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2015 Vermont Commercial Building Energy Standards

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PREFACE

This document is the 2015 Vermont Commercial Building Energy Standards (CBES). It is based on the 2015 International Energy Conservation Code (IECC) and includes many elements of ASHRAE/IESNA Standard 90.1-2013. Amendments have been made to suit Vermont's climate and special needs.

The Vermont Energy Act of 2009 (Act 45) directed the Commissioner of the Department of Public Service to amend the CBES to ensure that commercial building construction be designed and constructed in a manner that complies with ASHRAE/IESNA Standard 90.1-2007 or the 2009 edition of the IECC.

The Vermont Energy Act of 2009 (Act 45) legislation requires that at least every three years after January 1, 2011 the commissioner of public service shall amend and update the CBES.

30 V.S.A. §53 of the Vermont Statutes requires certification that both the design and the construction of a commercial building is in compliance with the CBES. Certification shall be issued by a completed and signed certificate permanently affixed to the outside of the heating or cooling equipment, to the electrical service panel and located inside the building, or in a visible location in the immediate vicinity of one of these three areas. Copies of the signed certification documents shall be sent to the local town clerk and to the Vermont Department of Public Service.

The Vermont Division of Fire Safety may request completed certificates at the time of inspection, and certificate of occupancy may be withheld until the CBES certificate and affidavits are posted.

Certificates, affidavits and contact information for questions about the energy code can be found at:
http://publicservice.vermont.gov/topics/energy_efficiency/cbes

The statute pertaining to CBES (30 V.S.A. §53) can be found at:

http://www.leg.state.vt.us/statutes/fullsection.cfm?Title=30&Chapter=002&Section=00053 Users of the code are encouraged to view the publicly available interpretations of the ASHRAE 90.1-2013 standard, available online at:
https://www.ashrae.org/standards-research--technology/standards-interpretations/interpretations-for-standard-90-1-2013

Effective Use of the 2015 Commercial Building Energy Standards

Arrangement and Format of the 2015 CBES

Before applying the requirements of the 2015 CBES it is beneficial to understand its arrangement and format. The 2015 CBES, like other codes published by ICC, is arranged and organized to follow sequential steps that generally occur during a plan review or inspection. The 2015 CBES is divided into five different parts:

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

The following is a chapter-by-chapter synopsis of the scope and intent of the provisions of the 2015 *Commercial Building Energy Standards:*

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

Chapter 2 Definitions. Chapter 2 is the repository of the definitions of terms used in the body of the code. Codes are technical documents and every word, term and punctuation mark can impact the meaning of the code text and the intended results. The code often uses terms that have a unique meaning in the code and the code meaning can differ substantially from the ordinarily understood meaning of the term as used outside of the code.

The terms defined in Chapter 2 are deemed to be of prime importance in establishing the mean- ing and intent of the code text. The user of the code should be familiar with and consult this chapter because the definitions are essential to the correct interpretation of the code and the user may not be aware that a term is defined.

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

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

Chapter 3 General Requirements. Chapter 3 provides interior design conditions that are used as a basis for assumptions in heating and cooling load calculations and provides basic material requirements for insulation materials and fenestration materials.

Climate has a major impact on the energy use of most buildings. The code establishes many requirements such as wall and roof insulation R-values, window and door thermal transmittance requirement (U-factors) as well as provisions that affect the mechanical systems.

Chapter 4 Commercial Energy Efficency, Chapter 4 contains the energy-efficiency-related requirements for the design and construction of most types of commercial buildings and residential buildings greater than three stories in height above grade. This chapter defines requirements for the portions of the building and building systems that impact energy use in new commercial construction and new residential construction greater than three stories in height, and promotes the effective use of energy. The provisions within the chapter promote energy efficiency in the building envelope, the heating and cooling system and the service water heating system of the building.

Chapter 5 Existing Buildings. Chapter 5 contains the technical energy-efficiency- requirements for existing buildings. Chapter 5 provisions address the maintenance of buildings in compliance with the code as well as how additions, alterations, repairs and changes of occupancy need to be addressed from the standpoint of energy efficiency. Specific provisions are

provided for historic buildings.

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

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

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CHAPTER 1

SCOPE AND ADMINISTRATION

PART 1—SCOPE AND APPLICATION

SECTION 101
SCOPE AND GENERAL REQUIREMENTS

101.1 Title. This code shall be known as the 2015 *Commercial Building Energy Standards (CBES) of Vermont*, and shall be cited as such. It is referred to herein as "this code."

101.2 Scope. This code applies to *commercial buildings* and the buildings' sites and associated systems and equipment. This code provides minimum energy-efficient requirements for the design and construction, and a plan for operation and maintenance of new equipment or building systems specifically identified in the code that are part of industrial or manufacturing processes.

Exceptions:

This code shall not apply to farm structures as defined in 24 V.S.A. § 4413.

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

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

101.4.1 Mixed occupancy. Where a building includes both *residential* and *commercial* occupancies, the following shall apply:

1. With respect to a structure that is three stories or less in height and is a mixed-use building that shares residential and commercial users,

   i. The term "residential building" shall include the living spaces in the structure and the nonliving spaces in the structure that serve only the residential users such as common hallways, laundry facilities, residential management offices, community rooms, storage rooms, and foyers.

   ii. The term "commercial building" shall include all commercial uses within the structure and all common areas and facilities that serve both residential and commercial uses; and

2. With respect to a structure that is four stories or more in height, the term "commercial building" shall include all uses and areas within the structure.

C101.4.2 Application to Existing Buildings. Existing buildings shall follow the provisions of Chapter 5 of this code.

101.5 Compliance. *Residential buildings* shall meet the provisions of the Vermont Residential Buildings Energy Standards (RBES). *Commercial buildings* shall meet the provisions of this code.

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

At the time of application for a construction permit, where required, the designer shall include a statement on the submitted stamped drawings that the design complies with the requirements of the CBES.

101.5.2 Exempt buildings. The following buildings, or portions thereof, separated from the remainder of the build- ing by *building thermal envelope* assemblies complying with Section 402 shall be exempt from the *building thermal envelope* provisions of section 402:

1. **Low energy use buildings.** Those with a peak design rate of energy usage less than 3.4 Btu/h·ft^2 (10.7 W/m^2) or 1.0 watt/ft^2 (10.7 W/m^2) of floor area for space conditioning purposes.
2. **Unconditioned buildings.** Those that do not contain *conditioned space*.
3. **Greenhouses**.
4. **Inflatable buildings.** Those above ground portions that are air-supported structures, when constructed for temporary purposes, shall be exempt *only* from the thermal envelope provisions of this code

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

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

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. Buildings *approved* in writing by such an energy efficiency program shall be considered in compliance with this code. The requirements

identified as "mandatory" in Chapter 4 of thiscode, shall be met.

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION 103
CONSTRUCTION DOCUMENTS

103.1 General. Where required, 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* or other authority having jurisdiction is authorized to require necessary construction documents to be prepared by a registered design professional.

Exception: The *code official* or other authority having jurisdiction is authorized to waive the requirements for construction documents or other supporting data if the *code official* or other authority having jurisdiction determines they are not necessary to confirm compliance with this code.

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* or other authority having jurisdiction. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, as applicable:

1. Insulation materials and their *R*-values;
2. Fenestration *U*-factors and SHGCs
3. Area-weighted *U*-factor and SHGC calculations;
4. Design ambient temperatures;
5. Interior tempera- tures for heating and cooling modes;
6. Relative humidity setpoints;
7. Ventilation rates;
8. Mechanical system design criteria;
9. Mechanical and service water heating system and equipment types, sizes and efficiencies;
10. Economizer description;
11. Equipment and systems controls;
12. Fan motor horsepower (hp) and controls;
13. Duct sealing, duct and pipe insulation and location;
14. Lighting fixture schedule with wattage and control narrative;
15. Location of *daylight* zones on floor plans
16. Air sealing details.

Mechanical equipment schedules shall be included in the submitted construction documents and shall include, but are not limited to, the following information:

1. Equipment efficiencies
2. Fan and pump nameplate motor and brake horsepower
3. Fan efficiency grade (FEG), where applicable.
4. Hydronic system (if applicable) supply and return water design temperatures for boilers and all terminal devices (e.g. baseboards, unit ventilators, etc.).
5. Steam system (if applicable) design pressure for boilers and all terminal devices

C103.2.1 Building thermal envelope depiction. The *building's thermal envelope* shall be represented on the construction drawings

103.3 Examination of documents. The *code official* or other authority having jurisdiction 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 and other pertinent laws or ordinances. The code official or authority having jurisdiction is authorized to utilize a registered design professional, or other approved entity not affiliated with the building design or construction, in conducting the review of the plans and specifications for compliance with the code.

103.3.1 Approval of construction documents. When the *code official* or other authority having jurisdiction 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* or other

authority having jurisdiction. 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* or other authority having jurisdiction.

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

103.3.3 Phased approval. The *code official* or other authority having jurisdiction 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 sys- tem have been submitted or *approved*, provided adequate information and detailed statements have been filed com- plying with all pertinent requirements of this code. The holders of such permit shall proceed at their own risk with- out 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. Where required, construction or work for which a permit is required shall be subject to inspection by the *code official* or other authority having jurisdiction . or his or her designated agent, and such construction or work shall remain accessible and exposed for inspection purposes until approved. It shall be the duty of the permit applicant to cause the work to remain accessible and exposed for inspection purposes. Neither the code official or authority having jurisdiction nor the jurisdiction shall be liable for expense entailed in the removal or replacement of any material, product, system or building component required to allow inspection to validate compliance with this code.

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* or other authority having jurisdiction. The code official or other authority having jurisdiction, 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. Any portions that do not comply shall be corrected and such portion shall not be covered or concealed until authorized by the *code official* or other authority having jurisdiction.

104.2.6 Final inspection. Where applicable, the building shall have a final inspection and not be occupied until *approved*. The final inspection shall include verification of the installation and proper operation of all required building controls, and documentation verifying activities associated with required building commissioning have been conducted and findings of noncompliance corrected.

104.3 Reinspection. A building shall be reinspected when determined necessary by the *code official* or other authority having jurisdiction.

104.4 Approved inspection agencies. The *code official* or other authority having jurisdiction is authorized to accept reports of *third-party inspection agencies not affiliated with the building design or construction*, provided such agencies are approved as to qualifications and reliability relevant to the building components and systems they are inspecting.

104.5 Inspection requests. It shall be the duty of the holder of the permit or their duly authorized agent to notify the *code official* or other authority having jurisdiction 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.

104.6 Reinspection and testing. Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made to achieve compliance with this code. The work or installation shall then be resubmitted to the *code official* or other authority having jurisdiction for inspection and testing.

104.7 Approval. After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the *code official* or other authority having jurisdiction.

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

SECTION 105
VALIDITY

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

SECTION 106
REFERENCED STANDARDS

106.1 General. The codes and standards referenced in this code shall be those listed in Chapter 6, and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and further regulated in Sections 106.1.1 and 106.1.2.

106.1.1 Conflicts. Where conflicts occur between provisions of this code and the referenced standards, the provisions of this code shall apply.

C106.1.2 Provisions in referenced codes and standards. Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code

106.2 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.

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

CHAPTER 2

DEFINITIONS

SECTION 201
GENERAL

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

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

201.3 Terms defined in other codes. Terms that are not defined in this code but are defined in the *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-GRADE WALL. See "Wall, above-grade."

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. Materials 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.

AIR CURTAIN. A device, installed at the building entrance, that generates and discharges a laminar air stream intended to prevent the infiltration of external, unconditioned air into the conditioned spaces, or the loss of interior, conditioned air to the outside.

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

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

APPROVED AGENCY. An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved by the code official or other authority having jurisdiction.

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").

BELOW-GRADE WALL. See "Wall, below-grade."

BOILER, MODULATING. A boiler that is capable of more than a single firing rate in response to a varying temperature or heating load.

BOILER SYSTEM. One or more boilers, their piping and controls that work together to supply steam or hot water to heat output devices remote from the boiler.

BUBBLE POINT. The refrigerant liquid saturation temperature at a specified pressure.

BUILDING. Any structure used or intended for supporting or sheltering any use or occupancy, including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building.

BUILDING COMMISSIONING. 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, and to minimum code requirements.

BUILDING ENTRANCE. Any door, set of doors, doorway, or other form of portal that is used to gain access to the building from the outside by the general public.

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

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

CBES. Commercial Building Energy Standards.

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

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

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

COEFFICENT OF PERFORMANCE (COP) – COOLING. The ratio of the rate of heat input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.

COEFFICIENT OF PERFORMANCE (COP) – HEATING. The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.

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

COMPUTER ROOM. A room whose primary function is to house equipment for the processing and storage of electronic data and that has a design electronic data equipment power density exceeding 20 watts per square foot of conditioned floor area.

CONDENSING UNIT. A factory-made assembly of refrigeration components designed to compress and liquefy a specific refrigerant. The unit consists of one or more refrigerant compressors, refrigerant condensers (air-cooled, evaporatively cooled, or water-cooled), condenser fans and motors (where used) and factory-supplied accessories.

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

CONDITIONED SPACE. An area, room or space that is enclosed within a building thermal envelope and is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with con- ditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or colling.

CONTINUOUS AIR BARRIER. A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

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

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

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

DAYLIGHT RESPONSIVE CONTROL. A device or system that provides automatic control of electric light levels based on the amount of daylight in a space.

DAYLIGHT ZONE. That portion of a building's interior floor area that is illuminated by natural light.

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.

DEMAND RECIRCULATION WATER SYSTEM. A water distribution system where pumps prime the service hot water piping with heated water upon demand for hot water.

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

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

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.

DYNAMIC GLAZING. Any fenestration product that has the fully reversible ability to change its performance properties, including U-factor, solar heat gain coefficient (SHGC), or visible transmittance (VT).

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.

ENCLOSED SPACE. A volume surrounded by solid surfaces such as walls, floors, roofs, and openable devices such as doors and operable windows

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

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

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

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

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

EQUIPMENT ROOM. A space that contains either electrical equipment, mechanical equipment, machinery, water pumps or hydraulic pumps that are a function of the building's services.

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

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

FAN EFFICIENCY GRADE (FEG). A numerical rating identifying the fan's aerodynamic ability to convert shaft power, or impeller power in the case of a direct-driven fan, to air power.

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 spaces* 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 spaces* and return it to the source or exhaust it to the outdoors.

FARMING. The cultivation or other use of land for growing food, fiber, Christmas trees, maple sap, or horticultural and orchard crops; or the raising, feeding, or management of livestock, poultry, fish, or bees; or the operation of greenhouses; or the production of maple syrup; or the on-site storage, preparation and sale of agricultural products principally produced on the farm; or the on-site production of fuel or power from agricultural products or wastes produced on the farm; or the raising, feeding, or management of four or more equines owned or boarded by the farmer, including training, showing, and providing instruction and lessons in riding, training, and the management of equines.

FARM STRUCTURE. A building, enclosure, or fence for housing livestock, raising horticultural or agronomic plants, or carrying out other practices associated with accepted agricultural or farming practices, including a silo, as "farming" is defined, but excludes a dwelling for human habitation.

FENESTRATION. Products classified as either vertical fenestration or skylights.

Skylight. Glass or other transparent or translucent glazing

material installed at a slope of less than 60 degrees (1.05 rad) from horizontal.

Vertical fenestration. Windows (fixed or moveable), opaque doors, glazed doors, glazed block and combination opaque/glazed doors composed of glass or other transpar- ent or translucent glazing materials and installed at a slope of at least 60 degrees (1.05 rad) from horizontal.**FENESTRATION PRODUCT, FIELD-FABRICATED.** A fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-built fenestration.

FENESTRATION PRODUCT, SITE-BUILT. Fenestration designed to be field-glazed or field assembled units using spe-

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cific factory cut or otherwise factory formed framing and glaz- ing units. Examples of site-built fenestration include storefront systems, curtain walls, and atrium roof systems.

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

FLOOR AREA, NET. The actual occupied area not including unoccupied accessory areas such as corridors, stairways, toilet rooms, mechanical rooms and closets.

FULLY SHIELDED FIXTURE. A fixture constructed and installed in such a manner that all light emitted by it, either directly from the lamp (bulb) or a diffusing element, or indirectly by reflection or refraction from any part of the fixture, is projected below the horizontal.

GENERAL LIGHTING. Lighting that provides a substantially uniform level of illumination throughout an area. General lighting shall not include decorative lighting or lighting that provides a dissimilar level of illumination to serve a specialized application or feature within such area.

GENERAL PURPOSE ELECTRIC MOTOR (SUBTYPE I). A motor that is designed in standard ratings with either of the following:

1. Standard operating characteristics and standard mechanical construction for use under usual service conditions, such as those specified in NEMA MG1, paragraph 14.02, "Usual Service Conditions," and without restriction to a particular application or type of application.

2. Standard operating characteristics or standard mechanical construction for use under unusual service conditions, such as those specified in NEMA MG1, paragraph 14.03, "Unusual Service Conditions," or for a particular type of application, and that can be used in most general purpose applications.

General purpose electric motors (Subtype I) are constructed in NEMA T-frame sizes or IEC metric equivalent, starting at 143T.

GENERAL PURPOSE ELECTRIC MOTOR (SUBTYPE II). A motor incorporating the design elements of a general purpose electric motor (Subtype I) that is configured as one of the following:

1. A U-frame motor.
2. A Design C motor.
3. A close-coupled pump motor.
4. A footless motor.
5. A vertical, solid-shaft, normal-thrust motor (as tested in a horizontal configuration).
6. An 8-pole motor (900 rpm).
7. A polyphase motor with voltage of not more than 600 volts (other than 230 or 460 volts).

GREENHOUSE. A structure or a thermally isolated area of a building that maintains a specialized sunlit environment exclusively used for, and essential to, the cultivation, protection or maintenance of plants.

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 SPEED DOOR. A nonswinging door used primarily to facilitate vehicular access or material transportation, with a minimum opening rate of 32 inches (813 mm) per second, a minimum closing rate of 24 inches (610 mm) per second and that includes an automatic-closing device.

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

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

HISTORIC BUILDING. Any building or structure that is one or more of the following:

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

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.

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

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.

LINER SYSTEM (Ls). A system that includes the following:

1. A continuous vapor barrier liner membrane that is installed below the purlins and that is uninterrupted by framing members.
2. An uncompressed, unfaced insulation resting on top of the liner membrane and located between the purlins.

For multilayer installations, the last rated *R-value* of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached.

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

LOW-SLOPED ROOF. A roof having a slope less than 2 units vertical in 12 units horizontal.

LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMER. A transformer that is air-cooled, does not use oil as a coolant, has an input voltage less than or equal to 600 volts and is rated for operation at a frequency of 60 hertz.

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 interven- tion (see "Automatic").

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

NONSTANDARD PART LOAD VALUE (NPLV). A sin- gle-number part-load efficiency figure of merit calculated and referenced to conditions other than IPLV conditions, for units that are not designed to operate at ARI standard rating condi- tions.

OCCUPANT SENSOR CONTROL. An automatic control device or system that detects the presence or absence of peo- ple within an area and causes lighting, equipment or appli- ances to be regulated accordingly.

ON-SITE RENEWABLE ENERGY. Energy derived from solar radiation, wind, waves, tides, landfill gas, biomass or the internal heat of the earth. The energy system providing on-site renewable energy shall be located on the project site.

OPAQUE DOOR. A door that is not less than 50-percent opaque in surface area.

POWERED ROOF/WALL VENTILATORS. A fan con- sisting of a centrifugal or axial impeller with an integral driver in a weather-resistant housing and with a base designed to fit, usually by means of a curb, over a wall or roof opening.

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

RADIANT HEATING SYSTEM. A heating system that transfers heat to objects and surfaces within a conditioned space, primarily by infrared radiation.

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*").

REFRIGERANT DEW POINT. The refrigerant vapor satu- ration temperature at a specified pressure.

REFRIGERATED WAREHOUSE COOLER. An enclosed storage space capable of being refrigerated to tem- peratures above 32°F (0°C), that can be walked into and has a total chilled storage area of not less than 3,000 square feet (279 m^2).

REFRIGERATED WAREHOUSE FREEZER. An enclosed storage space capable of being refrigerated to tem- peratures at or below 32°F (0°C), that can be walked into and has a total chilled storage area of not less than 3,000 square feet (279 m^2).

REFRIGERATION SYSTEM, LOW TEMPERATURE. Systems for maintaining food product in a frozen state in refrigeration applications.

REFRIGERATION SYSTEM, MEDIUM TEMPERA- TURE. Systems for maintaining food product above freezing in refrigeration applications.

REGISTERED DESIGN PROFESSIONAL. An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

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

RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses) as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.

ROOF 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.

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

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

ROOF REPLACMENT. The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering.

ROOFTOP MONITOR. A raised section of a roof containing vertical fenestration along one or more sides

***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 ft^2 °F/Btu) [(m^2 K)/W].

SATURATED CONDENSING TEMPERATURE. The saturation temperature corresponding to the measured refrigerant pressure at the condenser inlet for single component and azeotropic refrigerants, and the arithmetic average of the dew point and *bubble point* temperatures corresponding to the refrigerant pressure at the condenser entrance for zeotropic refrigerants.

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

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

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*.

SMALL ELECTRIC MOTOR. A general purpose, alternating current, single speed induction motor.

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

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

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

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

TIME SWITCH CONTROL. An automatic control device or system that controls lighting or other loads, including switching off, based on time schedules.

***U*-FACTOR (THERMAL TRANSMITTANCE).** The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit

area and unit temperature difference between the warm side and cold side air films (Btu/h ft^2 °F) [W/(m^2 K)].

VARIABLE REFRIGERANT FLOW SYSTEM. An engineered direct-expansion (DX) refrigerant system that incorporates a common condensing unit, at least one variable-capacity compressor, a distributed refrigerant piping network to multiple indoor fan heating and cooling units each capable of individual zone temperature control, through integral zone temperature control devices and a common communications network. Variable refrigerant flow utilizes three or more steps of control on common interconnecting piping.

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.

VISIBLE TRANSMITTANCE [VT]. The ratio of visible light entering the space through the fenestration product assembly to the incident visible light. Visible transmittance includes the effects of glazing material and frame and is expressed as a number between 0 and 1.

WALK-IN COOLER. An enclosed storage space capable of being refrigerated to temperatures above 32°F (0°C) and less than 55°F (12.8°C) that can be walked into, has a ceiling height of not less than 7 feet (2134 mm) and has a total chilled storage area of less than 3,000 square feet (279 m2).

WALK-IN FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 32°F (0°C) that can be walked into, has a ceiling height of not less than 7 feet (2134 mm) and has a total chilled storage area of less than 3,000 square feet (279 m2).

WALL, ABOVE-GRADE. A wall associated with the *building thermal envelope* that is more than 15 percent above grade and is on the exterior of the building or any wall that is associated with the *building thermal envelope* that is not on the exterior of the building.

WALL, BELOW-GRADE. A wall associated with the basement or first story of the building that is part of the building thermal envelope, is not less than 85 percent below grade and is on the exterior of the building.

WATER HEATER. Any heating appliance or equipment that heats potable water and supplies such water to the pota- ble hot water distribution system.

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

CHAPTER 3

GENERAL REQUIREMENTS

SECTION 301
DESIGN CONDITIONS

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

301.2 Climactic data.

- Heating Design Temperature: -11°F (ASHRAE/IESNA 90.1-2013 Table D-1, 99.6%)
- Cooling Design Temperature Dry-Bulb: 84°F (ASHRAE/IESNA 90.1-2013 Table D-1, 1%)
- Cooling Design Temperature Wet-Bulb: 69°F (ASHRAE/IESNA 90.1-2013 Table D-1, 1%)
- Heating Degree Days: 7,771 (ASHRAE/IESNA 90.1-2013 Table D-1, 65° Base)
- Cooling Degree Days: 2,228 (ASHRAE/IESNA 90.1-2013 Table D-1, 50° Base)

Adjustments may be made only in the following cases:

1. Winter heating design temperatures for projects either:
   i. Located at an elevation of 1,500 feet or higher or
   ii. located in Caledonia, Essex or Orleans counties.
   iii. Adjustments shall be made as listed in the National Climate Data Center for the specific weather station: http://cdo.ncdc.noaa.gov/climatenormals/clim81_supp/CLIM81_Sup_02.pdf.
2. As approved by the *code official* or other authority having jurisdiction.

SECTION 302
MATERIALS, SYSTEMS AND EQUIPMENT

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

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

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

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

302.1.3 Fenestration product rating. *U*-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100.

Exception: Where required, garage door *U*-factors shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

U-factors shall be determined by an accredited, inde- pendent laboratory, and *labeled* and certified by the manu- facturer

Products lacking such a labeled *U*-factor shall be assigned a default *U*-factor from Table 302.1.3(1) or 302.1.3(2). The solar heat gain coefficient (SHGC) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled SHGC shall be assigned a default SHGC from Table 302.1.3(3).

TABLE 302.1.3(1)
DEFAULT GLAZED FENESTRATION U-FACTOR

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

TABLE 302.1.3(2) DEFAULT DOOR U-FACTORS

DOOR TYPE	U-FACTOR
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

TABLE 302.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.6
VT	0.6	0.3	0.6	0.3	0.6

302.1.4 Insulation product rating. The thermal resistance (*R*-value) of insulation shall be determined in accordance with the U.S. Federal Trade Commission *R*-value rule (CFR Title 16, Part 460, May 31, 2005) in units of h x ft² x °F/Btu at a mean temperature of 75°F (24°C).

302.1.4.1 Insulated siding. The thermal resistance (*R*-value) of insulated siding shall be determined in accordance with ASTM C1363. Installation for testing shall be in accordance with the manufacturer's instructions

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

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

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

RESIDENTIAL ENERGY EFFICIENCY

<RESERVED>

CHAPTER 4

COMMERCIAL ENERGY EFFICIENCY

SECTION 401
GENERAL

401.1 Scope. The requirements contained in this chapter are applicable to commercial buildings and their *building sites*.

401.2 Application.

Commercial buildings shall comply with one of the following:

1. The requirements of Sections 402 through 405. In addition, commercial buildings shall comply with Sec- tion 406 and tenant spaces shall comply with Section C406.1.1.
2. The requirements of ANSI/ASHRAE/IESNA 90.1-2013. Commercial building projects utilizing the alternative compliance path of ANSI/ASHRAE/IESNA 90.1-2013 must follow all applicable provisions listed in Section 401.2.1.

401.2.1 Applicable provisions to Standard 90.1-2013.

1. All instances of the term *building official* in ASHRAE/IESNA 90.1-2013 shall be replaced with the terms *code official* or other authority having jurisdiction.
2. ASHRAE/IESNA 90.1-2013 *Section 5.1.4.1 United States Locations*. Delete the exception clause and replace with the following:

   Adjustments may be made only in the following cases:

   a. Winter heating design temperatures for pro- jects either:

      i. Located at an elevation of 1,500 feet or higher or

      ii. located in Caledonia, Essex or Orleans counties.

      iii. Adjustments shall be made as listed in the National Climate Data Center for the specific weather station: http://1.usa.gov/1s37CSa

   b. As approved by *code official* or other authority having jurisdiction.
3. ASHRAE/IESNA 90.1-2013 *Section 5 Building Envelope*. All envelope requirements shall comply with the following tables in the *2015 Vermont Commercial Building Energy Standards* (CBES):

   i. *Table 402.1, Building Envelope Require- ments-Opaque Assemblies and Element*,

   ii. *Table 402.1(2), Building Envelope Require- ments-Metal Building Assembly Descriptions*, and

   iii. *Table 402.3, Building Envelope Requirements: Fenestration*.
4. ASHRAE/IESNA 90.1-2013 *Section 5.5.3.1 Roof Insulation*. Delete section in its entirety and replace with *Section 402.2.2 Roof Assembly of the 2015 Vermont CBES*.
5. ASHRAE/IESNA 90.1-2013 *Section 5.4.3 Air Leakage*. Delete section in its entirety and replace with *Section C402.4 Air Leakage-thermal envelope of the 2015 Vermont CBES.*
6. ASHRAE/IESNA 90.1-2013 *Section 5.4.3.4 Vestibules*. Delete section in its entirety and replace with *Section 402.4.7 Vestibules of the 2015 Vermont CBES*.
7. ASHRAE/IESNA 90.1-2013 *Section 6.2 Compliance Path(s)*. Add new section as follows:

   a. *Section 6.2.3 Electric Resistance Space Heating*. Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, domestic hot water heaters and coils in terminal units and air systems is prohibited.

Exceptions to Section 6.2.3:

a.. Areas, such as stairways, that are not per- mitted to be penetrated with piping or duct and no other method of heating is possible.

b.. Replacement of existing electrical resis- tance unit.

c.. Special conditions of occupancy or use that require electrical resistance heat to maintain health, safety or environmental conditions.

d.. Limited areas where a practical application of resistance electrical heat is demonstrated (e.g. small interior space such as a rest room which is distant from the distribution sys- tem, hazardous material storerooms, stair- well or other means of emergency egress).

e.. Domestic hot water heaters less than 12 kW in total unit input capacity.

8. ASHRAE/IESNA 90.1-2013 *Section 6.3.2(e) Criteria*. Delete "an electric resistance heater."
9. ASHRAE/IESNA 90.1-2013 *Section 6.4.4.1.2 Duct and Plenum Insulation*. Delete section in its entirety and replace with *Section 403.2.9 Duct and plenum insulation and sealing of the 2015 Vermont CBES*.
10. ASHRAE/IESNA 90.1-2013 *Section 6.4.3.5 Heat Pump Auxiliary Heat Control*. Delete section in its entirety and replace with *Section 403.2.4.1.1 Heat Pump Supplementary Heat of the 2015 Vermont CBES*.

11. ASHRAE/IESNA 90.1-2013 *Section 6.4.3.8 Venti- lation Controls for High-Occupancy Areas*. Add *exception (6)*: Ventilation needs for process loads.

12. Add new section 6.4.7 to ASHRAE/IESNA 90.1-2013, titled *Economizer Fault Detection and Diagnostics (FDD)*. Insert Section 403.2.4.7 *Economizer fault detection and diagnostics (FDD)* from *2015 Vermont CBES.*

13. ASHRAE/IESNA 90.1-2013 *Section 6.5.1 Economizers*. Delete section in its entirety and replace with *Section 403.3Economizers* of the *2011 Vermont CBES*.

14. ASHRAE/IESNA 90.1-2013 *Table 6.5.6.1-1 and Table 6.5.6.1-2 Exhaust Air Energy Recovery Requirements*, delete requirement for systems with ≥10% and >20% outdoor air (second column of tables).

15. ASHRAE/IESNA 90.1-2013 *Section 6.7.2.4 System Commissioning*. Delete section in its entirety and replace with *Section 407 System Commissioningof the 2015Vermont CBES*.
16. ASHRAE/IESNA 90.1-2013 *Section 6.5.6.2 Heat Recovery for Service Water Heating*. Add exception (3): If compliance with Section 6.5.6.2 will be detrimental to chiller operating efficiency due to conflicts with optimized chiller head pressure control.
17. ASHRAE/IESNA 90.1-2013 *Section 7.1 General*. Add *new* section as follows:
    a. Section 7.1.1.4 Electrical Water Heating Limitation. Individual electric service water heating units shall be limited to a maximum of 12 kW total power input.

       Exception: Instantaneous electric water heaters used to serve emergency showers and emergency eye wash stations.
18. ASHRAE/IESNA 90.1-2013 *Table 7.8 Performance Requirements for Water Heating Equipment*. Delete entire thrid row for electric water heaters >12 kW.
19. ASHRAE/IESNA 90.1-2013 *Table 9.5.1 Lighting Power Densities Using the Building Area Method*.Replace Warehouse LPD with 0.60 W/ft^2.

401.2.2 Application to replacement fenestration prod*ucts.* Where some or all of an existing fenestration unit is replaced with a new fenestration product, including sash and glazing, the replacement fenestration unit shall meet the applicable requirements for U-factor and SHGC in Table 402.3.

Exception: An area-weighted average of the U-factor of replacement fenestration products being installed in the building for each fenestration product category listed in Table 402.3 shall be permitted to satisfy the U-factor requirements for each fenestration product category listed in Table 402.3. Individual fenestration products from different product categories listed in Table 402.3 shall not be combined in calculating the area-weighted average U-factor.

401.3 Certificate of compliance. 30 V.S.A. §53 requires certification that both the design and the construction of a commercial building is in compliance with the CBES.

Certification shall be issued by a completed and signed certificate permanently affixed to the outside of the heating or cooling equipment, to the electrical service panel and located inside the building, or in a visible location in the immediate vicinity of one of these three areas. Copies of the signed certification documents shall be sent to the local town clerk and to the Vermont Department of Public Service.

SECTION 402
BUILDING ENVELOPE REQUIREMENTS

402.1 General (Prescriptive). Building thermal envelope assemblies for buildings that are intended to comply with the code on a prescriptive basis, in accordance with the compli- ance path described in Item 2 of Section 401.2, shall comply with the following:

1. The opaque portions of the building thermal envelope shall comply with the specific insulation requirements of Section 402.2 and the thermal requirements of either the *R*-value-based method of Section 402.1.1; the *U*-, *C*- and *F*-factor-based method of Section 402.1.2; or the component performance alternative of Section 402.1.3.
2. Fenestration in building envelope assemblies shall comply with Section 402.3.
3. Air leakage of building envelope assemblies shall com- ply with Section 402.5.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section 402.3, the building and building thermal envelope shall com- ply with Section 401.2, Item 1 or SectionC401.2, Item 3.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section 403.2.15 or 403.2.16.

402.1.1 Insulation component *R*-value-based method.. *Building thermal envelope* opaque assemblies shall meet the requirements of Sections 402.2 and 402.3. For opaque portions of the *building thermal envelope* intended to comply on an insula- tion component R-value basis, the R-values for insulation in framing cavities, where required, and for continuous insula- tion, where required, shall be not less than that specified in Table 402.1. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the R-values from the "Group R" column of Table
402.1. 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 402.1. The thermal resis tance or R-value of the insulating material installed continu- ously within or on the below-grade exterior walls of the building envelope required in accordance with Table 402.1 shall extend to a depth of not less than 10 feet (3048 mm) below the outside finished ground level, or to the level of the lowest floor of the conditioned space enclosed by the below grade wall, whichever is less. Opaque doors shall comply with Table 402.1-

402.1.2 Assembly *U*-factor, *C*-factor or *F*-factor-based method. Building thermal envelope opaque assemblies intended to comply on an assembly *U*-, *C*- or *F*-factor basis shall have a *U*-, *C*- or *F*-factor not greater than that specified in Table 402.1. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *U*-, *C*- or *F*-factor from the "Group R" column of Table 402.1. Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *U*-, *C*- or *F*-factor from the "All other" column of Table 402.1. The *C*-factor for the below-grade exte- rior walls of the building envelope, as required in accor- dance with Table 402.1, shall extend to a depth of 10 feet (3048 mm) below the outside finished ground level, or to the level of the lowest floor, whichever is less. Opaque doors shall comply with Table 402.1

402.1.3 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the *U*-, *F*- and *C*-factors in Table 402.1.3and the maximum allowable fenestration areas in Section C402.3.1.

$A + B + C + D + E \leq \text{Zero}$ **(Equation 4-2)**

where:

A = Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade and below-grade walls.

UA Dif = UA Proposed - UA Table. UA Proposed = Proposed *U*-value · Area.

UA Table = (*U*-factor from Table C402.1) · Area.

B = Sum of the (FL Dif) values for each distinct slab-on-grade perimeter condition of the building thermal envelope.

FL Dif = FL Proposed - FL Table.

FL Proposed = Proposed *F*-value · Perimeter length.

FL Table = (*F*-factor specified in Table C402.1) · Perimeter length.

C = Sum of the (CA Dif) values for each distinct below-grade wall assembly type of the building thermal envelope.

CA Dif = CA Proposed - CA Table CA Proposed = Proposed *C*-value · Area.

CA Table = (Maximum allowable *C*-factor specified in Table C402.1) · Area.

Where the proposed vertical glazing area is less than or equal to the maximum vertical glazing area allowed by Section C402.3.1, the value of D (Excess Vertical Glazing Value) shall be zero. Otherwise:

$D = (DA \cdot UV) - (DA \cdot U_{Wall})$, but not less than zero.

DA = (Proposed Vertical Glazing Area) - (Vertical Glazing Area allowed by Section C402.3.1).

U_{Wall} = Area-weighted average *U*-value of all above-grade wall assemblies.

UAV = Sum of the (UA Proposed) values for each vertical glazing assembly.

UV = UAV/total vertical glazing area.

Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.3.1, the value of E (Excess Skylight Value) shall be zero. Otherwise:

$E = (EA \cdot US) - (EA \cdot U_{Roof})$, but not less than zero.

EA = (Proposed Skylight Area) - (Allowable Skylight Area as specified in Section C402.3.1).

U_{Roof} = Area-weighted average *U*-value of all roof assemblies.

UAS = Sum of the (UA Proposed) values for each skylight assembly.

US = UAS/total skylight area

402.2 Specific building thermal envelopeinsulation requirements (Prescriptive).
Insulation in building thermal envelope Opaque assemblies shall comply with Sections 402.2.1 through 402.2.6 and Table 402.1

402.2.1 Multiple layers of continuous insulation board. Where two or more layers of continuous insulation board are used in a construction assembly, the continuous insulation boards shall be installed in accordance with Section 303.2. Where the continuous insulation board manufacturer's instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

402.2.2 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 402.1, based on construction materials used in the roof assembly. Skylight curbs shall be insulated to the level of roofs with insulation entirely above deck or R-5, whichever is less.

Mechanical curbs shall be insulated to the level of roofs with insulation entirely above deck or R-5, whichever is less.

Exceptions:

1. Continuously insulated roof assemblies where the area-weighted *U*-factor is equivalent to the same assembly with the *R*-value specified in Table 402.1.
2. Unit skylight curbs included as a component of a skylight assembly tested in accordance with NFRC 100 and 200 shall not require additional insulation.

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

402.2.3 Thermal resistance of above-grade walls. The minimum thermal resistance (R-value) of materials installed in the wall cavity between framing members and continuously on the walls shall be as specified in Table 401.3, based on framing type and construction materials used in the wall assembly. The R-value of integral insulation installed in concrete masonry units shall not be used in determining compliance with Table 402.1

"Mass walls" shall include walls:

1. Weighing not less than 35 psf (170 kg/m^2) of wall surface area.
2. Weighing not less than 25 psf (120 kg/m^2) of wall surface area where the material weight is not more than 120 pcf (1900 kg/m^3).
3. Having a heat capacity exceeding 7 Btu/ft^2 · °F (144 cage/m^2 · K).

Having a heat capacity exceeding 5 Btu/ft2 · °F (103 kJ/m2 · K), where the material weight is not more than 120 pcf (1900 kg/m3).

402.2.4 Floors. The thermal properties (component *R*-values or assembly *U*-, *C*- or *F*-factors) of floor assemblies over outdoor air or unconditioned space shall be as specified in Table C402.1 based on the construc- tion materials used in the floor assembly. Floor framing cavity insulation or structural slab insulation shall be installed to maintain permanent contact with the underside of the subfloor decking or structural slabs.

Exceptions:

1. The floor framing cavity insulation or structural slab insulation shall be permitted to be in contact with the top side of sheathing or continuous insulation installed on the bottom side of floor assemblies where combined with insulation that meets or exceeds the minimum *R*-value in Table C402.1 for "Metal framed" or "Wood framed and other" values for "Walls, Above Grade" and extends from the bottom to the top of all perimeter floor framing or floor assembly members.
2. Insulation applied to the underside of concrete floor slabs shall be permitted an airspace of not more than 1 inch (25 mm) where it turns up and is in contact with the underside of the floor under walls associated with the *building thermal envelope*.

402.2.5 Slabs on grade perimeter insulation. Where the slab on grade is in contact with the ground, the mini- mum thermal resistance (R-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors designed in accordance with the R-value method of Section 402.1.3 shall be as specified in Table 402.1.3. 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. Insulation extending away from the building shall be protected by pavement or by not less than of 10 inches (254 mm) of soil.

Exception: Where the slab-on-grade floor is greater than 48 inches (122 mm) below the finished exterior grade, perimeter insulation is not required.

402.2.6 Insulation of radiant heating systems. *Radiant heating system* panels, and their associated components that are installed in interior or exterior non-slab assemblies shall be insulated with a minimum of R-3.5 (0.62 m^2/K · W) on all surfaces not facing the space being heated. *Radiant heat- ing system* panels that are installed in the *building thermal envelope* shall be separated from the exterior of the build- ing or unconditioned or exempt spaces by not less than the *R*-value of insulation installed in the opaque assembly in which they are installed or the assembly shall comply with Section 402.1.4.

Exception: Heated slabs on grade insulated in accordance with Section 402.2.5.

402.3 Fenestration (Prescriptive). Fenestration shall comply with Sections 402.3.1 through 402.3.4 and Table 402.3. Daylight responsive controls shall comply with this section and Section 405.2.3.1.

402.3.1 Maximum area. The vertical fenestration area (not including opaque doors and opaque spandrel panels) shall not be greater than 30 percent of the gross above-grade wall area. The skylight area shall not be greater than 3 percent of the gross roof area.

402.3.3 Maximum *U*-factor and SHGC. The maximum *U*-factor and solar heat gain coeffi- cient (SHGC) for fenestration shall be as specified in Table 402.3.

The window projection factor shall be determined in accordance with Equation 4-5.

$$PF = A/B \qquad \textbf{(Equation 5-1)}$$

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.

C402.4.3.1 Increased skylight SHGC. Skylights shall

be permitted a maxi- mum SHGC of 0.60 where located above *daylight zones* provided with *daylight responsive controls*.

402.3.3.2 Increased skylight *U*-factor. Where skylights are installed above *daylight zones* provided with *daylight responsive controls*, a maximum *U*-factor of 0.75 shall be permitted.

402.3.3.3 Dynamic glazing. Where *dynamic glazing* is intended to satisfy the SHGC and VT requirements of Table 402.3, the ratio of the higher to lower labeled SHGC shall be greater than or equal to 2.4, and the *dynamic glazing* shall be automatically controlled to modulate the amount of solar gain into the space in multiple steps. Dynamic glazing shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not dynamic glazing shall not be permitted.

Exception: Dynamic glazing is not required to comply with this section where both the lower and higher labeled SHGC already comply with the requirements of Table 402.3.

402.3.3.4 Area-weighted *U*-factor. An area- weighted average shall be permitted to satisfy the *U*- factor requirements for each fenestration product cate- gory listed in Table 402.3. Individual fenestration products from different fenestration product categories listed in Table 402.3 shall not be combined in calculating area-weighted average *U*-factor.

402.3.4 Doors. Opaque doors shall comply with the applicable requirements for doors as specified in Table 402.1 and be considered part of the gross area of above-grade walls that are part of the building ther- mal envelope. Other doors shall comply with the provi- sions of Section 402.3.3 for vertical fenestration.

TABLE 402.1
BUILDING ENVELOPE REQUIREMENTS–OPAQUE ASSEMBLIES AND ELEMENTS[a,b]

COMPONENT	MAXIMUM OVERALL U-FACTOR[a]		MINIMUM R-VALUES	
	All other	Group R	All other	Group R
Roofs				
Insulation entirely above deck	U-0.032		R-30ci	
Metal buildings[c]	U-0.031		R-25 + R-11 LS	
Attic and other	U-0.021		R-49	
Walls, Above grade				
Mass	U-0.080	U-0.071	R-13.3ci	R-15.2ci
Metal building[c]	U-0.052		R-13 + R-13ci or R-19.5ci	
Metal framed	U-0.064		R-13 + R-7.5ci or R-19.5ci	
Wood-framed and other	U-0.051		R-13 + R-7.5ci or R-20 + R-3.8ci or R-23 or R-19.5ci	
Walls, Below grade[e]				
Below-grade wal1	C-0.092		R-10ci	
Floors				
Mass[d]	U-0.064	U-0.057	R-12.5ci	R-14.6ci
Joist/framing-metal	U-0.032	U-0.032	R-38	R-38
Joist/framing—wood and other	U-0.033		R-30	
Slab-on-grade floors				
Unheated slabs	F-0.480	F-0.450	R-10 for 48 in. below	R-15 for 48 in. below
Heated slabs	F-0.550		R-10 for entire slab[f]	
Opaque doors				
Swinging	U-0.37		N/A	
Non-Swinging	N/A		R-4.75	
Upward-acting, sectional	N/A		R-10	

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3, ci = continuous insulation, LS = Liner system

a. Use of opaque assembly *U*-factors, *C*-factors and *F*-factors from ANSI/ASHRAE/ISNEA 90.1-2013 Appendix A shall be permitted, provided the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/ISNEA 90.1-2013 Appendix A.

b. Opaque assembly *U*-factors based on designs tested in accordance with ASTM C1363 shall be permitted. The *R*-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are placed below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

Refer to Table C402.1(3) for metal building roof assembly *U*-factors and Table 402.1(4) for metal building wall assembly *U*-factors.

d. "Mass floors" shall include floors weighing not less than:

1. 35 pounds per square foot of floor surface area; or
2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.

e. Evidence of compliance with the F-factors indicated in the table for heated slabs shall be demonstrated by the application of the unheated slab F-factors and R-values derived from ASHRAE 90.1-2013 Appendix A.

f. Insulation placed under entire heated slab and around perimeter.

TABLE 402.1(2)
BUILDING ENVELOPE REQUIREMENTS–METAL BUILDING ASSEMBLY DESCRIPTIONS

BUILDING ENVELOPE REQUIREMENTS-METAL BUILDING ASSEMBLY DESCRIPTIONS	DESCRIPTION	REFERENCE
ROOFS		
Liner system (Ls) R-25 + R-11 LS	A continuous membrane installed below 9 ½ inch minimum depth purlins and uninterrupted by the sub framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. Unfaced insulation is draped over and perpendicular to the purlins to make the total uncompressed insulation depth equal to the purlin depth plus 1inch. R5 thermal spacers are installed at the purlins and the metal roof is installed.	ANSI/ASHRAE/IESNA 90.1-2013
Filled Cavity (Fc) (See Table C402.1(3) for Qualifying Assemblies)	The first rated R-value of insulation is for faced insulation installed parallel to the purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer, parallel to and between the purlins and compressed when the metal roof panels are attached. The face of the first layer of insulation is of sufficient width to be continuously sealed to the top flange of the purlins and to accommodate the full thickness of the second layer of insulation. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of the second layer of insulation being installed above it. A minimum R-5 thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.	ANSI/ASHRAE/IESNA 90.1-2013

(continued)

TABLE 402.1(2)–continued
BUILDING ENVELOPE REQUIREMENTS–METAL BUILDING ASSEMBLY DESCRIPTIONS

BUILDING ENVELOPE REQUIREMENTS-METAL BUILDING ASSEMBLY DESCRIPTIONS	DESCRIPTION	REFERENCE
WALLS		
R-13 + R-13ci	The first rated *R*-Value of insulation is for insulation compressed between metal wall panels and the steel structure. The second rated *R*-value is for continuous insulation (e.g., insulation boards). It is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.	ANSI/ASHRAE/IESNA 90.1-2013
R-19.5ci	The rated R-value is for continuous insulation (e.g., insulation boards). It is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.	ANSI/ASHRAE/IESNA 90.1-2013

TABLE 402.1(3)
ASSEMBLY U-FACTORS FOR METAL BUILDING ROOFS

INSULATION SYSTEM	RATED R-VALUE OF INSULATION	OVERALL U-FACTOR FOR ENTIRE BASE ROOF ASSEMBLY	OVERALL U-FACTOR FOR ASSEMBLY OF BASE ROOF PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)					
			Rated R-Value of Continuous Insulation					
Standing Seam Roofs with Thermal Spacer Blocks[a]			**R-6.5**	**R-13**	**R-19.5**	**R-26**	**R-32.5**	**R-39**
Single layer[b]	None	1.280	0.137	0.137	0.049	0.037	0.030	0.025
	R-10	0.115	0.066	0.046	0.035	0.029	0.024	0.021
	R-11	0.107	0.063	0.045	0.035	0.028	0.024	0.021
	R-13	0.101	0.061	0.044	0.034	0.028	0.024	0.020
	R-16	0.096	0.059	0.043	0.033	0.027	0.023	0.020
	R-19	0.082	0.053	0.040	0.031	0.026	0.022	0.020
Double layer[b]	R-10 + R-10	0.088	0.056	0.041	0.032	0.027	0.023	0.020
	R-10 + R-11	0.086	0.055	0.041	0.032	0.027	0.023	0.020
	R-11 + R-11	0.085	0.055	0.040	0.032	0.026	0.023	0.020
	R-10 + R13	0.084	0.054	0.040	0.032	0.026	0.023	0.020
	R-11 + R-13	0.082	0.053	0.040	0.032	0.026	0.022	0.020
	R-13 + R-13	0.075	0.050	0.038	0.030	0.025	0.022	0.019
	R-10 + R-19	0.074	0.050	0.038	0.030	0.025	0.022	0.019
	R-11 + R-19	0.072	0.049	0.037	0.030	0.025	0.022	0.019
	R-13 + R-19	0.068	0.047	0.036	0.029	0.025	0.021	0.019
	R-16 + R-19	0.065	0.046	0.035	0.029	0.024	0.021	0.018
	R-19 + R-19	0.060	0.043	0.034	0.028	0.023	0.020	0.018
Liner system[b]	R-19 + R-11 Ls	0.037						
	R-25 + R-8 Ls	0.037						
	R-25 + R-11 Ls	0.031						
	R-30 + R-11 Ls	0.029						
	R-25 + R-11+ R-11 Ls	0.026						
Filled cavity[c]	R-10 + R-19 Fc	0.041	0.032	0.027	0.023	0.020	0.018	0.016
Standing Seam Roofs without Thermal Spacer Blocks								
Liner system	R-19 + R-11 Ls	0.040	—	—	—	—	—	—
Thru-fastened Roofs without Thermal Spacer Blocks								
Liner system	*R*-19 + R-11 Ls	0.044	—	—	—	—	—	—
(Multiple *R*-values are listed in order from inside to outside)								

a. A standing seam roof clip that provides a minimum 1.5 in. distance between the top of the purlins and the underside of the metal roof panels is required.
b. A minimum R-5 thermal spacer block is required.

TABLE 402.1(4)
ASSEMBLY U-FACTORS FOR METAL BUILDING WALLS

INSULATION SYSTEM	RATED R-VALUE OF INSULATION	OVERALL U-FACTORS FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)				
		Rated R-value of Continuous Insulation				
Single Layer		R-13	R-19.5	R-26	R-32.5	R-39
	None	0.072	0.049	0.037	0.030	0.025
	R-10	0.054	0.040	0.032	0.026	0.023
	R-11	0.054	0.040	0.032	0.026	0.023
	R-13	0.052	0.039	0.031	0.026	0.022
	R-16	0.051	0.039	0.031	0.026	0.022
	R-19	0.050	0.038	0.03	0.025	0.022

TABLE 402.3
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

Vertical fenestration (40% maximum of above-grade wall)	
Framing materials other than metal with or without metal reinforcement or cladding	
U-factor	0.35
Metal framing with or without thermal break	
Curtain wall/storefront *U*-factor	0.42
Entrance door *U*-factor	0.80
All other *U*-factor[a]	0.50
SHGC-all frame types	
SHGC: *PF* < 0.25	0.40
SHGC: 0.25 ◊ *PF* < 0.5	NR
SHGC: *PF* ;: 0.5	NR
Skylights (3% maximum)	
U-factor	0.60
SHGC	0.40

NR = No requirement.
PF = Projection factor (see Section 402.3.2).
a. All others includes operable windows, fixed windows and nonentrance doors.

402.4 Air leakage—thermal envelope (Mandatory). The thermal envelope of buildings shall comply with Sections 402.4.1 through 402.4.8, or the building thermal envelope shall be tested and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.50 cfm/per square foot of shell area (excluding area of slab and below grade walls) at 50 Pa in accordance with ASTM E 779 or an equivalent method approved by the code official or authority having jurisdiction . Where compliance is based on such testing, the building shall also comply with Sections C402.4.5, C402.4.6 and C402.4.7.

402.4.1 Air Barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections 402.4.1.1 and 402.4.1.2.

402.4.1.1. Air barrier construction. The continuous air barrier shall be con- structed to comply with the following:

1. The air barrier shall be continuous for all assemblies which are the thermal envelope of the building and across the joints and assemblies.
2. Air barrier joints and seams shall be sealed including sealing transitions in places and changes in materials. Air barrier penetrations shall be sealed in accordance with Section 402.4.2. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.
3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Joints and seals associated with penetrations shall be sealed in the same manner or taped or covered with moisture vapor-permeable wrapping mate- rial. Sealing materials shall be appropriate to the construction materials being sealed and shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.
4. Recessed lighting fixtures shall comply with Section 402.4.7. Where similar objects are installed which penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

402.4.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall meet the requirements of one of the compliance options in Section C402.4.1.2.1 or C402.4.1.2.2.

402.4.1.2.1 Materials. Materials with an air permeability no greater than 0.004 cfm/ft^2 (0.02 L/s·m^2) under a pressure differential of 0.3 inches water

402.4.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not to exceed 0.04 cfm/ft^2 (0.2 L/s·m^2) under a pressure differential of 0.3 inches of water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2357, ASTM E 1677 or ASTM E 283 shall comply with this section. Assemblies listed in items 1 through 2 shall be deemed to comply provided joints are sealed and requirements of Section 402.4.1.1 are met.

1. Concrete masonry walls coated with one appli- cation either of block filler and two applications of a paint or sealer coating;
2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches (102 mm) or more.
3. A Portland cement/sand parge, stucco or plaster minimum $^1/_2$ inch (12 mm) in thickness.

gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in items 1 through 16 shall be deemed to comply with this section provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than $^3/_8$ inch (10 mm).
2. Oriented strand board having a thickness of not less than $^3/_8$ inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than $^1/_2$ inch (12 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than $^1/_2$ inch (12 mm).
5. Closed cell spray foam a minimum density of 1.5 pcf (2.4 kg/m^3) having a thickness of not less than $1^1/_2$ inches (36 mm).
6. Open cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m^3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch (12 mm).
8. Cement board having a thickness of not less than 1/2 inch (12 mm).
9. Built up roofing membrane.
10. Modified bituminous roof membrane.
11. Fully adhered single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch (16 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.
16. Solid or hollow masonry constructed of clay or shale masonry units.

402.4.2 Air leakage of Fenestration. The air leakage of fenestration assemblies shall meet the provisions of Table 402.4.2. Test- ing shall be in accordance with the applicable reference test standard in Table 402.4.2 by an accredited independent test- ing laboratory labeled by the manufacturer.

Exceptions:

1. Field-fabricated fenestration assemblies that are sealed in accordance with Section 402.4.1.

2. Fenestration in buildings that comply with the testing alternative of Section 402.4 are not required to meet the air leakage requirements in Table 402.4.2.

TABLE 402.4.2
MAXIMUM AIR INFILTRATION RATE FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE (cfm/ft^2)	TEST PROCEDURE
Windows	0.20[a]	AAMA/WDMA/ CSA101/ I.S.2/A440 or NFRC 400
Sliding doors	0.20[a]	
Swinging doors	0.20[a]	
Skylights—with condensation weepage openings	0.30	
Skylights—all other	0.20[a]	
Curtain walls	0.06	NFRC 400 or ASTM E 283 at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105 NFRC 400, or ASTM E 283 at 1.57 psf (75 Pa)
Rolling doors	1.00	
High-Speed Doors	1.30	

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 6.24 psf (300 Pa).

402.4.4 Doors and Access Openings to Shafts, Chutes, Stairways, and Elevator Lobbies. Doors and access openings from conditioned space to shafts, chutes stairways and elevator lobbies not within the scope of the fenestra- tion assemblies covered by 402.4.2 shall be gasketed, weatherstripped, or sealed.

Exceptions:

1. Door openings required to comply with Section 716 or 716.4 of the *International Building Code.*
2. Doors and door openings required by comply with UL 1784 by the *International Building Code*

402.4.5 Outdoor air intakes and exhaust openings. Stairway enclosures and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be provided with dampers in accordance with Section 403.2.4.3.

402.4.6 Loading dock weather-seals and thermal requirements. Cargo doors and loading dock doors shall be equipped with weather-seals to restrict infiltration when vehicles are parked in the opening. If equipped with an interior dock leveler, the deck of the leveler and rear pit wall shall be insulated with a minimum of 1.5 inches of sprayed closed cell foam. The side pit walls and pit slab shall be insulated per the slab on grade standard in Table 402.1(1). The spaces between the pit wall and the deck skirts for the leveler shall be weather-stripped.

402.4.7 Vestibules. All building entrances shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time.

Exceptions:

1. Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use.
2. Doors opening directly from a *sleeping unit* or dwelling unit.
3. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area.
4. Revolving doors, where a required adjacent accessible entry has a complying vestibule enclosure.
5. Doors that have an air curtain with a velocity of not less than 6.56 feet per second (2 m/s) at the floor that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door.

402.4.7.1 Vestibule tempering. Where vestibule space tempering is included, a maximum temperature setting of 55°F (13°C) for heating mode shall be utilized. Mechanical cooling of vestibules is prohibited.

402.4.7.2 Vestibule construction. Vestibules meeting the requirements of Section 402.3.7.1 shall be constructed according to the building envelope requirements of Section 402.1.

402.4.7.3 Vestibule thermostatic controls. Vestibules meeting the requirements of Section 402.4.7.1 shall be zoned separately from the conditioned building. Thermostats located inside vestibules shall be programmable, and

1. Tamper-proof, or

2. Placed in a location inaccessible to the general public.

Exception: Vestibule spaces served by radiant floor heating may utilize a non-programmable thermostat.

402.4.8 Recessed lighting. Recessed luminaires and any other building component installed in the *building thermal envelope* shall be all o fthe following:

1. IC-rated

2. Labeled as having an air leakage rate of no more 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E 283 at a 1.57 psf (75 Pa) pressure differential.

3. Sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

SECTION 403
BUILDING MECHANICAL SYSTEMS

403.1 General. Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Section 403.2 and shall comply with 403.3 and 403.4 based on the equipment and systems pro- vided.

403.1.2 Electric resistance space heating. Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, domestic hot water heaters and coils in terminal units and air systems, is prohibited.

Exceptions:

1. Areas, such as stairways, that are not permitted to be penetrated with piping or duct and no other method of heating is possible.
2. Replacement of existing electrical resistance unit.
3. Special conditions of occupancy or use that require electrical resistance heat to maintain health, safety or environmental conditions.
4. Limited areas where a practical application of resistance electrical heat is demonstrated (e.g., small interior space such as a rest room which is distant from the distribution system, hazardous material storerooms, stairwell or other means of emergency egress).
5. Domestic hot water heaters less than12 kW in total unit input capacity.

403.2 Provisions applicable to all mechanical systems (Mandatory). Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Sections 403.2.1 throughC403.2.17.

403.2.1 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 account for the building envelope, lighting, ventilation and occupancy loads based on the project design. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook*. Alternatively, design loads shall be determined by an *approved* equivalent computation procedure, using the design parameters specified in Chapter 3.

403.2.2 Equipment and system sizing. The output capacity of heating and cooling equipment and systems shall not exceed the loads calculated in accordance with Section 403.2.1. 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.

403.2.3 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 403.2.3(1), 403.2.3(2), 403.2.3(3), 403.2.3(4), 403.2.3(5), and 403.2.3(6) 403.2.3(7), 403.2.3(8), 403.2.3(9), 403.2.3(10) and 403.2.3(11) 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 pro- gram exists, the equipment efficiency ratings shall be sup- ported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated require- ments. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that dem- onstrates that the combined efficiency of the specified com- ponents meets the requirements herein.

403.2.3.1 Water-cooled centrifugal chilling packages: Equipment not designed for operation at ARHI Standard 550/590 test conditions of
44°F (7°C) leaving chilled water temperature and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 I/s.kW) condenser water flow shall have maximum full load kW/ton (FL) and NPLV ratings adjusted using Equations 4-6 and 4-7:

$FL_{adj} = FL/K_{adj}$ **(Equation 4-6)**

$PLV_{adj} = IPLV/K_{adj}$ **(Equation 4-7)**where:

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

X = DT_{std} + LIFT

DT_{std} = {24+[full load kW/ton from Table

C403.2.3(6)] × 6.83}/Flow

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

LIFT = CEWT – CLWT (°F)

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

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

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

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

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

Condensing Water Flow: 1 to 6 gpm/ton 0.018 to 0.1076 1/s · kW) and X ;: 39 and ◆ 60

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

403.2.3.2 Positive displacement (air- and water- cooled) chilling packages. Equipment with a leaving fluid temperature higher than 32°F (0°C) and water- cooled positive displacement chilling packages with a condenser leaving fluid temperature below 115°F (46°C) shall meet the requirements of Table 403.2.3(7) when tested or certified with water at standard rating condi- tions, in accordance with the referenced test procedure

403.2.4 HVAC system controls. Each heating and cooling system shall be provided with thermostatic controls as required in Section 403.2.4.1, 403.2.4.2, 403.2.4.3, 403.2.4.4, 403.4, 403.4.1 or 403.4.4.

403.2.4.1 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.

403.2.4.1.1 Heat pump supplementary heat. Heat pumps having supplementary electric resistance heat are prohibited, except for use during defrost. Heat pumps having supplementary electric resistance heat shall have controls that, except during defrost, prevent supplementary heat operation.

403.2.4.2 Setpoint overlap restriction. Where a zone has a separate heating and a separate cooling thermostatic control located within the zone, a limit switch, mechanical stop or direct digital control sys- tem with software programming shall be provided with the capability to prevent the heating set point from exceeding the cooling set point and to maintain a deadband in accordance with Section 403.2.4.1.2.

403.2.4.2 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.

403.2.4.2.1 Thermostatic setback capabilities. Thermostatic setback controls shall have the capabil- ity 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).

403.2.4.2.2 Automatic setback and shutdown capa- bilities. Automatic time clock or programmable con- trols shall be capable of starting and stopping the system for seven different daily schedules per week and retain- ing 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.

403.2.4.3 Shutoff dampers. Outdoor air intake and exhaust openings and stairway and shaft vents shall be provided with Class I motorized dampers. The dampers shall have an air leakage rate not greater than 4 cfm/ft2 (20.3 L/s • m2) of damper surface area at 1.0 inch water gauge (249 Pa) and shall be labeled by an approved agency when tested in accordance with AMCA 500D for such purpose.

Outdoor air intake and exhaust dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or dur- ing unoccupied period warm-up and setback operation, unless the systems served require outdoor or exhaust air in accordance with the International Mechanical Code or the dampers are opened to provide intentional econo- mizer cooling.

Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper.

Exception:

Gravity (nonmotorized) dampers shall be permitted to be used as follows:

1. In buildings less than three stories in height above grade plane.
2. Where design exhaust capacity is not greater than 300 cfm (0.14 m^3/s).

403.2.4.4 Zone isolation. HVAC systems serving *zones* that are over 25,000 square feet (2323 m^2) in floor area or that span more than one floor and are designed to operate or be occupied nonsimultaneously shall be divided into isolation areas. Each isolation area shall be equipped with isolation devices and controls configured to automatically shut off the supply of con- ditioned air and outdoor air to and exhaust air from the isolation area. Each isolation area shall be controlled independently by a device meeting the requirements of Section 403.2.4.2.2. Central systems and plants shall be provided with controls and devices that will allow system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions:

1. Exhaust air and outdoor air connections to isola- tion areas where the fan system to which they connect is not greater than 5,000 cfm (2360 L/s).
2. Exhaust airflow from a single isolation area of less than 10 percent of the design airflow of the exhaust system to which it connects.

Isolation areas intended to operate continuously or intended to be inoperative only when all other isolation areas in a zone are inoperative.

403.2.4.5 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).

403.2.4.6 Freeze protection system controls. Freeze protection systems, such as heat tracing of outdoor pip- ing and heat exchangers, including self-regulating heat tracing, shall include automatic controls configured to shut off the systems when outdoor air temperatures are above 40°F (4°C) or when the conditions of the pro- tected fluid will prevent freezing.

403.2.4.7 Economizer fault detection and diagnos- tics (FDD). Air-cooled unitary direct-expansion units listed in Tables 403.2.3(1) through 403.2.3(3) and variable refrigerant flow (VRF) units that are 20 tons (240,000 Btu/h) or greater and equipped with an economizer in accordance with Section C403.3, shall include a fault detection and diagnostics (FDD) system complying with the following:

1. The following temperature sensors shall be per- manently installed to monitor system operation:
   1.1. Outside air.
   1.2. Supply air.
   1.3. Return air.
2. Temperature sensors shall have an accuracy of ±2°F (1.1°C) over the range of 40°F to 80°F (4°C to 26.7°C).
3. Refrigerant pressure sensors, where used, shall have an accuracy of ±3

percent of full scale.

4. The unit controller shall be capable of providing system status by indicating the following:
   - 4.1. Free cooling available.
   - 4.2. Economizer enabled.
   - 4.3. Compressor enabled.
   - 4.4. Heating enabled.
   - 4.5. Mixed air low limit cycle active.
   - 4.6. The current value of each sensor.
5. The unit controller shall be capable of manually initiating each operating mode so that the opera- tion of compressors, economizers, fans and the heating system can be independently tested and verified.
6. The unit shall be capable of reporting faults to a fault management application accessible by day- to-day operating or service personnel, or annun- ciated locally on zone thermostats.
7. The FDD system shall be capable of detecting the following faults:
   - 7.1. Air temperature sensor failure/fault.
   - 7.2. Not economizing when the unit should be economizing.
   - 7.3. Economizing when the unit should not be economizing.
   - 7.4. Damper not modulating.
   - 7.5. Excess outdoor air

403.2.5 Hot water boiler outdoor temperature set-back control. Hot water boilers that supply heat to the building through one- or two-pipe heating systems shall have an outdoor setback control that lowers the boiler water temperature based on the outdoor temperature.

[Note: All federal minimum efficiency tables have been replaced with 2015 IECC tables] **TABLE 403.2.3(1)**

MINIMUM EFFICIENCY REQUIREMENTS:

ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 1/1/2016	As of 1/1/2016	
Air conditioners, air cooled	< 65,000 Btu/h [b]	All	Split System	13.0 SEER	13.0 SEER	AHRI 210/240
			Single Package	13.0 SEER	14.0 SEER[c]	
Through-the-wall (air cooled)	[b]	All	Split system	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Small-duct high-velocity (air cooled)	≤ 30,000 Btu/h [b]	All	Split System	11.0 SEER	11.0 SEER	
Air conditioners, air cooled	< 65,000 Btu/h					AHRI 340/360
	≥ 65,000 Btu/h and < 135,000 Btu/h	None	Split System and Single Package	11.2 EER 11.4 IEER	11.2 EER 12.8 IEER	
		Non-Electric[c]	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.6 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	None	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.4 IEER	
		Non-Electric[c]	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 12.2 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	None	Split System and Single Package	10.1 EER 10.2 IEER	10.0 EER 11.6 IEER	
		Non-Electric[c]	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 11.4 IEER	
	≥ 760,000 Btu/h	None	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 11.2 IEER	
		Non-Electric[c]	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 11.0 IEER	
Air conditioners, water cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	None	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 13.9 IEER	AHRI 340/360
		Non-Electric[c]	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	None	Split System and Single Package	12.5 EER 12.5 IEER	12.5 EER 13.9 IEER	
		Non-Electric[c]	Split System and Single Package	12.3 EER 12.5 IEER	12.3 EER 13.7 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	None	Split System and Single Package	12.4 EER 12.6 IEER	12.4 EER 13.6 IEER	
		Non-Electric[c]	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.4 IEER	
	≥ 760,000 Btu/h	None	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.5 IEER	
		Non-Electric[c]	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 13.3 IEER	

(continued)

TABLE 403.2.3(1)—continued MINIMUM EFFICIENCY REQUIREMENTS:

ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	Split System and Single Package		12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	None	Split System and Single Package		12.1 EER 12.3 IEER	AHRI 340/360
		Non-Electric[c]	Split System and Single Package		11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	None	Split System and Single Package		12.0 EER 12.2 IEER	
		Non-Electric[c]	Split System and Single Package		11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	None	Split System and Single Package		11.9 EER 12.1 IEER	
		Non-Electric[c]	Split System and Single Package		11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	None	Split System and Single Package		11.7 EER 11.9 IEER	
		Non-Electric[c]	Split System and Single Package		11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h				10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h				13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h				13.5 EER 14.0 IEER	

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

a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.
b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.
c. Electric resistance space heating is prohibited per Section C403.1.2. Use "None" Heating Section Type category for exceptions to Section 403.1.2.

TABLE 403.2.3(2)

**MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS**

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 1/1/2016	As of 1/1/2016	
Air cooled (cooling mode)	< 65,000 Btu/h [b]	All	Split System	13.0 SEER[c]	14.0 SEER[c]	AHRI 210/240
			Single Package	13.0 SEER[c]	14.0 SEER[c]	
Through-the-wall, air cooled	[b]	All	Split System	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Single-duct high-velocity air cooled	≤ 30,000 Btu/h [b]	All	Split System	11.0 SEER	11.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	None	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.0 IEER	AHRI 340/360
		Non-Electric[c]	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.8 IEER	
	< 65,000 Btu/h	None	Split System and Single Package	10.6 EER 10.7 IEER	10.6 EER 11.6 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Non-Electric[c]	Split System and Single Package	10.4 EER 10.5 IEER	10.4 EER 11.4 IEER	
	≥ 240,000 Btu/h	None	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 10.6 IEER	
		Non-Electric[c]	Split System and Single Package	9.3 EER 9.4 IEER	9.3 EER 9.4 IEER	
Water to Air: Water Loop (cooling mode)	< 17,000 Btu/h	All	86ºF entering water	12.2 EER	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86ºF entering water	13.0 EER	13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86ºF entering water	13.0 EER	13.0 EER	
Water to Air: Ground Water (cooling mode)	< 135,000 Btu/h	All	59 F entering water	18.0 EER	18.0 EER	ISO 13256-1
Brine to Air: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77 F entering water	14.1 EER	14.1 EER	ISO 13256-1
Water to Water: WaterLoop (cooling mode)	< 135,000 Btu/h	All	86 F entering water	10.6 EER	10.6 EER	ISO 13256-2
Water to Water: Ground Water (cooling mode)	< 135,000 Btu/h	All	59 F entering water	16.3 EER	16.3 EER	
Brine to Water: Ground Loop (cooling mode)	< 135,000 Btu/h	All	77 F entering water	12.1 EER	12.1 EER	

(continued)

TABLE 403.2.3(2)—continued MINIMUM EFFICIENCY REQUIREMENTS:

ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 1/1/2016	As of 1/1/2016	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF[c]	8.2 HSPF[c]	AHRI 210/240
		—	Single Package	7.7 HSPF[c]	8.0 HSPF[c]	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	7.4 HSPF	
		—	Single Package	7.4 HSPF	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	6.8 HSPF	
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47ºF db/43ºF wb outdoor air	3.3 COP	3.3 COP	AHRI 340/360
			17ºF db/15ºF wb outdoor air	2.25 COP	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47ºF db/43ºF wb outdoor air	3.2 COP	3.2 COP	
			17ºF db/15ºF wb outdoor air	2.05 COP	2.05 COP	
Water to Air: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP	4.3 COP	ISO 13256-1
Water to Air: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.7 COP	3.7 COP	
Brine to Air: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.2 COP	3.2 COP	
Water to Water: Water Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	3.7 COP	ISO 13256-2
Water to Water: Ground Water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.1 COP	3.1 COP	
Brine to Water: Ground Loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	2.5 COP	

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

a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.
b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.
c. Electric resistance space heating is prohibited per Section C403.1.2. Use "None" Heating Section Type category for exceptions to Section 403.1.2.

TABLE C403.2.3(3)

**MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS,**

PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS,

SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
PTAC (cooling mode) new construction	All Capacities	95°F db outdoor air	14.0 – (0.300 × Cap/1000) EER	AHRI 310/380
PTAC (cooling mode) replacements[b]	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	14.0 - (0.300 × Cap/1000) EER	
PTHP (cooling mode) replacements[b]	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[b]	All Capacities	—	2.9 - (0.026 × Cap/1000) COP	
SPVAC (cooling mode)	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	9.0 EER	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/ 75°F wb outdoor air	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95°F db/ 75°F wb outdoor air	8.6 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/ 75°F wb outdoor air	9.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/ 75°F wb outdoor air	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95°F db/ 75°F wb outdoor air	8.6 EER	
SPVHP (heating mode)	<65,000 Btu/h	47°F db/ 43°F wb outdoor air	3.0 COP	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	47°F db/ 43°F wb outdoor air	3.0 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	47°F db/ 75°F wb outdoor air	2.9 COP	
Room air conditioners, with louvered sides	< 6,000 Btu/h	—	9.7 SEER	ANSI/ AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	9.7 EER	
	≥ 8,000 Btu/h and < 14,000 Btu/h	—	9.8 EER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	—	9.7 SEER	
	≥ 20,000 Btu/h	—	8.5 EER	
Room air conditioners, with louvered sides	< 8,000 Btu/h	—	9.0 EER	
	≥ 8,000 Btu/h and < 20,000 Btu/h	—	8.5 EER	
	≥ 20,000 Btu/h	—	8.5 EER	
Room air-conditioner heat pumps with louvered sides	< 20,000 Btu/h	—	9.0 EER	
	≥ 20,000 Btu/h	—	8.5 EER	
Room air-conditioner heat pumps without louvered sides	< 14,000 Btu/h	—	8.5 EER	
	≥ 14,000 Btu/h	—	8.0 EER	

(continued)

TABLE 403.2.3(3)—continued MINIMUM EFFICIENCY REQUIREMENTS:

ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS,

SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Room air conditioner casement only	All capacities	—	8.7 EER	ANSI/ AHAM RAC-1
Room air conditioner casement-slider	All capacities	—	9.5 EER	

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

"Cap" = The rated cooling capacity of the project in Btu/h. Where the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. Where the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Replacement unit shall 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) in height and less than 42 inches (1067 mm) in width.

TABLE 403.2.3(4)

WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE[a]
Warm-air furnaces, gas fired	< 225,000 Btu/h	—	78% AFUE or 80%E_t[c]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80%E_t[f]	ANSI Z21.47
Warm-air furnaces, oil fired	< 225,000 Btu/h	—	78% AFUE or [c]	DOE 10 CFR Part 430 or UL 727
	≥ 225,000 Btu/h	Maximum capacity[b]	81%E_t[g]	UL 727
Warm-air duct furnaces, gas fired	All capacities	[b]	80%E_t 80%E_c	ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	[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 shall 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 shall 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 403.2.3(5)

MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS

EQUIPMENT TYPE[a]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE
Boilers, hot water	Gas-fired	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	80% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	82% E_c	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	84% E_c	
Boilers, steam	Gas-fired	< 300,000 Btu/h	75% AFUE	10 CFR Part 430
	Gas-fired- all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	79% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	79% E_t	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	77% E_t	
		> 2,500,000 Btu/h[a]	77% E_t	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	81% E_t	10 CFR Part 431
		> 2,500,000 Btu/h[a]	81% E_t	

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

a. 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.
b. Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit's controls.
c. Includes oil-fired (residual).
d. E_c = Combustion efficiency (100 percent less flue losses).
e. E_t = Thermal efficiency. See referenced standard for detailed information.

TABLE 403.2.3(6)

**MINIMUM EFFICIENCY REQUIREMENTS:
CONDENSING UNITS, ELECTRICALLY OPERATED**

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

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

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. IPLVs are only applicable to equipment with capacity modulation.

TABLE 403.2.3(7)

WATER CHILLING PACKAGES – EFFICIENCY REQUIREMENTS[a, b, d]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS			AS OF 1/1/2015		TEST PROCEDURE[c]
					Path A	Path B	
Air-cooled chillers	< 150 Tons	EER (Btu/W)			≥ 10.100 FL	≥ 9.700 FL	AHRI 550/590
					≥ 13.700 IPLV	≥ 15,800 IPLV	
	≥ 150 Tons				≥ 10.100 FL	≥ 9.700 FL	
					≥ 14.000 IPLV	≥ 16.100 IPLV	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/W)			Air-cooled chillers without condenser shall be rated with matching condensers and comply with air-cooled chiller efficiency requirements.		
Water cooled, electrically operated positive displacement	< 75 Tons	kW/ton			≤ 0.750 FL	≤ 0.780 FL	
					≤ 0.600 IPLV	≤ 0.500 IPLV	
	≥ 75 tons and < 150 tons				≤ 0.720 FL	≤ 0.750 FL	
					≤ 0.560 IPLV	≤ 0.490 IPLV	
	≥ 150 tons and < 300 tons				≤ 0.660 FL	≤ 0.680 FL	
					≤ 0.540 IPLV	≤ 0.440 IPLV	
	≥ 300 tons and < 600 tons				≤ 0.610 FL	≤ 0.625 FL	
					≤ 0.520 IPLV	≤ 0.410 IPLV	
	≥ 600 tons				≤ 0.560 FL	≤ 0.585 FL	
					≤ 0.500 IPLV	≤ 0.380 IPLV	
Water cooled, electrically operated centrifugal	≤ 150 Tons	kW/ton			≤ 0.610 FL	≤ 0.695 FL	
					≤ 0.550 IPLV	≤ 0.440 IPLV	
	≥ 150 tons and < 300 tons				≤ 0.610 FL	≤ 0.635 FL	
					≤ 0.550 IPLV	≤ 0.400 IPLV	
	≥ 300 tons and < 400 tons				≤ 0.560 FL	≤ 0.595 FL	
					≤ 0.520 IPLV	≤ 0.390 IPLV	
	≥ 400 tons and < 600 tons				≤ 0.560 FL	≤ 0.585 FL	
					≤ 0.500 IPLV	≤ 0.380 IPLV	
	≥ 600 Tons				≤ 0.560 FL	≤ 0.585 FL	
					≤ 0.500 IPLV	≤ 0.380 IPLV	
Air cooled, absorption, single effect	All capacities	COP			≥ 0.600 FL	NA[c]	AHRI 560
Water cooled absorption, single effect	All capacities	COP			≥ 0.700 FL	NA[c]	
Absorption, double effect, indirect fired	All capacities	COP			≥ 1.000 FL	NA[c]	
					≥ 1.050 IPLV		
Absorption double effect direct fired	All capacities	COP			≥ 1.000 FL	NA[c]	
					≥ 1.050 IPLV		

a. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section 403.2.3.1 and are only applicable for the range of conditions listed in Section C403.2.3.1. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.

b. Both the full-load and IPLV requirements shall be met or exceeded to comply with this standard. Where there is a Path B, compliance can be with either Path A or Path B for any application.

c. NA means the requirements are not applicable for Path B and only Path A can be used for compliance.

d. FL represents the full-load performance requirements and IPLV the part-load performance requirements.

TABLE 403.2.3(8)

MINIMUM EFFICIENCY REQUIREMENTS: HEAT REJECTION EQUIPMENT

EQUIPMENT TYPE[a]	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION[i]	PERFORMANCE REQUIRED[b, c, d, g, h]	TEST PROCEDURE[e, f]
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 40.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201
Propeller or axial fan evaporative condensers	All	Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 134,000 Btu/h·hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 110,000 Btu/h·hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	R-507A Test Fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 157,000 Btu/h·hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-507A Test Fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 135,000 Btu/h·hp	CTI ATC-106
Air-cooled condensers	All	125°F Condensing Temperature 190°F Entering Gas Temperature 15°F subcooling 95°F entering db	≥ 176,000 Btu/h·hp	AHRI 460

For SI: °C = [(°F)-32]/1.8, L/s · kW = (gpm/hp)/(11.83), COP = (Btu/h · hp)/(2550.7),
db = dry bulb temperature, °F, wb = wet bulb temperature, °F.

a. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of wet and dry heat exchange sections.
b. For purposes of this table, open circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the fan nameplate-rated motor power.
c. For purposes of this table, closed-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the sum of the fan nameplate-rated motor power and the spray pump nameplate-rated motor power.
d. For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate-rated motor power.
e. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure. The certification requirements do not apply to field-erected cooling towers.
f. Where a certification program exists for a covered product and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program; or, where a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.
g. Cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of any project-specific accessories and/or options included in the capacity of the cooling tower
h. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table divided by the sum of the fan motor nameplate power and the integral spray pump nameplate power
i. Requirements for evaporative condensers are listed with ammonia (R-717) and R-507A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-507A shall meet the minimum efficiency requirements listed in this table with R-507A as the test fluid.

TABLE 403.2.3(9)

MINIMUM EFFICIENCY AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS

EQUIPMENT TYPE	NET SENSIBLE COOLING CAPACITY[a]	MINIMUM SCOP-127[b] EFFICIENCY DOWNFLOW UNITS / UPFLOW UNITS	TEST PROCEDURE
Air conditioners, air cooled	65,000 Btu/h	2.20 / 2.09	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.10 / 1.99	
	≥ 240,000 Btu/h	1.90 / 1.79	
Air conditioners, water cooled	65,000 Btu/h	2.60 / 2.49	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.50 / 2.39	
	≥ 240,000 Btu/h	2.40 /2.29	
Air conditioners, water cooled with fluid economizer	65,000 Btu/h	2.55 /2.44	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.45 / 2.34	
	≥ 240,000 Btu/h	2.35 / 2.24	
Air conditioners, glycol cooled (rated at 40% propylene glycol)	65,000 Btu/h	2.50 / 2.39	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.15 / 2.04	
	≥ 240,000 Btu/h	2.10 / 1.99	
Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer	65,000 Btu/h	2.45 / 2.34	
	≥ 65,000 Btu/h and < 240,000 Btu/h	2.10 / 1.99	
	≥ 240,000 Btu/h	2.05 / 1.94	

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

a. Net sensible cooling capacity: the total gross cooling capacity less the latent cooling less the energy to the air movement system. (Total Gross – latent – Fan Power).
b. Sensible coefficient of performance (SCOP-127): a ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheaters and humidifiers) at conditions defined in ASHRAE Standard 127. The net sensible cooling capacity is the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.

TABLE 403.2.3(10)

MINIMUM EFFICIENCY

ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF air conditioners, air cooled	<65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.2 EER 13.1 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.0 EER 12.9 IEER	
	≥240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	10.0 EER 11.6 IEER	

TABLE 403.2.3(11)

MINIMUM EFFICIENCY

ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF air cooled (cooling mode)	<65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.0 EER 12.3 IEER	
	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	VRF multisplit system with heat recovery	10.8 EER 12.1 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	10.6 EER 11.8 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	VRF multisplit system with heat recovery	10.4 EER 11.6 IEER	
	≥240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	9.5 EER 10.6 IEER	
	≥240,000 Btu/h	Electric resistance (or none)	VRF multisplit system with heat recovery	9.3 EER 10.4 IEER	
VRF water source (cooling mode)	<65,000 Btu/h	All	VRF multisplit systems 86°F entering water	12.0 EER	AHRI 1230
	<65,000 Btu/h	All	VRF multisplit systems with heat recovery 86°F entering water	11.8 EER	
	≥65,000 Btu/h and <135,000 Btu/h	All	VRF multisplit system 86°F entering water	12.0 EER	
	≥65,000 Btu/h and <135,000 Btu/h	All	VRF multisplit system with heat recovery 86°F entering water	11.8 EER	
	≥135,000 Btu/h	All	VRF multisplit system 86°F entering water	10.0 EER	
	≥135,000 Btu/h	All	VRF multisplit system with heat recovery 86°F entering water	9.8 EER	
VRF groundwater source (cooling mode)	<135,000 Btu/h	All	VRF multisplit system 59°F entering water	16.2 EER	AHRI 1230
	<135,000 Btu/h	All	VRF multisplit system with heat recovery 59°F entering water	16.0 EER	
	≥135,000 Btu/h	All	VRF multisplit system 59°F entering water	13.8 EER	
	≥135,000 Btu/h	All	VRF multisplit system with heat recovery 59°F entering water	13.6 EER	

TABLE 403.2.3(11)

MINIMUM EFFICIENCY

ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS (*Continued)*

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF ground source (cooling mode)	<135,000 Btu/h	All	VRF multisplit system 77°F entering water	13.4 EER	AHRI 1230
	<135,000 Btu/h	All	VRF multisplit system with heat recovery 77°F entering water	13.2 EER	
	≥135,000 Btu/h	All	VRF multisplit system 77°F entering water	11.0 EER	
	≥135,000 Btu/h	All	VRF multisplit system with heat recovery 77°F entering water	10.8 EER	
VRF air cooled (heating mode)	<65,000 Btu/h (cooling capacity)	—	VRF multisplit system	7.7 HSPF	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	—	VRF multisplit system 47°F db/43°F wb outdoor air	3.3 COP_H	
			17°F db/15°F wb outdoor air	2.25 COP_H	
	≥135,000 Btu/h (cooling capacity)	—	VRF multisplit system 47°F db/43°F wb outdoor air	3.2 COP_H	
			17°F db/15°F wb outdoor air	2.05 COP_H	
VRF water source (heating mode)	<135,000 Btu/h (cooling capacity)	—	VRF multisplit system 68°F entering water	4.2 COP_H	AHRI 1230
	≥135,000 Btu/h (cooling capacity)	—	VRF multisplit system 68°F entering water	3.9 COP_H	
VRF groundwater source (heating mode)	<135,000 Btu/h (cooling capacity)	—	VRF multisplit system 50°F entering water	3.6 COP_H	AHRI 1230
	≥135,000 Btu/h (cooling capacity)	—	VRF multisplit system 50°F entering water	3.3 COP_H	
VRF ground source (heating mode)	<135,000 Btu/h (cooling capacity)	—	VRF multisplit system 32°F entering water	3.1 COP_H	AHRI 1230
	≥135,000 Btu/h (cooling capacity)	—	VRF multisplit system 32°F entering water	2.8 COP_H	

403.2.6 Ventilation. Ventilation, either natural or mechanical, shall be provided in accordance with ASHRAE Standard 62.1.

Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air sup- ply to the minimum required by ASHRAE Standard 62. The design professional shall utilize ventila- tion rates based on the expected occupancy level of the space. Life safety maximum allowable occupancy den- sity shall not be used as a ventilation basis of design.

403.2.6.1 Demand control ventilation. Demand control ventilation (DCV) is required for spaces meeting the following three criteria:

1. Spaces larger than 500 ft^2 (50 m^2) and
2. Spaces with an average occupant load of ≥25 people per 1000 ft^2 (93 m^2) of floor area (as established in Table 6.1 in ASHRAE 62) and
3. Spaces 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).

        Exception: Demand control ventilation is not required for systems and spaces as follows:

        1. Systems with energy recovery complying with Section C403.2.7.
        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. Ventilation provided for process loads only.

403.2.6.2 Enclosed parking garage ventilation controls. Enclosed parking garages used for storing or han- dling automobiles operating under their own power shall employ contamination-sensing devices and auto- matic controls configured to stage fans or modulate fan average airflow rates to 50 percent or less of design capacity, or intermittently operate fans less than 20 per- cent of the occupied time or as required to maintain acceptable contaminant levels in accordance with *ASHRAE Standard 62* provisions. Failure of contamination sensing devices shall cause the exhaust fans to operate continuously at design airflow.

Exceptions:

1. Garages with a total exhaust capacity less than 22,500 cfm (10 620 L/s) with ventilation sys- tems that do not utilize heating or mechanical cooling.
2. Garages that have a garage area to ventilation system motor nameplate power ratio that exceeds 1125 cfm/hp (710 L/s/kW) and do not utilize heating or mechanical cooling.

403.2.7 Energy recovery ventilation systems. Where the supply airflow rate of a fan system exceeds the values specified in Tables C403.2.7(1) or for ventilation systems operating not less than 8,000 hours per year, the sys- tem shall include an energy recovery system. The energy recovery system shall have the capability to provide 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. Where an air economizer is required, the energy recovery system shall include a bypass or controls permit operation of the economizer as required by Section 403.3.

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. Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil.
6. Where the largest source of air exhausted at a single location at the building exterior is less than 75 percent of the design outdoor air flow rate.
7. Systems expected to operate less than 20 hours per week at the outdoor air percentage covered by Table C403.2.7(1).
8. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.
9. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

403.2.8 Kitchen exhaust systems. Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate. Conditioned supply air delivered to any space shall not exceed the greater of the following:

1. The ventilation rate required to meet the space heat- ing or cooling load.
2. The hood exhaust flow minus the available transfer air from adjacent space where available transfer air is considered that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressuriza- tion of adjacent spaces.

Where total kitchen hood exhaust airflow rate is greater than 5,000 cfm (2360 L/s), each hood shall be a factory- built commercial exhaust hood listed by a nationally recog- nized testing laboratory in compliance with UL 710. Each hood shall have a maximum exhaust rate as specified in Table 403.2.8 and shall comply with one of the following:

1. Not less than 50 percent of all replacement air shall be transfer air that would otherwise be exhausted.
2. Demand ventilation systems on not less than 75 per- cent of the exhaust air that are capable of not less than a 50-percent reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle.
3. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on not less than 50 percent of the total exhaust airflow.

Where a single hood, or hood section, is installed over appliances with different duty ratings, the max- imum allowable flow rate for the hood or hood sec- tion shall be based on the requirements for the highest appliance duty rating under the hood or hood section.

Exception: Where not less than 75 percent of all the replacement air is transfer air that would oth- erwise be exhausted

403.2.9 Duct and plenum insulation and sealing. All supply and return air ducts and plenums shall be insulated with a minimum of R-8 insulation when located in unconditioned spaces and a minimum of R-12 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-12 insulation. Buried ducts shall be insulated to a minimum of R-3.5.

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*.

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

403.2.9.1.1 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.

403.2.9.1.2 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 403.2.7. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

403.2.9.1.3 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 403.2.7. 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 4-8.

$$CL = F / P^{0.65} \qquad \textbf{(Equation 4-8)}$$

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.

403.2.10 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 403.2.10.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 60°F (13°C) and 105°F (41°C), inclusive.
4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
5. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.
6. Direct buried piping that conveys fluids at or below 60°F (15°C).

403.2.11 Mechanical Systems performance, verification and comple- tion. New buildings of 50,000 gross square feet of condi- tioned space or greater shall meet the provisions of Section C407.

TABLE 403.2.10 MINIMUM PIPE INSULATION THICKNESS(in inches)[a]

FLUID DESIGN OPERATING TEMPERATURE RANGE (F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu · in. (h · ft^2 · °F)	Mean Rating Temperature (°F)	< 1	1 to < 1$^1/_2$	1$^1/_2$ to < 4	4 to < 8	2: 8
> 350	0.32 - 0.34	250	2.5	3.0	3.0	4.0	4.0
251 - 350	0.29 - 0.32	200	1.5	2.5	3.0	3.0	3.0
201 - 250	0.27 - 0.30	150	1.5	1.5	2.0	2.0	2.0
141 - 200	0.25 - 0.29	125	1.0	1.0	1.0	1.5	1.5
105 - 140	0.25 - 0.28	100	0.5	0.5	1.0	1.0	1.0
40 - 60	0.22 - 0.28	100	0.5	0.5	1.0	1.0	1.0
< 40	0.22 - 0.28	100	0.5	1.0	1.0	1.0	1.5

For SI: 1 inch = 25.4 mm.

a. For Insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

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

where:

T = Minimum insulation thickness (in).

r = Actual outside radius of pipe (in).

t = Insulation thickness listed in this table for applicable fluid temperature and pipe size.

K = Conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu · in/hr · ft^2 · °F).

k = The upper value of the conductivity range listed in this table for applicable fluid temperature.

b. These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

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

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

403.2.11 Air system design and control. Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) (3.7 kW) shall meet the provisions of Sections 403.2.12.1 through 403.2.12.3.

403.2.12.1 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 403.2.12.1(1). This includes supply fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability. Single-zone variable air volume systems shall comply with the constant volume fan power limitation

Exceptions:

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

403.2.11.2 Motor nameplate horsepower. For each fan, the fan brake horsepower shall be indicated on the construction documents and the selected motor shall be not larger than the first avail- able motor size greater than the following:

1. For fans less than 6 bhp (4413 W), 1.5 times the fan brake horsepower.

TABLE 403.2.11.1(1) FAN POWER LIMITATION

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	hp ≤ CFM_S *0.0011	hp ≤ CFM_S *0.0015
Option 2: Fan system bhp	Allowable fan system bhp	bhp ≤ CFM_S *0.00094 + *A*	bhp ≤ CFM_S *0.0013 + *A*

where:

CFM_S = 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 = Sum of [*PD* x CFM_D / 4131].

where:

PD = Each applicable pressure drop adjustment from Table 403.2.11.1(2) in. w.c.

CFM_D = The design airflow through each applicable device from Table 403.2.11.1(2) in cubic feet per minute.

TABLE 403.2.11.1(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 airflow 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.
Biosafety cabinet	Pressure drop of device at fan system design condition.
Energy recovery device, other than coil runaround loop	(2.2 × energy recovery effectiveness) – 0.5 inch w.c. for each
Coil runaround loop	0.6 inch w.c. for each airstream.
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions
Sound attenuation section(fans serving spaces with design background noise goals below NC35)	0.15 in w.c.
Exhaust system serving fume hoods	0.35 inch w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100
Deductions	
Systems without central cooling device	- 0.6 in. w.c.
Systems without central heating device	- 0.3 in. w.c.
Systems with central electric resistance heat	- 0.2 in. w.c.

2. For fans 6 bhp (4413 W) and larger, 1.3 times the fan brake horsepower.

403.2.12.3 Fan efficiency. Fans shall have a fan efficiency grade (FEG) of not less than 67 when determined in accordance with AMCA 205 by an *approved*, independent testing laboratory and labeled by the manufacturer. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

Exception: The following fans are not required to have a fan efficiency grade:

1. Fans of 5 hp (3.7 kW) or less as follows:
   - 1.1. Single fan with a motor nameplate horsepower of 5 hp (3.7 kW) or less, unless Exception 1.2 applies.
   - 1.2. Multiple fans in series or parallel that have a combined motor nameplate horsepower of 5 hp (3.7 kW) or less and are operated as the functional equivalent of a single fan.
2. Fans that are part of equipment covered under Section C403.2.3.
3. Fans included in an equipment package certi- fied by an *approved agency* for air or energy performance.
4. Powered wall/roof ventilators.
5. Fans outside the scope of AMCA 205.

Fans that are intended to operate only during emergency conditions.

403.2.13 Heating outside a building. Systems installed to provide heat outside a building shall be radiant systems. Electric resistance heating is prohibited for heating spaces outside a building. Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is auto- matically deenergized when no occupants are present.

403.2.14 Refrigeration equipment performance. Refrigeration equipment shall have an energy use in

kWh/day not greater than the values of Tables C403.2.14(1) and C403.2.14(2) when tested and rated in accordance with AHRI Standard 1200. The energy use shall be verified through certification under an approved certification program or, where a certification program does not exist, the energy use shall be supported by data furnished by the equipment manufacturer.

TABLE 403.2.14(1)

MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATION

EQUIPMENT TYPE	APPLICATION	ENERGY USE LIMITS (kWh per day)[a]	TEST PROCEDURE
Refrigerator with solid doors	Holding Temperature	0.10 · V + 2.04	AHRI 1200
Refrigerator with transparent doors		0.12 · V + 3.34	
Freezers with solid doors		0.40 · V + 1.38	
Freezers with transparent doors		0.75 · V + 4.10	
Refrigerators/freezers with solid doors		the greater of 0.12 · V + 3.34 or 0.70	
Commercial refrigerators	Pulldown	0.126 · V + 3.51	

a. V = volume of the chiller or frozen compartment as defined in AHAM-HRF-1.

TABLE 403.2.14(2)

MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS

EQUIPMENT TYPE				ENERGY USE LIMITS (kWh/day)[a,b]	TEST PROCEDURE
Equipment Class[c]	Family Code	Operating Mode	Rating Temperature		
VOP.RC.M	Vertical open	Remote condensing	Medium	0.82 · TDA + 4.07	AHRI 1200
SVO.RC.M	Semivertical open	Remote condensing	Medium	0.83 · TDA + 3.18	
HZO.RC.M	Horizontal open	Remote condensing	Medium	0.35 · TDA + 2.88	
VOP.RC.L	Vertical open	Remote condensing	Low	2.27 · TDA + 6.85	
HZO.RC.L	Horizontal open	Remote condensing	Low	0.57 · TDA + 6.88	
VCT.RC.M	Vertical transparent door	Remote condensing	Medium	0.22 TDA + 1.95	
VCT.RC.L	Vertical transparent door	Remote condensing	Low	0.56 · TDA + 2.61	
SOC.RC.M	Service over counter	Remote condensing	Medium	0.51 · TDA + 0.11	
VOP.SC.M	Vertical open	Self-contained	Medium	1.74 · TDA + 4.71	
SVO.SC.M	Semivertical open	Self-contained	Medium	1.73 · TDA + 4.59	
HZO.SC.M	Horizontal open	Self-contained	Medium	0.77 · TDA + 5.55	
HZO.SC.L	Horizontal open	Self-contained	Low	1.92 · TDA + 7.08	
VCT.SC.I	Vertical transparent door	Self-contained	Ice cream	0.67 · TDA + 3.29	
VCS.SC.I	Vertical solid door	Self-contained	Ice cream	0.38 · V + 0.88	
HCT.SC.I	Horizontal transparent door	Self-contained	Ice cream	0.56 · TDA + 0.43	
SVO.RC.L	Semivertical open	Remote condensing	Low	2.27 · TDA + 6.85	
VOP.RC.I	Vertical open	Remote condensing	Ice cream	2.89 · TDA + 8.7	
SVO.RC.I	Semivertical open	Remote condensing	Ice cream	2.89 · TDA + 8.7	
HZO.RC.I	Horizontal open	Remote condensing	Ice cream	0.72 · TDA + 8.74	
VCT.RC.I	Vertical transparent door	Remote condensing	Ice cream	0.66 · TDA + 3.05	
HCT.RC.M	Horizontal transparent door	Remote condensing	Medium	0.16 · TDA + 0.13	

(continued)

TABLE 403.2.14(2)—continued

MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS

EQUIPMENT TYPE				ENERGY USE LIMITS (kWh/day)[a,b]	TEST PROCEDURE
Equipment Class[c]	Family Code	Operating Mode	Rating Temperature		
HCT.RC.L	Horizontal transparent door	Remote condensing	Low	0.34 · TDA + 0.26	AHRI 1200
HCT.RC.I	Horizontal transparent door	Remote condensing	Ice cream	0.4 · TDA + 0.31	
VCS.RC.M	Vertical solid door	Remote condensing	Medium	0.11 · V + 0.26	
VCS.RC.L	Vertical solid door	Remote condensing	Low	0.23 · V + 0.54	
VCS.RC.I	Vertical solid door	Remote condensing	Ice cream	0.27 · V + 0.63	
HCS.RC.M	Horizontal solid door	Remote condensing	Medium	0.11 · V + 0.26	
HCS.RC.L	Horizontal solid door	Remote condensing	Low	0.23 · V + 0.54	
HCS.RC.I	Horizontal solid door	Remote condensing	Ice cream	0.27 · V + 0.63	
HCS.RC.I	Horizontal solid door	Remote condensing	Ice cream	0.27 · V + 0.63	
SOC.RC.L	Service over counter	Remote condensing	Low	1.08 · TDA + 0.22	
SOC.RC.I	Service over counter	Remote condensing	Ice cream	1.26 · TDA + 0.26	
VOP.SC.L	Vertical open	Self-contained	Low	4.37 · TDA + 11.82	
VOP.SC.I	Vertical open	Self-contained	Ice cream	5.55 · TDA + 15.02	
SVO.SC.L	Semivertical open	Self-contained	Low	4.34 · TDA + 11.51	
SVO.SC.I	Semivertical open	Self-contained	Ice cream	5.52 · TDA + 14.63	
HZO.SC.I	Horizontal open	Self-contained	Ice cream	2.44 · TDA + 9.0	
SOC.SC.I	Service over counter	Self-contained	Ice cream	1.76 · TDA + 0.36	
HCS.SC.I	Horizontal solid door	Self-contained	Ice cream	0.38 · V + 0.88	

a. V = Volume of the case, as measured in accordance with Appendix C of AHRI 1200.
b. TDA = Total display area of the case, as measured in accordance with Appendix D of AHRI 1200.
c. Equipment class designations consist of a combination [(in sequential order separated by periods (AAA).(BB).(C))] of:

(AAA) An equipment family code where:

VOP = vertical open
SVO = semivertical open
HZO = horizontal open

VCT = vertical transparent doors
VCS = vertical solid doors

HCT = horizontal transparent doors
HCS = horizontal solid doors

SOC = service over counter

(BB) An operating mode code:

RC = remote condensing
SC = self-contained

(C) A rating temperature code:

M = medium temperature (38°F)
L = low temperature (0°F)

I = ice-cream temperature (15°F)

For example, ''VOP.RC.M'' refers to the "vertical-open, remote-condensing, medium-temperature" equipment class.

403.2.15 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers. *Refrigerated warehouse coolers* and *refrigerated warehouse freezers* shall comply with this section. *Walk-in coolers* and *walk-in freezers* that are not either site assembled or site constructed shall comply with the following:

1. Be equipped with automatic door-closers that firmly close walk-in doors that have been closed to within 1 inch (25 mm) of full closure.

   Exception: Automatic closers are not required for doors more than 45 inches (1143 mm) in width or more than 7 feet (2134 mm) in height.

2. Doorways shall have strip doors, curtains, spring-hinged doors or other method of minimizing infiltration when doors are open.
3. *Walk-in coolers* and *refrigerated warehouse coolers* shall contain wall, ceiling, and door insulation of not less than R-25 and *walk-in freezers* and *refrigerated warehouse freezers* shall contain wall, ceiling and door insulation of not less than R-32.

   Exception: Glazed portions of doors or structural members need not be insulated.

4. *Walk-in freezers* shall contain floor insulation of not less than R-28.
5. Transparent reach-in doors for *walk-in freezers* and windows in *walk-in freezer* doors shall be of triple-pane glass, either filled with inert gas or with heat-reflective treated glass.
6. Windows and transparent reach-in doors for *walk-in coolers* doors shall be of double-pane or triple-pane, inert gas-filled, heat-reflective treated glass.
7. Evaporator fan motors that are less than 1 hp (0.746 kW) and less than 460 volts shall use electronically commutated motors, brushless direct-current motors, or 3-phase motors.
8. Condenser fan motors that are less than 1 hp (0.746 kW) shall use electronically commutated motors, permanent split capacitor-type motors or 3-phase motors.
9. Where antisweat heaters without antisweat heater controls are provided, they shall have a total door rail, glass and frame heater power draw of not more than 7.1 W/ft^2 (76 W/m^2) of door opening for *walk-in freezers* and 3.0 W/ft^2 (32 W/m^2) of door opening for *walk-in coolers*.
10. Where antisweat heater controls are provided, they shall reduce the energy use of the antisweat heater as a function of the relative humidity in the air outside the door or to the condensation on the inner glass pane.
11. Lights in *walk-in coolers*, *walk-in freezers*, *refrigerated warehouse coolers* and *refrigerated warehouse freezers* shall either use light sources with an efficacy of not less than 40 lumens per watt, including ballast losses, or shall use light sources with an efficacy of not less than 40 lumens per watt, including ballast losses, in conjunction with a device that turns off the lights within 15 minutes when the space is not occupied.

403.2.16 Walk-in coolers and walk-in freezers. Site-assembled or site-constructed *walk-in coolers* and *walk-in freezers* shall comply with the following:

1. Automatic door closers shall be provided that fully close walk-in doors that have been closed to within 1 inch (25 mm) of full closure.

   Exception: Closers are not required for doors more than 45 inches (1143 mm) in width or more than 7 feet (2134 mm) in height.

2. Doorways shall be provided with strip doors, curtains, spring-hinged doors or other method of minimizing infiltration when the doors are open.
3. Walls shall be provided with insulation having a thermal resistance of not less than R-25, ceilings shall be provided with insulation having a thermal resistance of not less than R-25 and doors of *walk-in coolers* and *walk-in freezers* shall be provided with insulation having a thermal resistance of not less than R-32.

   Exception: Insulation is not required for glazed portions of doors or at structural members associated with the walls, ceiling or door frame.

4. The floor of *walk-in freezers* shall be provided with insulation having a thermal resistance of not less than R-28.
5. Transparent reach-in doors for and windows in opaque *walk-in freezer* doors shall be provided with triple-pane glass having the interstitial spaces filled with inert gas or provided with heat-reflective treated glass.
6. Transparent reach-in doors for and windows in opaque *walk-in cooler* doors shall be double-pane heat-reflective treated glass having the interstitial space gas filled.
7. Evaporator fan motors that are less than 1 hp (0.746 kW) and less than 460 volts shall be electronically commutated motors or 3-phase motors.
8. Condenser fan motors that are less than 1 hp (0.746 kW) in capacity shall be of the electronically commutated or permanent split capacitor-type or shall be 3-phase motors.

   Exception: Fan motors in *walk-in coolers* and *walk-in freezers* combined in a single enclosure greater than 3,000 square feet (279 m^2) in floor area are exempt.

9. Antisweat heaters that are not provided with antisweat heater controls shall have a total door rail, glass and frame heater power draw not greater than 7.1 W/ft^2 (76 W/m^2) of door opening for *walk-in freezers*, and not greater than 3.0 W/ft^2 (32 W/m^2) of door opening for *walk-in coolers*.

10. Antisweat heater controls shall be capable of reducing the energy use of the antisweat heater as a function of the relative humidity in the air outside the door or to the condensation on the inner glass pane.
11. Light sources shall have an efficacy of not less than 40 lumens per Watt, including any ballast losses, or shall be provided with a device that automatically turns off the lights within 15 minutes of when the *walk-in cooler* or *walk-in freezer* was last occupied.

403.2.17 Refrigerated display cases. Site-assembled or site-constructed refrigerated display cases shall comply with the following:

1. Lighting and glass doors in refrigerated display cases shall be controlled by one of the following:
   1.1. Time switch controls to turn off lights during nonbusiness hours. Timed overrides for display cases shall turn the lights on for up to 1 hour and shall automatically time out to turn the lights off.
   1.2. Motion sensor controls on each display case section that reduce lighting power by at least 50 percent within 3 minutes after the area within the sensor range is vacated.
2. Low-temperature display cases shall incorporate temperature-based defrost termination control with a time-limit default. The defrost cycle shall terminate first on an upper temperature limit breach and second upon a time limit breach.
3. Antisweat heater controls shall reduce the energy use of the antisweat heater as a function of the relative humidity in the air outside the door or to the condensation on the inner glass pane.

403.3 403.3Economizers (Prescriptive). Each cooling system that has a fan shall include an air economizer meeting the requirements of Sections 403.3.1 through 403.3.4. The total capacity of all fan-cooling units without economizers shall not exceed 20 percent of the total supply capacity of all fan-cooling units in the building or 300,000 Btu/h (88 kW), whichever is greater.

Exceptions: Economizers are not required for the systems listed below.

1. Where indi- vidual cooling units have a capacity of less than 54,000 Btu/h (15.8 kW) and meet one of the follow- ing:

   1.1. Have direct expansion cooling coils.

   1.2. The total chilled water system capacity less the capacity of fan units with air economizers is less than the minimum specified in Table 403.3(1).

2. Where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F dew-point temperature to satisfy process needs.

3. Systems that serve residential spaces where the system capacity is less than five times the minimum requirement (< 270,000 Btu/h).

4. Systems expected to operate less than 20 hours per week.

5. Where the use of *outdoor air* for cooling will affect supermarket open refrigerated casework systems.

6. Where the cooling *efficiency* meets or exceeds a 50% efficiency improvement in cooling equipment performance (EER or IPLV).

7. Chilled-water cooling systems that are passive (without a fan) or use induction where the total chilled water system capacity less the capacity of fan units with air economizers is less than the mini- mum specified in Table 403.3(1).

8. Systems that include a heat recovery system in accordance with Section 403.4.5.

403.3.1 Integrated economizer control. Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even where additional mechanical cooling is required to provide the remainder of the cooling load. Controls shall not be capable of creating a false load in the mechanical cooling systems by limiting or disabling the economizer or any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

Exceptions:

1. Direct expansion systems that include controls that reduce the quantity of outdoor air required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is no greater than 25% of the total system capacity.
2. Individual direct expansion units that have a rated cooling capacity less than 54,000 Btu/h and use non-integrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.

TABLE 403.3(1)

MINIMUM CHILLED-WATER SYSTEM COOLING CAPACITY FOR DETERMINING ECONOMIZER COOLING REQUIREMENTS

CLIMATE ZONES (COOLING)	TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS	
	Local Water-cooled Chilled-water Systems	Air-cooled Chilled-water Systems or District Chilled-Water Systems
6a	1,320,000 Btu/h	1,720,000 Btu/h

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

TABLE 403.3.1

DX COOLING STATESTAGE REQUIREMENTS FOR MODULATING AIRFLOW UNITS

RATING CAPACITY	MINIMUM NUMBER OF MECHANICAL COOLING STAGES	MINIMUM COMPRESSOR DISPLACEMENT[a]
≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% of full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load

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

a. For *mechanical cooling* stage control that does not use variable compressor displacement, the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

TABLE 403.3.3.3

HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS[a]

DEVICE TYPE		REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):	
		Equation	Description
Fixed dry bulb		$T_{OA} > 70°F$	Outdoor air temperature exceeds 70°F
Differential dry bulb		$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperatures		$h_{OA} > 28$ Btu/lb or $T_{OA} > 70°F$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air or Outdoor air temperature exceeds 70°F
Differential enthalpy with fixed dry-bulb temperature		$h_{OA} > h_{RA}$ or $T > 70°F$	Outdoor air enthalpy exceeds return air enthalpy or Outdoor air temperature exceeds 70°F

For SI: 1 foot = 305 mm, °C = (°F - 32)/1.8, 1 Btu/lb = 2.33 kJ/kg.

Units that include an air economizer shall comply with the following:

1. Unit controls shall have the mechanical cooling capacity control interlocked with the air economizer controls, such that:
   i. the outdoor air damper is at the 100-percent open position when mechanical cooling is on and
   ii. the outdoor air damper does not begin to close until the leaving air temperature is less than 45°F (7°C) (to prevent coil freezing due to minimum compressor run time)
2. Direct expansion (DX) units that control 75,000 Btu/h (22 kW) or greater of rated capacity of the mechanical cooling directly based on occupied space temperature shall have not fewer than two stages of mechanical cooling capacity
3. Other DX units, including those that control space temperature by modulating the airflow to the space, shall be in accordance with

Table 403.3.1.

403.3.2 Economizer heating system impact. HVAC system design and economizer controls shall be such that economizer operation does not increase building heating energy use during normal operation.

Exception: Economizers on variable air volume (VAV) systems that cause zone level heating to increase due to a reduction in supply air temperature.

403.3.3 Air Economizers.

403.3.3.1 Design Capacity. Air economizer sys- tems shall be capable of modulating *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.

403.3.1.1.2 Control Signal. Economizer dampers shall be capable of being sequenced with the mechan- ical cooling equipment and shall not be controlled by mixed air temperature.

Exception: The use of mixed air temperature limit control shall be permitted for systems controlled from space temperature (such as single-zone sys- tems).

403.3.1.1.3 High-Limit Shutoff. All air econo- mizers shall be capable of automatically reducing *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will no longer reduce cooling energy usage. High-limit shutoff control types shall be chosen from Table 403.3.3.3. High-limit shutoff con- trol settings for these control types shall be those listed in Table 403.3.3.3.

403.3.1.1.4 Relief of Excess Outdoor Air. Systems shall be capable of relieving excess outdoor air during air economizer operation to prevent over-pressurizing the building. The relief air outlet shall be located to avoid recirculation into the building.

C403.3.4 Water-side economizers. Water-side economizers shall comply with Sections C403.3.4.1 and C403.3.4.2.

403.3.4.1 Design Capacity. Water economizer systems shall be capable of cooling supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at outdoor air temperatures of 50°F dry bulb/45°F wet bulb and below.

Exceptions:

1. Systems primarily serving computer rooms in which 100 percent of the expected system cool- ing load at 40°F (4°C) dry bulb/35°F (1.7°C) wet bulb is met with evaporative water econo- mizers.
2. Systems primarily serving computer rooms with dry cooler water economizers which sat- isfy 100 percent of the expected system cool- ing load at 35°F (1.7°C) dry bulb.
3. Systems where dehumidification requirements cannot be met using outdoor air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and where 100 percent of the expected system cooling load at 45°F (7°C) dry bulb/40°F (4°C) wet bulb is met with evaporative water econo- mizers

403.3.4.2 Maximum Pressure Drop. Pre-cooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a water-side pressure drop of less than 15 feet (45 kPa) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (non-economizer) mode.

403.4 Hydronic and multiple-zone HVAC systems controls and equipment. (Prescriptive). Hydronic and multiple- zone HVAC system controls and equipment shall comply with this section.

C403.4.1 Fan control. Controls shall be provided for fans in accordance with Sections 403.4.1. through 403.4.1.3.

403.4.1.1 Fan airflow control. Each cooling system listed in Table 403.4.1.1 shall be designed to vary the indoor fan airflow as a function of load and shall com- ply with the following requirements:

1. Direct expansion (DX) and chilled water cooling units that control the capacity of the mechanical cooling directly based on space temperature shall have not fewer than two stages of fan control. Low or minimum speed shall not be greater than 66 percent of full speed. At low or minimum speed, the fan system shall draw not more than 40 percent of the fan power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.
2. Other units including DX cooling units and chilled water units that control the space tempera- ture by modulating the airflow to the space shall have modulating fan control. Minimum speed shall be not greater than 50 percent of full speed. At minimum speed the fan system shall draw not more than 30 percent of the power at full fan speed. Low or minimum speed shall be used dur- ing periods of low cooling load and ventilation-only operation.
3. Units that include an airside economizer in accor- dance with Section C403.3 shall have not fewer than two speeds of fan control during economizer operation.

Exceptions:

1. Modulating fan control is not required for chilled water and evaporative cooling units with fan motors of less than 1 hp (0.746 kW) where the units are not used to provide *ventilation* air and the indoor fan cycles with the load.
2. Where the volume of outdoor air required to comply with the *ventilation* requirements of ASHRAE

Standard 62 at low speed exceeds the air that would be deliv- ered at the speed defined in Section C403.4.1, the minimum speed shall be selected to provide the required *ventilation air*.

4. **TABLE 403.4.1.1 EFFECTIVE DATES FOR FAN CONTROL**

COOLING SYSTEM TYPE	FAN MOTOR SIZE	MECHANICAL COOLING CAPACITY
DX cooling	Any	≥ 75,000 Btu/h (before 1/1/2016)
		≥ 65,000 Btu/h (after 1/1/2016
Chilled water and evaporative cooling	≥ 5 hp	Any
	≥ $^1/_4$ hp	Any

5. For SI: 1 British thermal unit per hour = 0.2931 W; 1 hp = 0.746 kW.

403.4.1.2 Static Pressure Sensor Location. Static pressure sensors used to control VAV fans shall be located such that the controller setpoint is not greater than 1.2 inches w.c. (299 Pa). Where this results in one or more sensors being located downstream of major duct splits, not less than one sensor shall be located on each major branch to ensure that static pressure can be maintained in each branch. Location of the static pressure sensor near the supply fan discharge would result in non-compliance.

403.4.1.3 Set points for direct digital control. 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. The direct digital controls shall be capable of monitoring *zone* damper positions or shall have an alternative method of indicating the need for static pressure that is capable of all of the following:

1. Automatically detecting any *zone* that excessively drives the reset logic.
2. Generating an alarm to the system operational location.
3. Allowing an operator to readily remove one or more *zones* from the reset algorithm.

403.4.2 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 403.4.2.1 through 403.4.2.3. 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.

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

403.4.3.2 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.

403.4.3.3 Hydronic (water loop) heat pump systems. Hydronic heat pump systems shall comply with Sections 403.4.2.3.1 through 403.4.2.3.3.

403.4.2.3.1 Temperature dead band. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addi- tion 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 rejec- tion and heat addition by the central devices.

Exception: Where a system loop temperature optimization controller is installed and can deter- mine 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.

403.4.3.3.2 Heat rejection. If an open- or closed-cir- cuit 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.

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

403.4.3.3.3 Two position valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 horsepower (hp) (7.5 kW) shall have a two-position valve.

403.4.2.4 Part-load controls. Hydronic systems greater than or equal to 500,000 Btu/h (146.5 kW) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability to do all of the following:

1. Automatically reset the supply-water tempera- tures in response to varying building heating and cooling demand using coil valve position, zone-return water temperature, building-return water temperature or outside air temperature. The tem- perature shall be capable of being reset by not less than 25 percent of the design supply-to-return water temperature difference.
2. Automatically vary fluid flow for hydronic sys- tems with a combined motor capacity of 10 hp (7.5 kW) or larger with three or more control valves or other devices by reducing the system design flow rate by not less than 50 percent by designed valves that modulate or step open and close, or pumps that modulate or turn on and off as a function of load.
3. Automatically vary pump flow on chilled-water systems and heat rejection loops serving water-cooled unitary air conditioners with a combined motor capacity of 5 hp (3.75 kW) or larger by reducing pump design flow by not less than 50 percent, utilizing adjustable speed drives on pumps, or multiple-staged pumps where not less than one-half of the total pump horsepower is capable of being automatically turned off. Pump flow shall be controlled to maintain one control valve nearly wide open or to satisfy the minimum differential pressure.

Exceptions:

1. Supply-water temperature reset for chilled-water systems supplied by off-site district chilled water or chilled water from ice storage systems.
2. Minimum flow rates other than 50 percent as required by the equipment manufacturer for proper operation of equipment where using flow bypass or end-of-line 3-way valves.
3. Variable pump flow on dedicated equipment cir- culation pumps where configured in primary/sec- ondary design to provide the minimum flow requirements of the equipment manufacturer for proper operation of equipment.

403.4.2.5 Boiler turndown. *Boiler systems* with design input of greater than 1,000,000 Btu/h (293 kW) shall comply with the turndown ratio specified in Table 403.4.2.5.

The system turndown requirement shall be met through the use of multiple single input boilers, one or more *modulating boilers* or a combination of single input and *modulating boilers*.

TABLE 403.4.2.5
BOILER TURNDOWN

BOILER SYSTEM DESIGN INPUT (Btu/h)	MINIMUM TURNDOWN RATIO
≥ 1,000,000 and less than or equal to 5,000,000	3 to 1
> 5,000,000 and less than or equal to 10,000,000	4 to 1
> 10,000,000	5 to 1

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

403.4.2.6 Pump isolation. Chilled water plants includ- ing 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 pur- pose of increased temperature differential shall be con- sidered as one chiller.

TABLE 403.4.2.7 PIPING SYSTEM DESIGN MAXIMUM FLOW RATE IN GPM

Operating Hours/Year	≤2000 Hours/Year		>2000 and ≤4400 Hours/Year		>4400 Hours/Year	
Nominal Pipe Size (in.)	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed
2 1/2	120	180	85	130.0	68	110
3	180	270	140	210	110	170
4	350	530	260	400	210	320
5	410	620	310	470	250	370
6	740	1100	570	860	440	680
8	1200	1800	900	1400	700	1100
10	1800	2700	1300	2000	1000	1600
12	2500	3800	1900	2900	1500	2300
Maximum velocity for pipes over 14-24 in. in size	8.5 ft/s	13.0 ft/s	6.5 ft/s	9.5 ft/s	5.0 ft/s	7.5 ft/s

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.

403.4.2.7 Pipe Sizing. All chilled-water and condenserwater piping shall be designed such that the design flow rate in each piping segment shall not exceed the values listed in Table 403.4.2.7 for the appropriate total annual hours of operation. Piping size selections for systems that operate under variable flow conditions (e.g., modulating two-way control valves at coils) and that contain variable-speed pump motors are allowed to be made from the "Variable Flow/Variable Speed" columns. All others shall be made from the "Other" columns.

Exceptions:

1. Design flow rates exceeding the values in Table 403.4.2.7 are allowed in specific sections of piping if the piping in question is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during more than 30% of operating hours.
2. Piping systems that have equivalent or lower total pressure drop than the same system constructed with standard weight steel pipe with piping and fittings sized per Table 403.4.2.7.

403.4.3 Heat rejection equipment. Heat rejection equipment such as air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers and evaporative condensers used for comfort cooling applications shall comply with this section.

Exception: Heat rejection devices where energy usage is included in the equipment efficiency ratings listed in Tables 403.2.3(6) and 403.2.3(7).

403.4.3.1 Fan speed control. The fan speed shall be controlled as provided in Sections 403.4.3.2.1 and 403.4.3.2.2.

403.4.3.1.1 Fan motors not less than 7.5 hp. 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 con- trols that automatically change the fan speed to con- trol the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exception: The following fan motors over 7.5 hp (5.6 kW) are exempt:

1. Condenser fans serving multiple refrigerant circuits.
2. Condenser fans serving flooded condens- ers.

403.4.3.1.2 Multiple-cell heat rejection equipment. Multiple-cell heat rejection equipment with variable speed fan drives shall be controlled in both of the following manners:

1. To operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components.
2. So all fans can operate at the same fan speed required for the instantaneous cooling duty, as opposed to staged (on/off) operation.

Minimum fan speed shall be the minimum allowable speed of the fan drive system in accordance with the manufacturer's recommendations.

403.4.3.2 Limitation on centrifugal fan open-circuit cooling towers. Centrifugal fan open-circuit cooling towers with a combined rated capacity of 1,100 gpm (4164 L/m) or greater at 95°F (35°C) condenser water return, 85°F (29°C) condenser water supply, and 75°F (24°C) outdoor air wet-bulb temperature shall meet the energy efficiency requirement for axial fan open-circuit cooling towers listed in Table 403.2.3(8).

Exception: Centrifugal open-circuit cooling towers that are designed with inlet or discharge ducts or require external sound attenuation.

403.4.3.3 Tower flow turndown. Open-circuit cool- ing towers used on water-cooled chiller systems that are configured with multiple- or variable-speed con- denser water pumps shall be designed so that all open- circuit cooling tower cells can be run in parallel with the larger of the flow that is produced by the smallest pump at its minimum expected flow rate or at 50 per- cent of the design flow for the cell

403.4.4 Requirements for complex mechanical systems serving multiple zones. Sections 403.4.4.1 through 403.4.4.4 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 ASHRAE Standard 62.1-2007.
4. Any higher rate that can be demonstrated to reduce overall system annual energy use by offsetting reheat/recool energy losses through a reduction in *outdoor air* intake for the system, as *approved* by the *code official or authority having jurisdiction*.
5. The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates

Exception: The following individual zones or 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 per- cent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. Zones where special humidity levels are required to satisfy process needs.

4. Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.
5. Zones where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventila- tio n requirements of ASHRAE Standard 62..
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.

403.4.4.1 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.

403.4.42 Dual duct and mixing VAV systems, termi- nal 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.

403.4.4.3 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.

403.4.4.4 Fractional hp fan motors. Motors for fans that are not less than 1/12 hp (0.082 kW) and less than 1 hp (0.746 kW) shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent, rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. The use of belt- driven fans to sheave adjustments for airflow balancing instead of a varying motor speed shall be permitted.

Exceptions: The following motors are not required to comply with this section:

1. Motors in the airstream within fan coils and terminal units that only provide heating to the space served.
2. Motors in space-conditioning equipment that comply with Section 403.2.3 or 403.2.12.
3. Motors that comply with Section 405.8

403.4.5.4 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 reset- ting 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.

403.4.4.6 Multiple-zone VAV system ventilation opti- mization control. Multiple-zone VAV systems with direct digital control of individual zone boxes reporting to a central control panel shall have automatic controls con- figured to reduce outdoor air intake flow below design rates in response to changes in system *ventilation* effi- ciency (E_v) as defined by the A*SHRAE Standard 62.*

Exceptions:

1. VAV systems with zonal transfer fans that recir- culate air from other zones without directly mix- ing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered ter- minal units.
2. Systems having exhaust air energy recovery com- plying with Section 403.2.7.
3. Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements.

403.4.5 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).

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.
3. If compliance with Section 403.4.5 will be detrimental to chiller operating efficiency due to conflicts with optimized chiller head pressure control.

403.4.7 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 403.4.6

As limited by Section C403.3.1.

TABLE 403.4.6
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.

C403.5 Refrigeration systems. Refrigerated display cases, *walk-in coolers* or *walk-in freezers* that are served by remote compressors and remote condensers not located in a *condens- ing unit*, shall comply with Sections 403.5.1 and 403.5.2.

Exception: Systems where the working fluid in the refrig- eration cycle goes through both subcritical and supercriti- cal states (transcritical) or that use ammonia refrigerant are exempt.

403.5.1 Condensers serving refrigeration systems. Fan-powered condensers shall comply with the following:

1. The design *saturated condensing temperatures* for air-cooled condensers shall not exceed the design dry-bulb temperature plus 10°F (5.6°C) for low-*tem- perature refrigeration systems*, and the design dry- bulb temperature plus 15°F (8°C) for *medium tem- perature refrigeration systems* where the *saturated condensing temperature* for blend refrigerants shall be determined using the average of liquid and vapor temperatures as converted from the condenser drain pressure.
2. Condenser fan motors that are less than 1 hp (0.75 kW) shall use electronically commutated motors, permanent split-capacitor-type motors or 3-phase motors.
3. Condenser fans for air-cooled condensers, evapora- tively cooled condensers, air- or water-cooled fluid coolers or cooling towers shall reduce fan motor demand to not more than 30 percent of design watt- age at 50 percent of design air volume, and incorpo- rate one of the following continuous variable speed fan control approaches:
   - 3.1. Refrigeration system condenser control for air-cooled condensers shall use variable setpoint control logic to reset the condens- ing temperature setpoint in response to ambient dry-bulb temperature.
   - 3.2. Refrigeration system condenser control for evaporatively cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient wet-bulb temperature.
4. Multiple fan condensers shall be controlled in unison.
5. The minimum condensing temperature setpoint shall be not greater than 70˚F (21˚C).

403.5.2 Compressor systems. Refrigeration compressor systems shall comply with the following:

1. Compressors and multiple-compressor system suction groups shall include control systems that use floating suction pressure control logic to reset the target suction pressure temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.

   Exception: Controls are not required for the following:

   1. Single-compressor systems that do not have variable capacity capability.
   2. Suction groups that have a design saturated suction temperature of 30˚F (-1.1˚C) or higher, suction groups that comprise the high stage of a two-stage or cascade system, or suction groups that primarily serve chillers for secondary cooling fluids.
2. Liquid subcooling shall be provided for all low-temperature compressor systems with a design cooling capacity equal to or greater than 100,000 Btu/hr (29.3 kW) with a design-saturated suction temperature of -10˚F (-23˚C) or lower. The sub-cooled liquid temperature shall be controlled at a maximum temperature setpoint of 50˚F (10˚C) at the exit of the subcooler using either compressor economizer (interstage) ports or a separate compres-

sor suction group operating at a saturated suction temperature of 18˚F (-7.8˚C) or higher.

2.1. Insulation for liquid lines with a fluid operating temperature less than 60˚F (15.6˚C) shall comply with Table 403.2.10.

3. Compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

SECTION 404
SERVICE WATER HEATING
(Mandatory)

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

404.1.1 Electrical water heating limitation. Individual electric service water heating units shall be limited to a maximum of 12 kW total power input.

Exception: Instantaneous electric water heaters used to serve emergency showers and emergency eye wash stations.

404.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table 404.2. The efficiency shall be verified through data furnished by the manufacturer of the equipment or through certification under an *approved* certification program. Water-heating equipment also intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

C404.2.1 High input-rated service water-heating sys- tems. Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water-heating equipment serves the entire building and the input rating of the equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, E_t, of not less than 90 percent. Where multiple pieces of water-heating equipment building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, the combined input-capacity-weighted-average thermal efficiency, *Et*, shall be not less than 90 percent.

Exceptions:

1. Where 25 percent of the annual *service water- heating* requirement is provided by site-solar or site-recovered energy, the minimum thermal effi- ciency requirements of this section shall not apply.
2. The input rating of water heaters installed in indi- vidual dwelling units shall not be required to be included in the total input rating of *service water- heating* equipment for a building.
3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of *service water-heating* equip- ment for a building.

404.3 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.

404.4 Insulation of piping. Piping from a water heater to the termination of the heated water fixture supply pipe shall be insulated in accordance with Table 403.2.10. On both the inlet and outlet piping of a storage water heater or heated water storage tank, the piping to a heat trap or the first 8 feet (2438 mm) of piping, whichever is less, shall be insulated. Piping that is heat traced shall be insulated in accordance with Table 403.2.10 or the heat trace manufacturer's instructions. Tubular pipe insulation shall be installed in accordance with the insulation manufacturer's instructions. Pipe insulation shall be continuous except where the piping passes through a framing member. The minimum insulation thickness requirements of this section shall not supersede any greater insulation thick- ness requirements necessary for the protection of piping from freezing temperatures or the protection of personnel against external surface temperatures on the insulation.

Exception: Tubular pipe insulation shall not be required on the following:

1. The tubing from the connection at the termination of the fixture supply piping to a plumbing fixture or plumbing appliance.
2. Valves, pumps, strainers and threaded unions in piping that is 1 inch (25 mm) or less in nominal diameter.
3. Piping from user-controlled shower and bath mixing valves to the water outlets.
4. Cold-water piping of a demand recirculation water system.
5. Tubing from a hot drinking-water heating unit to the water outlet.
6. Piping at locations where a vertical support of the piping is installed.
7. Piping surrounded by building insulation with a thermal resistance (*R*-value) of not less than R-3.

404.5 Efficient heated water supply piping. Heated water supply piping shall be in accordance with Section 404.5.1 or 404.5.2. The flow rate through 1/ -inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through 5/ -inch (7.9 mm) piping shall be not greater than 1 16 gpm (3.8 L/m). The flow rate through 3/ -inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m).

404.5.1 Maximum allowable pipe length method. The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table 404.5.1.

1. For a public lavatory faucet, use the "Public lavatory faucets" column in Table 404.5.1.
2. For all other plumbing fixtures and plumbing valves, within flexible water supply connectors to a fix appliances, use the "Other fixtures and appliances" column in Table 404.5.1.
3.

404.5.2 Maximum allowable pipe volume method. The water volume in the piping shall be calculated in accordance with Section 404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).

est source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table 404.5.1. The volume contained within fixture shutoff

2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

404.5.2.1 Water volume determination. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table 404.5.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

404.6 Heated-water circulating and temperature maintenance systems. Heated-water circulation systems shall be in accordance with Section 404.6.1. Heat trace temperature maintenance systems shall be in accordance with Section 404.6.2. Controls for hot water storage shall be in accordance with Section 404.6.3. Automatic controls, temperature sensors and pumps shall be *accessible*. Manual controls shall be *readily accessible*.

404.6.1 Circulation systems. Heated-water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermo-syphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water.

404.6.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1. Controls for such systems shall be able to automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy. Heat trace shall be arranged to be turned off automatically when there is no hot water demand.

404.6.3 Controls for hot water storage. The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

404.7 Demand recirculation controls. A water distribution system having one or more recirculation pumps that pump water from a heated-water supply pipe back to the heated-water source through a cold-water supply pipe shall be a *demand recirculation water system*. Pumps shall have controls that comply with both of the following:

1. The control shall start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance.
2. The control shall limit the temperature of the water entering the cold-water piping to 104°F (40°C).

404.8 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2. Potable water-side pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. For Group R occupancies, the efficiency of drain water heat recovery unit efficiency shall be in accordance with CSA B55.1.

404.9 Energy consumption of pools and permanent spas. (Mandatory). The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections 404.9.1 through 404.9.3.

C404.9.1 Heaters. The electric power to all heaters shall be controlled by a readily accessible on-off switch that is an integral part of the heater, mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the po wer to the heater. Gas- or LPG-fired heaters shall not be equipped with continuously burning ignition pilots.

404.9.2 Time switches. Time switches or other control methods that can automatically turn off and on heaters and pump motors according to a pre- set schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built-in time switches shall be in compliance with this section.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Pumps that operate solar-and waste-heat-recovery pool heating systems.

404.9.3 Covers. Outdoor heated pools and outdoor permanent spas shall be provided with a vapor retardant cover or other approved vapor retardant means. Hot tubs and spas capable of being heated to more than 90°F (32°C) shall be provided with a cover having a minimum insulation value of R-12.

Exception: Where more than 70 percent of the energy for heating computed over an operating season is from site-recovered energy such as from a heatpump or solar energy source, covers or other vapor retardant means shall not be required

C404.10 Energy consumption of portable spas (Mandatory). The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

TABLE 404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Water heaters, Electric	≤ 5 kW	Resistance	0.97 - 0.00132*V*, EF	DOE 10 CFR Part 430
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00132*V*, EF	DOE 10 CFR Part 430
Storage water heaters, Gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019*V*, 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 - 0.0019*V*, 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 - 0.0019*V*, 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 - 0.0019*V*, 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	AHRI 1160
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 $(h \cdot ft^2 \cdot °F)/Btu$	(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.

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.

TABLE C404.5.1

PIPING VOLUME AND MAXIMUM PIPING LENGTHS

NOMINAL PIPE SIZE (inches)	VOLUME (liquid ounces per foot length)	MAXIMUM PIPING LENGTH (feet)	
		Public lavatory faucets	Other fixtures and appliances
$^{1}/_{4}$	0.33	6	50
$^{5}/_{16}$	0.5	4	50
$^{3}/_{8}$	0.75	3	50
$^{1}/_{2}$	1.5	2	43
$^{5}/_{8}$	2	1	32
$^{3}/_{4}$	3	0.5	21
$^{7}/_{8}$	4	0.5	16
1	5	0.5	13
$1^{1}/_{4}$	8	0.5	8
$1^{1}/_{2}$	11	0.5	6
2 or larger	18	0.5	4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.

SECTION 405
ELECTRICAL POWER AND LIGHTING SYSTEMS
(Mandatory)

405.1 General (Mandatory). This section covers lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consuption.

Exception: Dwelling units within commercial buildings shall not be required to comply with Sections 405.2 through405.5 provided that not less than 75 percent of the lamps in permanently installed lighting fixtures or not less than 75 percent of the permanently installed lighting fixtures shall contain only high-efficacy lamps.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section 403.2.15 or 403.2.16.

405.2 Lighting controls (Mandatory). Lighting systems shall be provided with controls as required in Sections 405.2.1,405.2.2, 405.2.3, 405.2.4 and 405.2.5.

Exceptions: Lighting controls are not required for the fol- lowing:

1. Areas designated as security or emergency areas that are required to be continuously lighted.
2. Interior exit stairways, interior exit ramps and exit passageways.
3. Emergency egress lighting that is normally off.

405.2.1 Occupant sensor controls. Occupant *sensor controls* shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges.
5. Employee lunch and break rooms.
6. Private offices.
7. Restrooms.
8. Storage rooms.
9. Janitorial closets.
10. Locker rooms.
11. Other spaces 300 square feet (28 m^2) or less that are enclosed by floor-to-ceiling height partitions.
12. Warehouses

405.2.1.1 Occupant sensor control function. Occupant sensor controls in spaces other than warehouses specified in Section 405.2.1 shall comply with the following:

1. Automatically turn off lights within 30 minutes of all occupants leaving the space.
2. Be manual on or controlled to automatically turn the lighting on to not more than 50 percent power.

   Exception: Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.
3. Shall incorporate a *manual control* to allow occu- pants to turn lights off.

405.2.1.2 Occupant sensor control function in warehouses. In warehouses, the lighting in aisleways and open areas shall be controlled with occupant sen- sors that automatically reduce lighting power by not less than 50 percent when the areas are unoccupied. The occupant sensors shall control lighting in each aisleway independently and shall not control lighting beyond the aisleway being controlled by the sensor.

405.2.2 Time-switch controls. Each area of the building that is not provided with *occupant sensor controls* com- plying with Section 405.2.1.1 shall be provided with *time switch controls* complying with Section 405.2.2.1.

Exception: Where a *manual control* provides light reduction in accordance with Section 405.2.2.2, auto- matic controls shall not be required for the following:

1. *Sleeping units*.
2. Spaces where patient care is directly provided.
3. Spaces where an automatic shutoff would endan- ger occupant safety or security.
4. Lighting intended for continuous operation.
5. Shop and laboratory classrooms.

405.2.2.1 Time-switch control function. Each space provided with *time-switch controls* shall also be pro- vided with a *manual control* for light reduction in accordance with Section 405.2.2.2. Time-switch *con- trols* shall include an override switching device that complies with the following:

1. Have a minimum 7-day clock.
2. Be capable of being set for seven different day types per week
3. Incorporate an automatic holiday "shutoff" fea- ture, which turns off all controlled lighting loads for at least 24 hours and then resumes normally scheduled operations.
4. Have program backup capabilities, which prevent the loss of program and time settings for at least 10 hours, if power is

interrupted.

5. Include an override switch that complies with the following:
   5.1. The override switch shall be a manual control.
   5.2. The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.
   5.3. Any individual override switch shall control the lighting for an area not larger than 5,000 square feet (465 m^2).

Exceptions:

1. Within malls, arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas:
   1.1. The time limit shall be permitted to be greater than 2 hours, provided that the override switch is a captive key device.
   1.2. The area controlled by the override switch is permitted to be greater than 5,000 square feet (465 m^2), but shall not be greater than 20,000 square feet (1860 m^2).
2. Where provided with *manual control*, the following areas are not required to have light reduction control:
   2.1. Spaces that have only one luminaire with a rated power of less than 100 watts.
   2.2. Spaces that use less than 0.6 watts per square foot (6.5 W/m^2).

Corridors, equipment rooms, public lobbies, electrical or mechanical rooms.

405.2.2.2 Light reduction controls. Spaces required to have light-reduction controls shall have a manual control that allows the occupant to reduce the connected lighting load in a rea- sonably uniform illumination pattern by at least 50 per- cent. 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: Light reduction controls are not required in daylight zones with daylight responsive controls com- plying with Section 405.2.3

505.2.2.2 Automatic lighting shutoff. Buildings larger than 5,000 square feet (465 m^2) shall be equipped with an automatic control device to shut off lighting in those

C405.2.2.3 Manual controls. *Manual controls* for lights shall comply with the following:

1. Shall be readily accessible to occupants.
2. Shall be located where the controlled lights are visible, or shall identify the area served by the lights and indicate their status.

C405.2.3 Daylight-responsive controls. *Daylight-respon- sive controls* complying with Section C405.2.3.1 shall be provided to control the electric lights within *daylight zones* in the following spaces:

1. Spaces with a total of more than 150 watts of *gen- eral lighting* within sidelight *daylight zones* comply- ing with Section C405.2.3.2. *General lighting* does not include lighting that is required to have specific application control in accordance with Section C405.2.4.
2. Spaces with a total of more than 150 watts of *gen- eral lighting* within toplight *daylight zones* comply- ing with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific applica- tion control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 (Such as restaurants and banquet halls or buildings containing food preparation areas) and Group M (Mercantile, such as grocery stores, department stores, gas stations, etc.) occupancies.

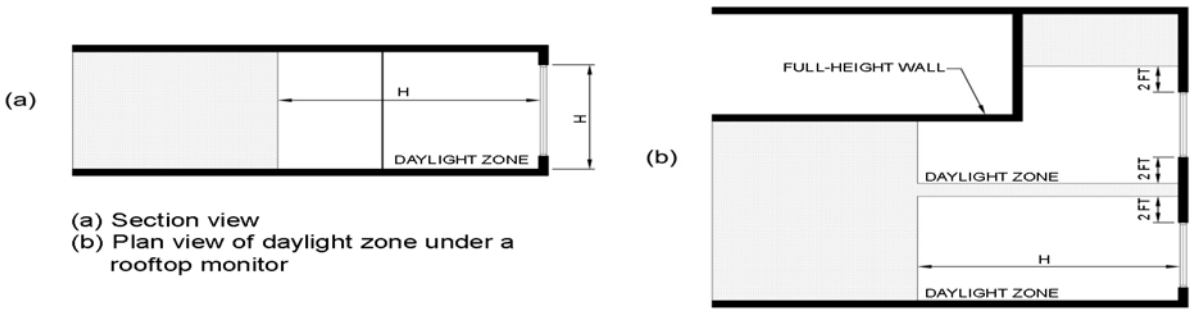
C405.2.3.1 Daylight-responsive control function. Where required, *daylight-responsive controls* shall be provided within each space for control of lights in that space and shall comply with all of the following:

1. Lights in toplight *daylight zones* in accordance with Section C405.2.3.3 shall be controlled inde- pendently of lights in sidelight *daylight zones* in accordance with Section C405.2.3.2.
2. Calibration mechanisms shall be r*eadily accessi- ble*.
3. Where located in offices, classrooms, laborato- ries and library reading rooms, *daylight respon- sive controls* shall dim lights continuously from full light output to 15 percent of full light output or lower.
4. *Daylight responsive controls* shall be capable of a complete shutoff of all controlled lights.
5. Lights in sidelight *daylight zones* in accordance with Section C405.2.3.2 facing different cardinal orientations [i.e., within 45 degrees (0.79 rad) of due north, east, south, west] shall be controlled independently of each other.

Exception: Up to 150 watts of lighting in each space is permitted to be controlled together with lighting in a daylight zone facing a different cardinal orientation.

C405.2.3.2 Sidelight daylight zone. The sidelight *day- light zone* is the floor area adjacent to vertical *fenestra- tion* which complies with all of the following:

1. Where the fenestration is located in a wall, the daylight zone shall extend laterally to the nearest full-height wall, or up to 1.0 times the height from the floor to the top of the fenestration, and longitudinally from the edge of the fenestration to the nearest full-height wall, or up to 2 feet (610 mm), whichever is less, as indicated in Figure C405.2.3.2(1).
2. Where the *fenestration* is located in a rooftop monitor, the *daylight zone* shall extend laterally to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 1.0 times the height from the floor to the bottom of the *fenes-*



(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

tration, whichever is less, and longitudinally from the edge of the *fenestration* to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.25 times the height from the floor to the bottom of the *fenestration*, whichever is less, as indicated in Figures C405.2.3.2(2) and C405.2.3.2(3).

3. The area of the *fenestration* is not less than 24 square feet (2.23 m^2).
4. The distance from the *fenestration* to any building or geological formation which would block access to daylight is greater than the height from the bottom of the *fenestration* to the top of the building or geologic formation.
5. Where located in existing buildings, the *visible transmittance* of the *fenestration* is not less than 0.20.

405.2.3.3 Toplight daylight zone. The toplight *daylight zone* is the floor area underneath a roof fenestration assembly which complies with all of the following:

1. The *daylight zone* shall extend laterally and longitudinally beyond the edge of the roof *fenestration* assembly to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.7 times the ceiling height, whichever is less, as indicated in Figure C405.2.3.3.
2. No building or geological formation blocks direct sunlight from hitting the roof *fenestration* assembly at the peak solar angle on the summer solstice.
3. Where located in existing buildings, the product of the *visible transmittance* of the roof *fenestration* assembly and the area of the rough opening of the roof *fenestration* assembly divided by the area of the *daylight zone* is not less than 0.008.

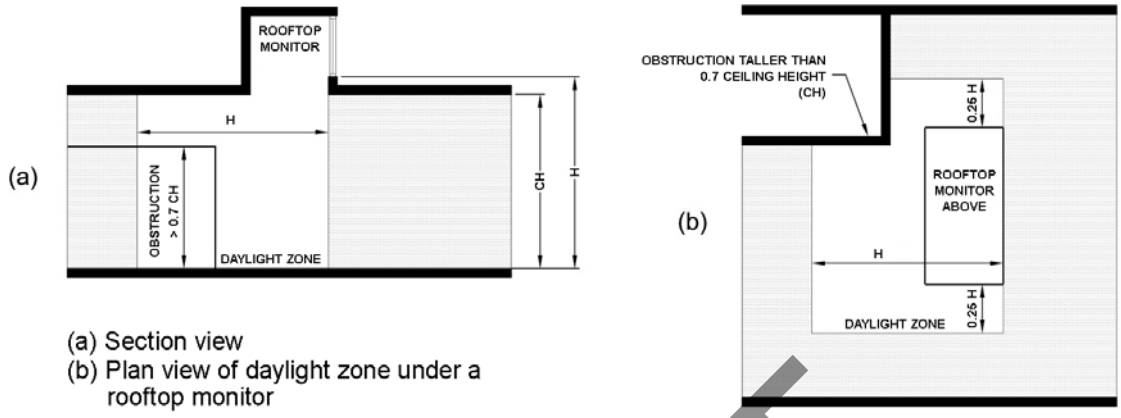


FIGURE C405.2.3.2(2)
DAYLIGHT ZONE UNDER A ROOFTOP MONITOR

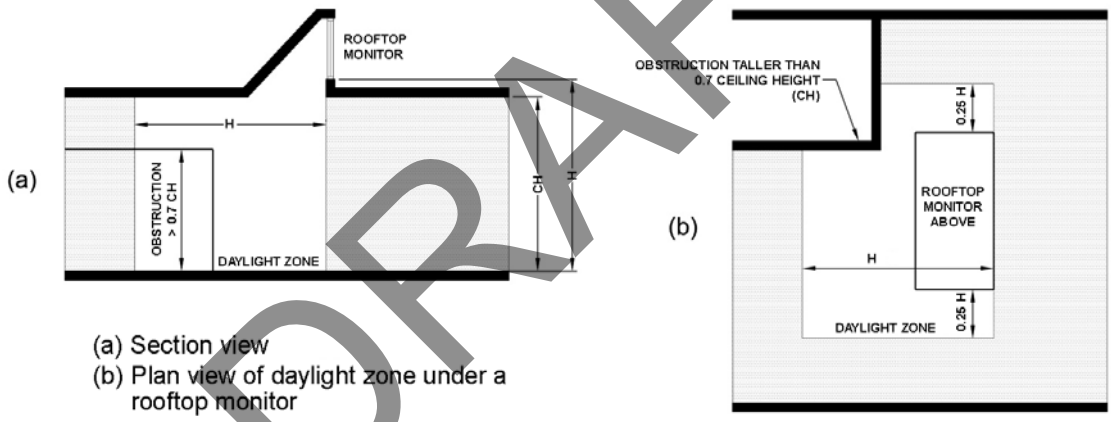
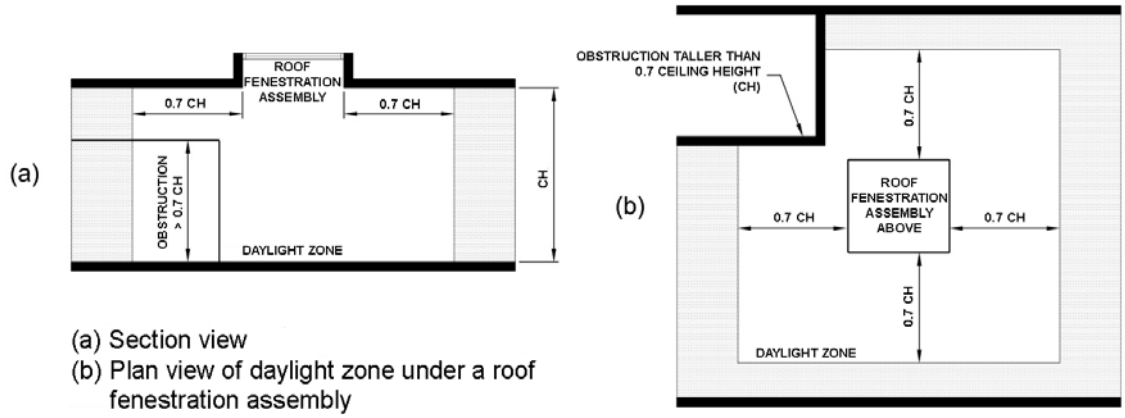


FIGURE C405.2.3.2(3)



(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly

FIGURE C405.2.3.3
DAYLIGHT ZONE UNDER A ROOF FENESTRATION ASSEMBLY

405.2.4 Specific application controls. Specific application controls shall be provided for the following:

1. Display and accent light shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.
2. Lighting in cases used for display case purposes shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.
3. Hotel and motel sleeping units and guest suites shall have a master control device that is capable of auto- matically switching off all installed luminaires and switched receptacles within 20 minutes after all occupants leave the room.

Exception: Lighting and switched receptacles controlled by captive key systems.

4. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting, shall have a control device integral to the luminaires or be controlled by a wall-mounted control device pro- vided that the control device is readily accessible.
5. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.
6. Lighting equipment that is for sale or for demonstrations in lighting education shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.

405.2.5 Exterior lighting controls. Lighting for exterior applications other than emergency lighting that is intended to be automatically off during building operation, lighting specifically required to meet health and life safety require- ments or decorative gas lighting systems shall:

1. Be provided with a control that automatically turns off the lighting as a function of available daylight.
2. Where lighting the building façade or landscape, the lighting shall have controls that automatically shut off the lighting as a function of dawn/dusk and a set opening and closing time.
3. Where not covered in Item 2, the lighting shall have controls configured to automatically reduce the con- nected lighting power by not less than 30 percent from not later than midnight to 6 a.m., from one hour after business closing to one hour before business opening or during any period when activity has not been detected for a time of longer than 15 minutes.

All time switches shall be able to retain programming and the time setting during loss of power for a period of at least 10 hours.

Exception: Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security or eye adaptation.

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

405.4 Interior lighting power requirements (Prescriptive). A building complies with this section if its total connected lighting power calculated under Section 405.4.1 is no greater than the interior lighting power calculated under Section 405.4.2.

405.4.1 Total connected interior lighting power. The total connected interior lighting power shall determine in accordance with Equation 4-9.

$$TCLP = [SL + LV + LTPB + \text{Other}] \quad \textbf{(Equation 4-9)}$$

where:

TCLP = Total connected lighting power (watts).

SL = Labeled wattage of luminaires for screw-in lamps.

LV = Wattage of the transformer supplying low- voltage lighting.

LTPB = Wattage of line-voltage lighting tracks and plug- in busways as the specified wattage of the

luminaires, but at least 30 W/lin. ft. (100 W/lin m), or the wattage limit of the system's circuit breaker, or the wattage limit of other permanent current-limiting devices on the system.

Other = The wattage of all other luminaires and lighting sources not covered previously and associated with interior lighting verified by data supplied by the manufacturer or other *approved* sources

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. lighting in *Sleeping units* providing the lighting complies with RBES section 404.1
   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.
   1.7. Mirror lighting in dressing rooms.
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.
15. Exit signs

405.4.2 Interior lighting power. The total interior lighting power allowance (watts) is determined according to Table405.4.2(1) using the Building Area Method, or Table
405.4.2(2) using the Space-by-Space Method, for all areas in the building covered in this permit.

405.4.2.1 Building Area Method, For the Building Area Method, the interior lighting power allowance is the floor area for each building area type listed in Table 405.4.2(1) times the value from Table 405.4.2(1) 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 405.4.2(1). 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.

405.4.2.2 Space-by-Space Method, For the Space by Space Method, the interior lighting power allowance shall be determined by multiplying the floor area of each space times the value for the space type in Table 405.4.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Trade-offs among spaces within the building are permitted.

405.4.2.2.1 Additional interior lighting power. Where using the Space-by-Space Method, an increase in the interior lighting power allowance is permitted for specific lighting functions. Additional power shall be permitted only where the specified lighting is installed and automatically controlled separately from the general lighting, to be turned off during nonbusiness hours. This additional power shall be used only for the specified luminaires and shall not be used for any other purpose. An increase in the interior lighting power allowance is permitted in the following cases

1. For lighting equipment to be installed in sales areas specifically to highlight merchandise, the additional lighting power shall be determined in accordance with Equation 4-10.

   Additional interior lighting power allowance = 500 watts + (Retail Area 1 · 0.6 W/ft^2) + (Retail Area 2 · 0.6 W/ft^2) + (Retail Area 3 · 1.4 W/ft^2) + (Retail Area 4 · 2.5 W/ft^2)

   (Equation 4-10)

10. Lighting demonstration equipment in lighting education facilities.

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, provided that justification documenting the need for additional lighting power based on visual inspection, contrast or other critical display is approved by the code official or authority having jurisdiction.

2. For spaces in which lighting is specified to be installed in addition to the general lighting for the purpose of decorative appearance or for highlighting art or exhibits, provided that the additional lighting power shall be not more than 10.7 w/ft2 of such spaces.

TABLE 505.5.2(1)
INTERIOR LIGHTING POWER ALLOWANCES
BUILDING AREA METHOD

LIGHTING POWER DENSITY	
Building Area Type	**LPD (W/ft^2)**
Automotive Facility	0.80
Convention Center	1.01
Court House	1.01
Dining: Bar Lounge/Leisure	1.01
Dining: Cafeteria/Fast Food	0.90
Dining: Family	0.95
Dormitory	0.57
Exercise Center	0.84
Fire Station	0.67
Gymnasium	0.94
Healthcare—clinic	0.90
Hospital	1.05
Hotel/Motel	0.87
Library	1.19
Manufacturing Facility	1.17
Motion Picture Theater	0.76
Multifamily	0.51
Museum	1.02
Office	0.82
Parking Garage	0.21
Penitentiary	0.81
Performing Arts Theater	1.39
Police Station	0.87
Post Office	0.87
Religious Building	1.0
Retail	1.26
School/University	0.87
Sports Arena	0.91
Town Hall	0.89
Transportation	0.70
Warehouse	0.60
Workshop	1.19

TABLE C405.4.2(2)

INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/sq.ft)
Atrium	
Less than 40 feet in height	0.03 per foot in total height
Greater than 40 feet in height	0.40 + 0.02 per foot in total height
Audience seating area	
In an auditorium	0.63
In a convention center	0.82
In a gymnasium	0.65
In a motion picture theater	1.14
In a penitentiary	0.28
In a performing arts theater	2.43
In a religious building	1.53
In a sports arena	0.43
Otherwise	0.43
Banking activity area	1.01
Breakroom (See Lounge/Breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	1.34
Otherwise	1.24
Conference/meeting/multipurpose room	1.23
Copy/print room	0.72
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.92
In a hospital	0.79
In a manufacturing facility	0.41
Otherwise	0.66
Courtroom	1.72
Computer room	1.71
Dining area	
In a penitentiary	0.96
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.90
In bar/lounge or leisure dining	1.07
In cafeteria or fast food dining	0.65
In family dining	0.89
Otherwise	0.65
Electrical/mechanical room	0.95
Emergency vehicle garage	0.56

(continued)

TABLE C405.4.2(2)—continued INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/sq.ft)
Food preparation area	1.21
Guest room	0.47
Laboratory	
In or as a classroom	1.43
Otherwise	1.81
Laundry/washing area	0.60
Loading dock, interior	0.47
Lobby	
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.80
For an elevator	0.64
In a hotel	1.06
In a motion picture theater	0.59
In a performing arts theater	2.00
Otherwise	0.90
Locker room	0.75
Lounge/breakroom	
In a healthcare facility	0.92
Otherwise	0.73
Office	
Enclosed	1.11
Open plan	0.98
Parking area, interior	0.19
Pharmacy area	1.68
Restroom	
In a facility for the visually impaired (and not used primarily by the staff[b]	1.21
Otherwise	0.98
Sales area	1.59
Seating area, general	0.54
Stairway (See space containing stairway)	
Stairwell	0.69
Storage room	0.63
Vehicular maintenance area	0.67
Workshop	1.59
BUILDING TYPE SPECIFIC SPACE TYPES[a]	**LPD (watts/sq.ft)**
Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	2.21
In a recreation room (and not used primarily by the staff)	2.41
Automotive (See Vehicular Maintenance Area above)	
Convention Center—exhibit space	1.45
Dormitory—living quarters	0.38
Fire Station—sleeping quarters	0.22
Gymnasium/fitness center	
In an exercise area	0.72
In a playing area	1.20

(continued)

TABLE C405.4.2(2)—continued INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD (watts/sq.ft)
healthcare facility	
In an exam/treatment room	1.66
In an imaging room	1.51
In a medical supply room	0.74
In a nursery	0.88
In a nurse's station	0.71
In an operating room	2.48
In a patient room	0.62
In a physical therapy room	0.91
In a recovery room	1.15
Library	
In a reading area	1.06
In the stacks	1.71
Manufacturing facility	
In a detailed manufacturing area	1.29
In an equipment room	0.74
In an extra high bay area (greater than 50′ floor-to-ceiling height)	1.05
In a high bay area (25-50′ floor-to-ceiling height)	1.23
In a low bay area (less than 25' floor-to-ceiling height)	1.19
Museum	
In a general exhibition area	1.05
In a restoration room	1.02
Performing arts theater—dressing room	0.61
Post Office—Sorting Area	0.94
Religious buildings	
In a fellowship hall	0.64
In a worship/pulpit/choir area	1.53
Retail facilities	
In a dressing/fitting room	0.71
In a mall concourse	1.10
Sports arena—playing area	
For a Class I facility	3.00
For a Class II facility	1.90
For a Class III facility	1.20
For a Class IV facility	0.70
Transportation facility	
In a baggage/carousel area	0.53
In an airport concourse	0.36
At a terminal ticket counter	0.80
Warehouse—storage area	
For medium to bulky, palletized items	0.58
For smaller, hand-carried items	0.95

a. In cases where both a common space type and a building area specific space type are listed, the building area specific space type shall apply

A 'Facility for the Visually Impaired' is a facility that is licensed or will be licensed by local or state authorities for senior long-term care, adult daycare, senior support or people with special visual needs

a.

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 405.5.1 and405.5.2. Appropriate exterior lighting designs including maximum exterior illuminance levels may be required by the District Environmental Commission for Act 250 projects.

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

405.5.1 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 405.5.2(2) for the applicable lighting *zone*. Tradeoffs are allowed only among exterior lighting applications listed in Table 405.5.2(2), Tradable Surfaces section. The lighting zone for the building exterior is determined from Table 405.5.2(1) unless otherwise specified by the local jurisdiction.

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;
9. Used to highlight features of public monuments and registered historic landmark structures or buildings.

TABLE 405.5.2(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 or commercial business areas, or residential mixed use areas
3	All other areas not classified as lighting zone 1, 2 or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

405.5.2 Exterior Fixtures. Exterior lighting shall be full cut off fixtures, limiting the light output to less than 10% at and below 10 degrees below the horizontal. Fixtures shall be independently certified by manufacturer as full cut-off, or meet the definition of a fully shielded light fixture.

405.6 Electrical energy consumption. (Mandatory). Each dwelling unit located in a Group R-2 building (see occupancy classification) shall have a separate electrical meter

.

C405.7 Electrical transformers (Mandatory). Electric transformers shall meet the minimum efficiency requirements of Table C405.7 as tested and rated in accordance with the test procedure listed in DOE 10 CFR 431. The efficiency shall be verified through certification under an approved cer- tification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the transformer manufacturer.

Exceptions: The following transformers are exempt:

1. Transformers that meet the Energy Policy Act of 2005 exclusions based on the DOE 10 CFR 431 definition of special purpose applications.
2. Transformers that meet the Energy Policy Act of 2005 exclusions that are not to be used in general purpose applications based on information pro- vided in DOE 10 CFR 431.
3. Transformers that meet the Energy Policy Act of 2005 exclusions with multiple voltage taps where the highest tap is at least 20 percent more than the lowest tap.
4. Drive transformers.
5. Rectifier transformers.
6. Auto-transformers.
7. Uninterruptible power system transformers.
8. Impendance transformers.
9. Regulating transformers.
10. Sealed and nonventilating transformers.
11. Machine tool transformers.
12. Welding transformers.
13. Grounding transformers.

14. Testing transformers.

TABLE 405.6.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.)		500 W	600 W	750 W	1300 W
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**Uncovered Parking Areas**				
	Parking areas and drives	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.2 W/ft^2
	Stairways	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
	Pedestrian tunnels	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2
	Building Entrances and Exits				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
	Sales Canopies				
	Free-standing and attached	0.6 W/ft^2	0.6 W/ft^2	0.8 W/ft^2	1.0 W/ft^2
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ft^2	0.25 W/ft^2	0.5 W/ft^2	0.7 W/ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.075 W/ft^2 of gross above-grafe all area.	0.113 W/ft^2 of gross above-grade wall.	0.15 W/ft^2 of gross above-grade wall area.
	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area
	Drive-up windows/doors	400 W per drive-through	400 W per drive-through	400 W per drive-through	400 W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

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

405.8 Electric motors (Mandatory). Electric motors shall comply with the requirements of Tables 405.8(1) through 405.8(4). The efficiency shall be ver-ified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data fur- nished by the motor manufacturer.

405.9 Vertical and horizontal transportation systems and equipment. Vertical and horizontal transportation sys- tems and equipment shall comply with this section.

405.9.1 Elevator cabs. For the luminaires in each elevator cab, not including signals and displays, the sum of the lumens divided by the sum of the watts shall be not less than 35 lumens per watt. Ventilation fans in elevators that do not have their own air-conditioning system shall not con- sume more than 0.33 watts/cfm at the maximum rated speed of the fan. Controls shall be provided that will de-energize ventilation fans and lighting systems when the elevator is stopped, unoccupied and with its doors closed for over 15 minutes.

405.9.2 Escalators and moving walks. Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have automatic controls configured to reduce speed to the minimum permitted speed in accordance with ASME A17.1/CSA B44 or applicable local code when not conveying passengers.

405.9.2.1 Regenerative drive. An escalator designed either for one-way down operation only or for revers- ible operation shall have a variable frequency regenera- tive drive that supplies electrical energy to the building electrical system when the escalator is loaded with pas- sengers whose combined weight exceeds 750 pounds (340 kg).

TABLE 405.7
MINIMUM NOMINAL EFFICIENCY LEVELS FOR 10 CFR 431 LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

SINGLE-PHASE TRANSFORMERS		THREE-PHASE TRANSFORMERS	
kVA[a]	Efficiency (%)[b]	kVA[a]	Efficiency (%)[b]
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
		750	98.8
		1000	98.9

a. kiloVolt-Amp rating.

b. Nominal efficiencies shall be established in accordance with the DOE 10 CFR 431 test procedure for low-voltage dry-type transformers.

TABLE 405.8(1)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR 60 HZ NEMA GENERAL PURPOSE ELECTRIC MOTORS (SUBTYPE I) RATED 600 VOLTS OR LESS (Random Wound)[a]

MOTOR HORSEPOWER	NUMBER OF POLES	OPEN DRIP-PROOF MOTORS			TOTALLY ENCLOSED FAN-COOLED MOTORS		
		2	4	6	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200	3600	1800	1200
1		77.0	85.5	82.5	77.0	85.5	82.5

1.5		84.0	86.5	86.5	84.0	86.5	87.5
2		85.5	86.5	87.5	85.5	86.5	88.5
3		85.5	89.5	88.5	86.5	89.5	89.5
5		86.5	89.5	89.5	88.5	89.5	89.5
7.5		88.5	91.0	90.2	89.5	91.7	91.0
10		89.5	91.7	91.7	90.2	91.7	91.0
15		90.2	93.0	91.7	91.0	92.4	91.7
20		91.0	93.0	92.4	91.0	93.0	91.7
25		91.7	93.6	93.0	91.7	93.6	93.0
30		91.7	94.1	93.6	91.7	93.6	93.0
40		92.4	94.1	94.1	92.4	94.1	94.1
50		93.0	94.5	94.1	93.0	94.5	94.1
60		93.6	95.0	94.5	93.6	95.0	94.5
75		93.6	95.0	94.5	93.6	95.4	94.5
100		93.6	95.4	95.0	94.1	95.4	95.0
125		94.1	95.4	95.0	95.0	95.4	95.0
150		94.1	95.8	95.4	95.0	95.8	95.8
200		95.0	95.8	95.4	95.4	96.2	95.8
250		95.0	95.8	95.4	95.8	96.2	95.8
300		95.4	95.8	95.4	95.8	96.2	95.8
350		95.4	95.8	95.4	95.8	96.2	95.8
400		95.8	95.8	95.8	95.8	96.2	95.8
450		95.8	96.2	96.2	95.8	96.2	95.8
500		95.8	96.2	96.2	95.8	96.2	95.8

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

TABLE 405.8(2)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY OF
GENERAL PURPOSE ELECTRIC MOTORS (SUBTYPE II) AND ALL DESIGN B MOTORS GREATER THAN 200 HORSEPOWER[a]

MOTOR HORSEPOWER	NUMBER OF POLES	OPEN DRIP-PROOF MOTORS				TOTALLY ENCLOSED FAN-COOLED MOTORS			
		2	4	6	8	2	4	6	8
	Synchronous Speed (RPM)	3600	1800	1200	900	3600	1800	1200	900
1		NR	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1.5		82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2		84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3		84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
5		85.5	87.5	87.5	87.5	87.5	87.5	87.5	84.0
7.5		87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10		88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15		89.5	91.0	90.2	89.5	90.2	91.0	90.2	88.5
20		90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
25		91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
30		91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
40		91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0
50		92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
60		93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
75		93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
100		93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0

125		93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150		93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
200		94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
250		94.5	95.4	95.4	94.5	95.4	95.0	95.0	94.5
300		95.0	95.4	95.4	NR	95.4	95.4	95.0	NR
350		95.0	95.4	95.4	NR	95.4	95.4	95.0	NR
400		95.4	95.4	NR	NR	95.4	95.4	NR	NR
450		95.8	95.8	NR	NR	95.4	95.4	NR	NR
500		95.8	95.8	NR	NR	95.4	95.8	NR	NR

NR = No requirement.
a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

TABLE 405.8(3)
MINIMUM AVERAGE FULL LOAD EFICIENCY POLYPHASE SMALL ELECTRIC MOTORS[a]

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25		65.6	69.5	67.5
0.33		69.5	73.4	71.4
0.50		73.4	78.2	75.3
0.75		76.8	81.1	81.7
1		77.0	83.5	82.5
1.5		84.0	86.5	83.8
2		85.5	86.5	N/A
3		85.5	86.9	N/A

a. Average full load efficiencies shall be established in accordance with 10 CFR 431.

TABLE 405.8(4)
MINIMUM AVERAGE FULL LOAD EFFICIENCY FOR
CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS[a]

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25		66.6	68.5	62.2
0.33		70.5	72.4	66.6
0.50		72.4	76.2	76.2
0.75		76.2	81.8	80.2
1		80.4	82.6	81.1
1.5		81.5	83.8	N/A
2		82.9	84.5	N/A
3		84.1	N/A	N/A

a. Average full load efficiencies shall be established in accordance with 10 CFR 431.

SECTION 406
ADDITIONAL EFFICIENCY PACKAGE OPTIONS AND RENEWABLE REQUIREMENTS

406.1 Additional efficiency package requirements. Buildings shall comply with at least one of the following:

1. More efficient HVAC performance in accordance with Section 406.2.
2. Reduced lighting power density system in accordance with Section 406.3.
3. Enhanced lighting controls in accordance with Section 406.4.
4. On-site supply of renewable energy in accordance with Section 406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section 406.7.

b. **406.1.1 Renewable energy requirements.** Buildings with *footprint* greater than 20,000 square feet must install on-site renewable generation (or mandatory solar?) ADD CRITERIA FOR MINIMUM PRODUCTION

Buildings with footprint under 20,000 square feet that do not choose to comply with Section C406.5 as the mandatory additional efficiency package must comply with Section 406.1.1 for renewable-ready energy systems.

C406.1.2 Tenant spaces. Tenant spaces shall comply with Section 406.2, 406.3, 406.4, 406.6 or 406.7. Alter- natively, tenant spaces shall comply with Section 406.5 where the entire building is in compliance.

C406.2 More efficient HVAC equipment performance. Equipment shall exceed the minimum efficiency require- ments listed in Tables 403.2.3(1) through 403.2.3(7) by 10 percent, in addition to the requirements of Section 403. Where multiple performance requirements are provided, the equipment shall exceed all requirements by 10 percent. *Vari- able refrigerant flow systems* shall exceed the energy effi- ciency provisions of ANSI/ASHRAE/IES 90.1-2013 by 10 percent. Equipment not listed in Tables 403.2.3(1) through 403.2.3(7) shall be limited to 10 percent of the total build- ing system capacity.

406.3 Reduced lighting power density. The total interior lighting power (watts) of the building shall be determined by using 90 percent of the lighting power values specified in Table 405.4.2(1) times the floor area for the building types, or by using 90 percent of the interior lighting power allow- ance calculated by the Space-by-Space Method in Section 405.4.2.

406.4 Enhanced digital lighting controls. Interior lighting in the building shall have the following enhanced lighting controls that shall be located, scheduled and operated in accordance with Section 405.2.2.

1. Luminaires shall be capable of continuous dimming.
2. Luminaires shall be capable of being addressed individ- ually. Where individual addressability is not available for the luminaire class type, a controlled group of not more than four luminaries shall be allowed.
3. Not more than eight luminaires shall be controlled together in a *daylight zone*.
4. Fixtures shall be controlled through a digital control system that includes the following function:
   - 4.1. Control reconfiguration based on digital addressability.
   - 4.2. Load shedding.
   - 4.3. Individual user control of overhead general illumination in open offices.
   - 4.4. Occupancy sensors shall be capable of being reconfigured through the digital control system.
5. Construction documents shall include submittal of a Sequence of Operations, including a specification out- lining each of the functions in Item 4 of this section.
6. Functional testing of lighting controls shall comply with Section 408.

406.5 On-site renewable energy. Total minimum ratings of on-site renewable energy systems shall comply with one of the following:

1. Provide not less than 0.50 watts per square foot (5.4 W/ m^2) of conditioned floor area.
2. Provide not less than 3 percent of the energy used within the building for building mechanical and service water heating equipment and lighting regulated in Chapter 4.

406.6 Dedicated outdoor air system. Buildings covered by Section 403.4 shall be equipped with an independent ventilation system designed to provide not less than the mini- mum 100-percent outdoor air to each individual occupied space, as specified by the *ASHRAE Standard 62.1-2013*. The ventilation system shall be capable of total energy recov- ery. The HVAC system shall include supply-air temperature controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperatures. The controls shall reset the supply-air tempera- ture at least 25 percent of the difference between the design supply-air temperature and the design room-air temperature.

406.7 Reduced energy use in service water heating. Buildings shall be of the following types to use this compli- ance method:

1. Group R-1: Boarding houses, hotels or motels.

2. Group I-2: Hospitals, psychiatric hospitals and nursing homes.
3. Group A-2: Restaurants and banquet halls or buildings containing food preparation areas.
4. Group F: Laundries.
5. Group R-2: Buildings with residential occupancies.
6. Group A-3: Health clubs and spas.
7. Buildings showing a service hot water load of 10 per- cent or more of total building energy loads.

406.7.1 Load fraction. The building service water-heat- ing system shall have one or more of the following that are sized to provide not less than 60 percent of hot water requirements, or sized to provide 100 percent of hot water requirements if the building shall otherwise comply with Section 403.4.7:

1. Waste heat recovery from service hot water, heat- recovery chillers, building equipment, process equipment, or a combined heat and power system.
2. Solar water-heating systems.

SECTION 407 SYSTEM COMMISSIONING

407.1 General. New buildings of 50,000 gross square feet of conditioned space or greater shall meet the provisions of Sections
C408.2 through C408.4.

407.2 Qualifications. The scope required by Section C407.3 shall be completed by the project commissioning authority. The commissioning authority shall:

1. Have experience as a commissioning authority on at least (3) previous projects each at least 20,000 square feet or greater, and
2. Be an independent third party entity. The commissioning authority shall not be an employee of the design team, construction team, owner or developer.

407.3 Equipment performance verification testing. Equipment performance verification testing shall demonstrate the correct installation and operation of power consumption of systems in accordance with the energy performance criteria noted in Section 407.3.1.

407.3.1 Equipment requiring performance verification.

1. Economizers (Section 403.3)
2. Variable Air Volume (VAV) fan control (Section 403.4.1)
3. Part Load Hydronic Controls (Section 403.4.2.4)
4. Lighting control systems (405.2)

407.3.2 Mechanical system performance verification requirements. The scope of performance verification testing shall test and record the following:

A. Economizers (Section 403.3)

1. Method of economizer control
2. Economizer setpoints
3. Economizer operates in full 100 percent outside air mode when enabled.
4. Economizer operates with additional mechanical cooling when 100 percent outside air mode is active.
5. When economizer is disabled, outside air dampers revert to minimum outside air mode that pro- vides for the minimum amount of outside air necessary.

B. Variable Air Volume (VAV) fan control (Section 403.4.1) and Part Load Hydronic Controls (Section 403.4.2.4)

1. Power input (watts or kW) when system operates in full load mode
2. Power input (watts or kW) when system operates at 50 percent of design air or water flow

2.1. Verify that power input at 50 percent of design air or water flow is no greater than 30 percent of the full load power input

2.2. The 50 percent of design flow test in B.2.2.1 shall be conducted with actual reduced flow and flow measured by:

2.2.1. Hydronic flow measurement devices such as balance valves, venturi metering devices equipped with test ports or permanent or temporary calibrated electronic flow measurement devices.

2.2.2. Airflow measurement devices such as portable direct air flow measurement (pitot tubes) or permanent calibrated electronic flow measurement station devices or summation of terminal unit air flow measurement or by fan curve extrapolation based on measured fan speed and pressures.

2.2.3. Reducing the fan or pump speed or pressure control setpoint using only manual overrides for purposes of conducting the 50 percent flow performance verification is prohibited.

2.2.4. Visually inspect and verify the pressure control device is installed in a location in accordance with Sections 403.4.1 and 403.4.3.

2.2.5. Where air systems utilizing a duct static pressure control device, verify the static pressure control setpoint is reset in accordance with Section 403.4.1.

2.2.6. Power input units shall only be kW or watt engineering units. Amperage alone is not an acceptable unit.

2.2.7. Power input shall be permitted to be

determined using kW display read- out where variable speed drives are utilized.

407.3.3 Lighting system functional testing. Controls for automatic lighting systems shall comply with this section.

407.3.3.1 Functional testing. Prior to passing final inspection, the commissioning authority shall provide evidence that the lighting control systems have been tested to ensure that control hardware and software are calibrated, adjusted, programmed and in proper working con- dition in accordance with the *construction documents* and manufacturer's instructions. Functional testing shall be in accordance with Sections 407.3.4.1.1 and 407.3.4.1.2 for the applicable control type.

407.3.3.1.1 Occupant sensor controls. Where *occupant sensor controls* are provided, the following procedures shall be performed:

1. Certify that the *occupant sensor* has been located and aimed in accordance with manufacturer recommendations.
2. For projects with seven or fewer *occupant sensors,* each sensor shall be tested.
3. For projects with more than seven *occupant sensors*, testing shall be done for each unique combi- nation of sensor type and space geometry. Where multiples of each unique combination of sensor type and space geometry are provided, not less than 10 percent, but in no case less than one, of each combination shall be tested unless the *code officialcode official or authority having jurisdiction* or design professional requires a higher percentage to be tested. Where 30 percent or more of the tested controls fail, all remaining identical combinations shall be tested.

For *occupant sensor controls* to be tested, verify the following:

3.1. Where *occupant sensor controls* include status indicators, verify correct operation.

3.2. The controlled lights turn off or down to the permitted level within the required time.

3.3. For auto-on *occupant sensor controls*, the lights turn on to the permitted level when an occupant enters the space.

3.4. For manual-on *occupant sensor controls*, the lights turn on only when manually activated.

3.5. The lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

407.3.3.1.2 Time-switch controls. Where t*ime-switch controls* are provided, the following procedures shall be performed:

1. Confirm that the *time-switch control* is programmed with accurate weekday, weekend and holiday schedules.
2. Provide documentation to the owner of *time-switch controls* programming including weekday, weekend, holiday schedules, and set-up and pref- erence program settings.
3. Verify the correct time and date in the time switch.
4. Verify that any battery back-up is installed and energized.
5. Verify that the override time limit is set to not more than 2 hours.
6. Simulate occupied condition. Verify and document the following:

6.1. All lights can be turned on and off by their respective area control switch.

6.2. The switch only operates lighting in the enclosed space in which the switch is located.

7. Simulate unoccupied condition. Verify and document the following:

7.1. Nonexempt lighting turns off.

407.3.4 Acceptance and Documentation. The commissioning authority shall submit completed, dated and signed performance verification test documents certifying the performance verification process has been successfully completed and the applicable system performance conforms to this energy code, prior to occupancy.

407.4 Lighting system functional testing. Controls for automatic lighting systems shall comply with this section.

407.4.1 Functional testing. Prior to passing final inspection, the *registered design professional* shall pro- vide evidence that the lighting control systems have been tested to ensure that control hardware and software are cal- ibrated, adjusted, programmed and in proper working con- dition in accordance with the *construction documents* and manufacturer's instructions. Functional testing shall be in accordance with Sections 407.3.1.1 and 407.3.1.2 for the applicable control type.

407.4.1.1 Occupant sensor controls. Where *occupant sensor controls* are provided, the following proce- dures shall be performed:

1. Certify that the *occupant sensor* has been located and aimed in accordance with manufacturer rec- ommendations.
2. For projects with seven or fewer occupant sensors, each sensor shall be tested. For projects with more than seven *occupant sen- sors*, testing shall be done for each unique combi- nation of sensor type and space geometry. Where multiples of each unique combination of sensor type and

space geometry are provided, not less than 10 percent, but in no case less than one, of each combination shall be tested unless the *code officialcode official or authority having jurisdiction* or design professional requires a higher percentage to be tested. Where 30 percent or more of the tested controls fail, all remaining identical combinations shall be tested.

For *occupant sensor controls* to be tested, verify the following:

2.1. Where *occupant sensor controls* include status indicators, verify correct operation.

2.2. The controlled lights turn off or down to the permitted level within the required time.

2.3. For auto-on *occupant sensor controls*, the lights turn on to the permitted level when an occupant enters the space.

2.4. For manual-on *occupant sensor controls*, the lights turn on only when manually acti- vated.

2.5. The lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

407.4.1.2 Time-switch controls. Where t*ime-switch controls* are provided, the following procedures shall be performed:

1. Confirm that the *time-switch control* is programmed with accurate weekday, weekend and holiday schedules.
2. Provide documentation to the owner of *time-switch controls* programming including weekday, weekend, holiday schedules, and set-up and pref- erence program settings.
3. Verify the correct time and date in the time switch.
4. Verify that any battery back-up is installed and energized.
5. Verify that the override time limit is set to not more than 2 hours.
6. Simulate occupied condition. Verify and document the following:

   6.1. All lights can be turned on and off by their respective area control switch.

   6.2. The switch only operates lighting in the enclosed space in which the switch is located.

7. Simulate unoccupied condition. Verify and document the following:

   7.1. Nonexempt lighting turns off.

   7.2. Manual override switch allows only the lights in the enclosed space where the over- ride switch is located to turn on or remain on until the next scheduled shutoff occurs.

8. Additional testing as specified by the *registered design professional*.

407.4.1.3 Daylight responsive controls. Where *daylight responsive controls* are provided, the following shall be verified:

1. Control devices have been properly located, field calibrated and set for accurate setpoints and threshold light levels.
2. Daylight controlled lighting loads adjust to light level set points in response to available daylight.
3. The locations of calibration adjustment equip- ment are readily accessible only to authorized personnel.

CHAPTER 5 CE

EXISTING BUILDINGS

SECTION 501 GENERAL

501.1 Scope. The provisions of this chapter shall control the *alteration*, *repair*, *addition* and *change of occupancy* of existing buildings and structures.

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

501.3 Maintenance. Buildings and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems that are required by this code shall be maintained in conformance to the code edition under which installed. The owner or the owner's authorized agent shall be responsible for the maintenance of buildings and structures. The requirements of this chapter shall not provide the basis for removal or abrogation of energy conservation, fire protec- tion and safety systems and devices in existing structures.

501.4 Compliance. *Alterations*, *repairs*, *additions* and changes of occupancy to, or relocation of, existing buildings and structures shall comply with the provisions for *altera- tions*, *repairs*, *additions* and changes of occupancy or reloca- tion, respectively, in the *International Building Code*, *International Fire Code*, *International Fuel Gas Code*, *Inter- national Mechanical Code*,

International Plumbing Code, *International Property Maintenance Code*, *International Private Sewage Disposal Code* and NFPA 70.

501.5 New and replacement materials. Except as other- wise required or permitted by this code, materials permitted by the applicable code for new construction shall be used. Like materials shall be permitted for *repairs*, provided haz- ards to life, health or property are not created. Hazardous materials shall not be used where the code for new construc- tion would not permit use of these materials in buildings of similar occupancy, purpose and location.

** **501.6 Historic buildings.** No provisions of this code relating to the construction, *repair, alteration*, restoration and movement of structures, and *change of occupancy* shall be mandatory for *historic buildings* provided a report has been submitted to the *code official or authority having jurisdiction* and signed by a *registered design professional*, or a representative of the State Historic Preservation Office or the historic preservation authority having jurisdiction, demonstrating that compliance with that pro- vision would threaten, degrade or destroy the historic form, fabric or function of the building. If a report was signed by anyone other than a representative of the State Historic Preservation Officer, the signatory of the report shall provide a copy to the State Historic Preservation Office.

SECTION 502
ADDITIONS

502.1 General. *Additions* to an existing building, building system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction with- out requiring the unaltered portion of the existing building or building system to comply with this code. *Additions* shall not create an unsafe or hazardous condition or overload existing building systems. An *addition* shall be deemed to comply with this code if the *addition* alone complies or if the existing building and *addition* comply with this code as a single build- ing. *Additions* shall comply with Section 502.2.

Additions need not comply with 406. *Additions* complying with ANSI/ASHRAE/IESNA 90.1-2013. need not comply with Sections 402, 403, 404 and 405.

502.2 Prescriptive compliance. *Additions* shall comply with Sections 502.2.1 through 502.2.6.2.

502.2.1 Vertical fenestration. New *vertical fenestration* area that results in a total building *fenestration* area less than or equal to that specified in Section 402.3.1 shall comply with Section 402.3. *Additions* with *vertical fen- estration* that result in a total building *fenestration* area greater than Section 402.3.1 or *additions* that exceed the fenestration area greater than Section 402.3.1 shall com- ply with Section 402.3.1.1 for the *addition* only.

502.2.2 Skylight area. New *skylight* area that results in a total building *fenestration* area less than or equal to that specified in Section 402.3.1 shall comply with Section 402.3. *Additions* with *skylight* area that result in a total building *skylight* area greater than 402.3.1 or additions that exceed the *skylight* area shall comply with Section 402.3.1.2 for the *addition* only.

502.2.3 Building mechanical systems. New mechanical systems and equipment that are part of the *addition* and serve the building heating, cooling and ventilation needs shall comply with Section 403.

502.2.4 Service water-heating systems. New service water-heating equipment, controls and service water heat- ing piping shall comply with Section 404.

502.2.5 Pools and inground permanently installed spas. New pools and inground permanently installed spas shall comply with Section 404.9.

502.2.6 Lighting power and systems. New lighting systems that are installed as part of the addition shall comply with Section 405.

502.2.6.1 Interior lighting power. The total interior lighting power for the *addition* shall comply with Section 405.4.2 for the *addition* alone, or the existing building and the *addition* shall comply as a

single building.

502.2.6.2 Exterior lighting power. The total exterior lighting power for the *addition* shall comply with Section 405.5.1 for the *addition* alone, or the existing building and the *addition* shall comply as a single building.

SECTION C503 ALTERATIONS

503.1 General. *Alterations* to any building or structure shall comply with the requirements of the code for new con- struction. *Alterations* shall be such that the existing building or structure is no less conforming to the provisions of this code than the existing building or structure was prior to the *alteration*. *Alterations* to an existing building, building sys- tem or portion thereof shall conform to the provisions of this code as those provisions relate to new construction without requiring the unaltered portions of the existing building or building system to comply with this code. *Alterations* shall not create an unsafe or hazardous condition or overload existing building systems.

Alterations need not comply with 406. *Alterations* complying with ANSI/ASHRAE/IESNA 90.1-2013 need not comply with Sections 402, 403, 404 and 405.

Exception: The following *alterations* need not comply with the requirements for new construction, provided the energy use of the building is not increased:

1. Storm windows installed over existing *fenestration*.
2. Surface-applied window film installed on existing single-pane *fenestration* assemblies reducing solar heat gain, provided the code does not require the glazing or *fenestration* to be replaced.
3. Existing ceiling, wall or floor cavities exposed during construction, provided that these cavities already are filled with insulation.
4. Construction where the existing roof, wall or floor cavity is not exposed.
5. *Roof recover*.
6. *Air barriers* shall not be required for *roof recover* and roof replacement where the *alterations* or reno- vations to the building do not include *alterations*, renovations or *repairs* to the remainder of the build- ing envelope.

503.2 Change in space conditioning. Any nonconditioned or low-energy space that is altered to become conditioned space shall be required to be brought into full compliance with this code.

503.3 Building envelope. New building envelope assem- blies that are part of the *alteration* shall comply with Sections 402.1 through 402.5.

503.3.1 Roof replacement. *Roof replacements* shall comply with Table C402.1 where the existing roof assembly is part of the *building thermal envelope* and contains insulation entirely above the roof deck.

503.3.2 Vertical fenestration. The addition of *vertical fenestration* that results in a total building *fenestration* area less than or equal to that specified in Section 402.3.1 shall comply with Section 402.3. The addition of *vertical fenestration* that results in a total building *fenestration* area greater than Section 402.3.1 shall comply with Section 402.3.1.1 for the space adjacent to the new fenestration only. *Alterations* that result in a total building vertical glass area exceeding that specified in Section 402.3.1.1 shall comply with Section 407.

503.3.3 Skylight area. The addition of *skylight* area that results in a total building *skylight* area less than or equal to that specified in Section 402.3.1 shall comply with Section 402.3. The addition of *skylight* area that results in a total building skylight area greater than Section 402.3.1 shall comply with Section 402.3.1.2 for the space adjacent to the new skylights. *Alterations* that result in a total building skylight area exceeding that specified in Section 402.3.1.2 shall comply with Section 407.

503.4 Heating and cooling systems. New heating, cooling and duct systems that are part of the *alteration* shall comply with Sections 403.

503.4.1 Economizers. New cooling systems that are part of *alteration* shall comply with Section 403.3.

503.5 Service hot water systems. New service hot water systems that are part of the *alteration* shall comply with Sec- tion 404.

503.6 Lighting systems. New lighting systems that are part of the *alteration* shall comply with Section C405.

Exception. Alterations *that replace less than 10 percent of the luminaires in a space, provided that such* alterations *do not increase the installed interior lighting power.*

SECTION C504 REPAIRS

504.1 General. Buildings and structures, and parts thereof, shall be repaired in compliance with Section 501.3 and this section. Work on nondamaged components that is necessary for the required *repair* of damaged components shall be con- sidered part of the *repair* and shall not be subject to the requirements for *alterations* in this chapter. Routine maintenance required by Section 501.3, ordinary *repairs* exempt from *permit* and abatement of wear due to normal service conditions shall not be subject to the requirements for *repairs* in this section.

Repairs need not comply with 406. Where a building was constructed to comply with ANSI/ ASHRAE/IESNA 90.1-2013, repairs shall comply with the standard and need not comply with Sections 402, 403, 404 and 405.

504.2 Application. For the purposes of this code, the following shall be considered repairs:

1. Glass-only replacements in an existing sash and frame.

2. Roof repairs.

3. Air barriers shall not be required for roof repair where the repairs to the building do not include alterations, renovations or repairs to the remainder of the building envelope.

4. Replacement of existing doors that separate conditioned space from the exterior shall not require the installation of a vestibule or revolving door, provided that an existing vestibule that separates a conditioned space from the exterior shall not be removed.

5. Repairs where only the bulb, the ballast or both within the existing luminaires in a space are replaced, pro- vided that the replacement does not increase the installed interior lighting power.

SECTION 505

CHANGE OF OCCUPANCY OR USE

505.1 General. Spaces undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this code. Where the use in a space changes from one use in Table 405.4.2(1) or 405.4.2(2) to another use in Table 405.4.2(1) or 405.4.2(2), the installed lighting wattage shall comply with Section 405.4.

CHAPTER 6

REFERENCED STANDARDS

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

AAMA

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

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

AHAM

Association of Home Appliance Manufacturers
1111 19th Street NW, Suite 402
Washington, DC 20036

Standard reference number	Title	Referenced in code section number
ANSI/AHAM RAC-1—2008	Room Air Conditioners	Table 503.2.3(3)

AHRI

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

Standard reference number	Title	Referenced in code section number
210/240—03	Unitary Air-Conditioning and Air-Source Heat Pump Equipment	Table C403.2.3(1), Table C403.2.3(2)
310/380—93	Standard for Packaged Terminal Air-conditioners and Heat Pumps	Table C403.2.3(3)
340/360—2000	Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment	Table C403.2.3(1), Table C403.2.3(2)
365—02	Commercial and Industrial Unitary Air-conditioning Condensing Units	Table C403.2.3(1), Table C403.2.3(6)
390—03	Performance Rating of Single Package Vertical Air Conditioners and Heat Pumps	Table C403.2.3(3)
440—05	Room Fan-coil	.C403.2.8
550/590—98	Water Chilling Packages Using the Vapor Compression Cycle—with Addenda	Table C403.2.3(6)
560—00	Absorption Water Chilling and Water Heating Packages	Table C403.2.3(6)
840—1998	Unit Ventilators	.C403.2.8
13256-1 (2005)	Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps	Table C403.2.3(2)
13256-2(2005)	Water-source Heat Pumps—Testing and Rating for Performance—Part 2: Water-to-water and Brine-to-water Heat Pumps	Table C403.2.3(2)
1160—2004	Performance Rating of Heat Pump Pool Heaters	Table 504.2

AMCA

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

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

ANSI

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

Standard reference number	Title	Referenced in code section number
Z21.10.3—01	Gas Water Heaters, Volume III - Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous—with Addenda Z21.10.3a-2003 and Z21.10.3b-2004	Table 504.2
Z21.13—04	Gas-fired Low Pressure Steam and Hot Water Boilers	Table
C403.2.3(5) Z21.47—03	Gas-fired Central Furnaces	
.Table C403.2.3(4) Z83.8—02	Gas Unit Heaters and Gas-Fired Duct Furnaces—with Addendum Z83.8a-2003	
. . Table C403.2.3(4)		

ASHRAE

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

Standard reference number	Title	Referenced in code section number
146—1998	Testing and Rating Pool Heaters	Table 504.2
ANSI/ASHRAE/ACCA Standard 183—2007 C403.2.1	Peak Cooling and Heating Load Calculations in Buildings Except Low-rise Residential Buildings	
13256-1 (2005)	Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps (ANSI/ASHRAE/IESNA 90.1-2004)	Table C403.2.3(2)
90.1—2007	Energy Standard for Buildings Except Low-rise Residential Buildings (ANSI/ASHRAE/IESNA 90.1-2007)	501.1, 501.2, 502.1.1, Table 502.2(2)
ASHRAE—2004 C403.2.1	ASHRAE HVAC Systems and Equipment Handbook-2004	
62.1—2007	Ventilation for Acceptable Indoor Air Quality	C403.2.5, C403.2.5.1,
C403.4.5		

ASME

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

Standard reference number	Title	Referenced in code section number
PTC 4.1 - 1964 C403.2.3(5) (Reaffirmed 1991)	Steam Generating Units	Table

ASTM

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

Standard reference number	Title	Referenced in code section number
C 90—06b	Specification for Load-bearing Concrete Masonry Units	Table 502.1(1)
E 283—04	Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen	502.4.1.2(2), Table 502.4.3
E2178—03	Standard Test Method for Air Permeance of Building Materials	502.4.1.2(1)
E2357—05	Standard Test Method for Determining Air Leakage of Air Barrier Assemblies	502.4.1.2(2)
E779—03	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	502.4.1.2(3)
E1677—95	Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls	502.4.1.2(2)

CSA

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

Standard Referenced

REFERENCED STANDARDS

reference number	Title	in code section number
101/I.S.2/A440—08	Specifications for Windows, Doors and Unit Skylights	Table 502.4.3

DASMA

Door and Access Systems Manufacturers Association
1300 Sumner Avenue
Cleveland, OH 44115-2851

Standard reference number	Title	Referenced in code section number
105-92 (R 2004)	Test Method for Thermal Transmittance and Air Infiltration of Garage Doors	Table 502.4.3

DOE

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

Standard reference number	Title	Referenced in code section number
10 CFR Part 430, Subpart B, Appendix E (1998)	Uniform Test Method for Measuring the Energy Consumption of Water Heaters	Table 504.2
10 CFR Part 430, Subpart B, Appendix N (1998)	Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers	Table C403.2.3(4), Table C403.2.3(5)
10 CFR Part 431, Subpart E 2004	Test Procedures and Efficiency Standards for Commercial Packaged Boilers	Table C403.2.3(6)

ICC

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

Standard reference number	Title	Referenced in code section number
IBC—09	International Building Code®	201.3, 303.2
IFC—09	International Fire Code®	201.3
IFGC—09	International Fuel Gas Code®	201.3
IMC—09	International Mechanical Code®	C403.2.6, C403.2.7.1, C403.2.7.1.1, C403.2.7.1.2, C403.2.9.1
IPC—09	International Plumbing Code®	201.3

IESNA

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

Standard reference number	Title	Referenced in code section number
90.1—2007	Energy Standard for Buildings Except Low-rise Residential Buildings	501.1, 501.2, 502.1.1, Table 502.1(2)

NFRC

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

Standard reference number	Title	Referenced in code section number
100—04	Procedure for Determining Fenestration Product U-factors—Second Edition	302.1.3, 502.2.1
200—04	Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and	

	Visible Transmittance at Normal Incidence—Second Edition	302.1.3, 502.2.1
400—04	Procedure for Determining Fenestration Product Air Leakage—Second Edition	402.4.2, Table 502.4.3

SMACNA

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

Standard reference number	Title	Referenced in code section number
SMACNA—85	HVAC Air Duct Leakage Test Manual	C403.2.7.1.3

UL

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

Standard reference number	Title	Referenced in code section number
727—06	Oil-fired Central Furnaces	Table C403.2.3(4)
731—95	Oil-fired Unit Heaters—with Revisions through February 2006	Table C403.2.3(4)

WDMA

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

Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A440—08	Specifications for Windows, Doors and Unit Skylights	Table 502.4.3

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