	0.610	0.510	N/A	N/A
	> 300 tons	0.600	0.490	N/A	N/A
Water Cooled, Centrifugal	< 150 tons	0.610	0.620	0.630	0.400
	³ 150 tons and < 300 tons	0.590	0.560	0.600	0.400
	300 tons and < 600 tons	0.570	0.510	0.580	0.400
	> 600 tons	0.550	0.510	0.550	0.400

- a. Compliance with full load efficiency numbers and IPLV numbers are both required.
- b. Only Chillers with Variable Speed Drives(VSD) may use the optional compliance path here for chiller efficiency.

**TABLE 507.2.1(6)
ABSORPTION CHILLERS - EFFICIENCY REQUIREMENTS**

EQUIPMENT TYPE	REQUIRED EFFICIENCY FULL LOAD COP (IPLV)
Air Cooled, Single Effect	0.60, but only allowed in heat recovery applications
Water Cooled, Single Effect	0.70, But only allowed in heat recovery applications
Double Effect - Direct Fired	1.0 (1.05)
Double Effect - Indirect Fired	1.20

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507.2.2 Reduced Lighting Power Density.

Whole Building Lighting Power Density (Watts/sf) must be reduced by at least 10% from the values in table 505.5.2, or as shown in table 507.2.2.

507.2.2.1 Automatic Daylighting Controls.

Automatic daylighting controls shall be installed in the daylight zone and shall meet the requirements of 505.2.2.2.3.

**TABLE 507.2.2
REDUCED INTERIOR LIGHTING POWER ALLOWANCES**

LIGHTING POWER DENSITY	
Building Area Type^a	Reduced whole building (W/ft²)
Automotive Facility	0.8
Convention Center	1.1
Court House	1.1
Dining: Bar Lounge/Leisure	1.2
Dining: Cafeteria/Fast Food	1.3
Dining: Family	1.4
Dormitory	0.9
Exercise Center	0.9
Gymnasium	1.0
Healthcare-Clinic	0.9
Hospital	1.1
Hotel	0.9
Library	1.2
Manufacturing Facility	1.2
Motel	0.9
Motion Picture Theater	1.1
Multi-Family	0.6
Museum	1.0
Office	0.8
Parking Garage	0.3
Penitentiary	0.9
Performing Arts Theater	1.4
Police/Fire Station	0.9
Post Office	1.0
Religious Building	1.2
Retail ^b	1.2
School/University	1.1
Sports Arena	1.0
Town Hall	1.0
Transportation	0.9
Warehouse	0.5
Workshop	1.3

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

- a. In cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.
- b. Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

Calculate the additional lighting power as follows:

$$\text{Additional Interior Lighting Power Allowance} = 1000\text{watts} + (\text{Retail Area 1} \times 0.6 \text{ W/ft}^2) + (\text{Retail Area 2} \times 0.6\text{W/ft}^2) + (\text{Retail Area 3} \times 1.4 \text{ W/ft}^2) + (\text{Retail Area 4} \times 2.5 \text{ W/ft}^2).$$

where:

Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.

Retail Area 2 = The floor area used for the sale of vehicles, sporting goods and small electronics.

Retail Area 3 = The floor area used for the sale of furniture, clothing, cosmetics and artwork.

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Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.

Exception: Other merchandise categories are permitted to be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is *approved* by the authority having jurisdiction.

507.2.3 On-site Supply of Renewable Energy

The building or surrounding property shall incorporate an on-site renewable energy system that supplies 3% or more of total building electrical loads. On-site power generation using nonrenewable resources does not meet this requirement.

The jurisdiction shall be provided with an energy analysis that documents the renewable energy contribution to the building or a calculation demonstrating that the on-site supply of renewable energy:

- a) Is capable of providing at least 3 percent of the total energy load of the building, or
- b) Has an installed maximum generating capacity equal to or greater than 0.50 watts per square foot of usable floor space.

Insert IECC 2009 Chapter 6 – Referenced Standards