# CHAPTER 1 [CE]
# SCOPE AND ADMINISTRATION

## SECTION C101
## SCOPE AND GENERAL REQUIREMENTS

**C101.1 Title.** This code shall be known as the *Washington State Energy Code***,** and shall be cited as such. It is referred to herein as "this code."

The ~~2021~~ 2024 edition of the Washington State Energy Code—Commercial Provisions is hereby adopted. The Washington State Energy Code—Commercial Provisions adopted under chapter 51-11C WAC shall become effective in all counties and cities of this state on ~~March 15, 2024~~November 1, 2026.

**C101.2 Scope.** This code applies to ~~*commercial buildings* and the buildings sites and associated systems and equipment~~the design and construction of buildings not covered by the scope of the Washington State Energy Code, Residential Provisions, as adopted under chapter 51-11R WAC. References in this code to Group R shall include Group I-1, Condition 2 assisted living facilities licensed by Washington state under chapter 388-78A WAC and Group I-1, Condition 2 residential treatment facilities licensed by Washington state under Chapter 246-337 WAC. Building areas that contain Group R sleeping units, regardless of the number of stories in height, are required to comply with the commercial sections of the energy code.

**Exception**: The provisions of this code do not apply to *temporary growing structures* used solely for the commercial production of horticultural plants including ornamental plants, flowers, vegetables, and fruits. A temporary growing structure is not considered a building for the purposes of this code. However, the installation of other than listed, portable mechanical equipment or listed, portable lighting fixtures is not allowed.

~~C101.6~~ C101.2.1 **Appendices.** Appendices A, B, C and D are included in the adoption of this code. Provisions in appendices E and F shall not apply unless specifically adopted by the local jurisdiction.

**C101.3 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.

~~[~~C101.3 Intent. ~~[~~C101.3 Intent. The IECC—Commercial Provisions provide ~~market-driven,~~ enforceable requirements for the design and construction of *commercial buildings*, providing minimum efficiency requirements for buildings that result in the maximum level of energy efficiency that is safe, technologically feasible, ~~and life cycle cost effective, considering economic feasibility, including potential costs and savings for consumers and building owners, and return on investment. Additionally, the code provides jurisdictions with supplemental requirements, including ASHRAE 90.1, and optional requirements that lead to achievement of zero energy buildings, presently, and through glidepaths that achieve zero energy buildings by 2030 and on additional timelines sought by governments, and achievement of additional policy goals as identified by the Energy and Carbon Advisory Council and approved by the Board of Directors. Requirements contained in the code will include, but not be limited to, prescriptive- and performance-based pathways. The code may include nonmandatory appendices incorporating additional energy efficiency and greenhouse gas reduction resources developed by the International Code Council and others. The code will aim to simplify code requirements to facilitate the code's use and compliance rate. The code is updated on a 3-year cycle with each subsequent edition providing increased energy savings over the prior edition.~~ This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this intent. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.~~]~~

~~C101.5~~C101.4 **Compliance.** *Residential buildings* shall meet the provisions of WSEC--Residential Provisions. *Commercial buildings* shall meet the provisions of WSEC--Commercial Provisions.

~~C101.5.1~~C101.4.1 **Compliance materials.** The *code official* shall be permitted to approve specific computer software, worksheets, compliance manuals and other similar materials that meet the intent of this code.

## SECTION C102
## APPLICABILITY

**Commented [BK(1]:** These are the changes adopted by ICC. It will need additional modification if included in the WSEC. I've started by striking the reference to 90.1, which is not currently a path for compliance. The WSEC appendices currently overwrite the IECC appendices.

**Commented [KA2R1]:** So if we include this we'd strike the other C101.3 Intent? Or is this additional to that one?

**Commented [BK(3R1]:** I think we either keep the language we have now or amend it with some of the ICC language. I would not recommend adoption of the unamended ICC language as it conflicts with the statute in a number of areas.

**Commented [BK(4]:**

**Commented [DJ5R4]:** I've stricken everything outside the first sentence and last two sentences, and much of the first sentence as well. The last two sentences match. So, we could keep our WA first sentence, or switch it out for half of the IECC first sentence,.

~~C101.4~~C102.1 **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 requirement and a specific requirement, the specific requirement shall govern.

~~C101.4.1~~C102.1.1 **Mixed residential and commercial buildings.** Where a building includes both *residential building* and *commercial building* portions, each portion shall be separately considered and meet the applicable provisions of WSEC--Commercial Provisions or WSEC--Residential Provisions.

~~C108.3~~C102.2 **Other laws.** The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law. In addition to the requirements of this code, all occupancies shall conform to the provisions included in the State Building Code (chapter 19.27 RCW). In case of conflicts among the codes enumerated in RCW 19.27.031 (1) through (4) and this code, an earlier named code shall govern over those following. In the case of conflict between the duct sealing and insulation requirements of this code and the duct insulation requirements of Sections 603 and 604 of the *International Mechanical Code*, the duct insulation requirements of this code, or where applicable, a local jurisdiction's energy code shall govern.

~~C108.2~~C102.3 **Application of references.** References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

~~C108.1~~C102.4 **Referenced codes and standards.** 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 as further regulated in Sections ~~C106.1.1~~C102.4.1 and ~~C106.1.2~~C1042.4.2.

~~C108.1.1~~C102.4.1 **Conflicts.** Where differences occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

~~C108.1.2~~C102.4.2 **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 or standard.

~~C107.1~~C102.5 ~~General~~**Partial invalidity.** 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 C103
## CODE COMPLIANCE AGENCY

~~C103.1 Creation~~ **of enforcement agency.** The **[INSERT NAME OF DEPARTMENT]** is hereby created and the official in charge thereof shall be known as the authority having jurisdiction (AHJ). The function of the agency shall be the implementation, administration and enforcement of the provisions of this code.

**C103.2 Appointment.** The AHJ shall be appointed by the chief appointing authority of the jurisdiction.

**C103.3 Deputies.** In accordance with the prescribed procedures of this jurisdiction and with the concurrence of the appointing authority, the AHJ shall have the authority to appoint a deputy AHJ, other related technical officers, inspectors and other employees. Such employees shall have powers as delegated by the AHJ.

**Commented [DJ6]:** This is bizarre. Nobody is creating a new agency.

**Commented [DJ7R6]:** The energy code uses "code official," not AHJ, throughout.

**Commented [KA8]:** This isn't the SBCC, so who is it?

**Commented [BK(9R8]:** This would be the local jurisdiction or division within the local building department responsible for enforcement of the energy code.

## SECTION ~~C102~~C104
## ALTERNATIVE MATERIALS, DESIGN AND METHODS OF CONSTRUCTION AND EQUIPMENT

~~C102.1~~C104.1 **General.** The provisions of this code are not intended to prevent the installation of any material, or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*. The *code official* shall have the authority to approve an alternate material, design or method of construction upon the written application of the owner or the owner's authorized agent. The *code official* shall first find that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability, energy conservation, and safety. The *code official* shall respond to the applicant, in writing, stating the reasons why the alternative was approved or was not approved.

## SECTION ~~C103~~C105
## CONSTRUCTION DOCUMENTS

~~C103.1~~C105.1 **General.** Construction documents and other supporting data shall be submitted in one or more sets, or in a digital format where allowed by the ~~building code~~ *official*, with each application for a permit. The *construction documents* shall be prepared by a *registered design professional* where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the *code official* is authorized to require necessary *construction documents* to be prepared by a *registered design professional*.

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

~~C103.2~~C105.2 **Information on construction documents.** Construction documents shall be drawn to scale upon suitable material. Electronic media documents are permitted to be submitted when *approved* by the *code official*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and 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. Energy compliance path per Section C401 or C501.
2. Insulation materials and their *R*-values.
3. Fenestration *U*-factors and SHGCs.
4. Area-weighted *U*-factor and SHGC calculations.
5. Air barrier details including all air barrier boundaries and associated square foot calculations on all six sides of the air barrier as applicable.
~~4.~~6. Thermal bridges as identified in Section C402.6.
~~5.~~7. Mechanical system design criteria.
~~6.~~8. Mechanical and service water heating system and equipment types, sizes and efficiencies.
~~7.~~9. Economizer description.
~~8.~~10. Equipment and systems controls.
~~9.~~11. Fan motor horsepower (hp) and controls.
~~10.~~12. Duct sealing, duct and pipe insulation and location.
~~11.~~13. Lighting fixture schedule with wattage and control narrative.
~~12.~~14. Location of daylight zones on floor plan.
15. ~~Air barrier details including all air barrier boundaries and associated square foot calculations on all six sides of the air barrier as applicable~~Location of pathways for routing of raceways or cable from the on-site renewable energy system to the electrical distribution equipment.
16. Location reserved for inverters, metering equipment and energy storage systems (ESS), and a pathway reserved for routing of raceways or conduit from the renewable energy system to the point of interconnection with the electrical service and the ESS.
17. Location and layout of a designated area for ESS.
~~13.~~18. Rated energy capacity and rated power capacity of the installed or planned ESS.

~~C103.2.1~~C105.2.1 **Building thermal envelope depiction.** The building's thermal envelope shall be represented on the construction documents.

~~C103.3~~C105.3 **Examination of documents.** The *code official* shall examine or cause to be examined the accompanying construction documents and shall ascertain whether the construction indicated and described is in accordance with the requirements of this code and other pertinent laws or ordinances.

~~C103.3.1~~C105.3.1 **Approval of construction documents.** When the *code official* issues a permit where construction documents are required, the construction documents shall be endorsed in writing and stamped "Reviewed for Code Compliance." Such *approved* construction documents shall not be changed, modified or altered without authorization from the *code official*. Work shall be done in accordance with the *approved* construction documents.

One set of construction documents so reviewed shall be retained by the *code official*. The other set shall be returned to the applicant, kept at the site of work and shall be open to inspection by the *code official* or a duly authorized representative.

~~C103.3.2~~C105.3.2 **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

**Commented [DJ10]:** I don't think we require an ESS, so we shouldn't put that reference in here

**Commented [DJ11R10]:** Same with next two items

after the effective date of this code and has not been abandoned.

~~C103.3.3~~C105.3.3 **Phased approval.** The *code official* shall have the authority to issue a permit for the construction of part of an energy conservation system before the construction documents for the entire system have been submitted or *approved*, provided adequate information and detailed statements have been filed complying with all pertinent requirements of this code. The holders of such permit shall proceed at their own risk without assurance that the permit for the entire energy conservation system will be granted.

~~C103.4~~C105.4 **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.

~~C103.5~~C105.5 **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.

~~C103.6~~C105.6 **Building documentation and close out submittal requirements.** The construction documents shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within a maximum of 90 days of the date of receipt of the certificate of occupancy.

~~C103.6.1~~C105.6.1 **Record documents.** Construction documents shall be updated by the installing contractor and architect or engineer of record to convey a record of the completed work. Such updates shall include *building thermal envelope*, mechanical, plumbing, electrical and control drawings red-lined, or redrawn if specified, that show all changes to size, type and locations of components, equipment and assemblies. Record documents shall include the location and model number of each piece of equipment as installed. The architect, engineer of record or installing contractor is required to provide consolidated record drawings in compliance with this section to the building owner or owner's authorized agent with the timeline specified in Section ~~C103.6~~C105.6.

~~C103.6.2~~C105.6.2 **Building operations and maintenance information.** Required regular maintenance actions for equipment and systems shall be clearly stated on a readily visible label on the equipment. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product and the manufacture date or installation date.

~~C103.6.2.1~~C105.6.2.1 **Manuals.** An operating and maintenance manual shall be provided for each component, device, piece of equipment, and system governed by this code. The manual shall include all of the following:

1. Submittal data indicating all selected options for each piece of equipment and control device.
2. Manufacturer's operation manuals and maintenance manuals for each device, piece of equipment, and system requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions, cleaning and recommended relamping shall be clearly identified.
3. Name and address of at least one service agency.
4. Controls system inspection schedule, maintenance and calibration information, wiring diagrams, schematics, and control sequence descriptions. A schedule for inspecting and recalibrating all lighting controls. Desired or field-determined setpoints shall be PERMANENTLY recorded on control drawings at control devices or, for digital control systems, on the graphic where settings may be changed.
5. A narrative of how each system is intended to operate, including recommended setpoints. Sequence of operation alone is not acceptable for this requirement.

~~C103.6.3~~C105.6.3 **Compliance documentation.** All energy code compliance forms and calculations shall be delivered in one document to the building owner as part of the project record documents or manuals, or as a standalone document. This document shall include the specific energy code year utilized for compliance determination for each system, NFRC certificates for the installed windows, list of total area for each NFRC certificate, the interior lighting power compliance path (building area, space-by-space) used to calculate the lighting power allowance.

For projects complying with Section C401.2 item 1, the documentation shall include:

1. The envelope insulation compliance path (prescriptive or component performance).
2. All completed code compliance forms, and all compliance calculations including, but not limited to, those required by sections C402.1.5, C403.2.12.1, C405.4, and C405.5.
3. ~~2.~~ A plan for annual energy use data gathering and disclosure as specified in Section C409.1

**Commented [BK(12]:** The IECC has this information in Section C405.13. Their metering requirements are somewhat less detailed than that in the WSEC.

For projects complying with C401.2 item 2, the documentation shall include:

1. A list of all proposed envelope component types, areas and *U*-values.
2. A list of all lighting area types with areas, lighting power allowance, and installed lighting power density.
3. A list of each HVAC system modeled with the assigned and proposed system type.
4. Electronic copies of the baseline and proposed model input and output file. The input files shall be in a format suitable for rerunning the model and shall not consist solely of formatted reports of the inputs

~~C103.6.4~~C105.6.4 **Systems operation training.** Training of the maintenance staff for equipment included in the manuals required by Section ~~C103.6.2~~C105.6.2.1 shall include at a minimum:

1. Review of manuals and permanent certificate.
2. Hands-on demonstration of all normal maintenance procedures, normal operating modes, and all emergency shutdown and start-up procedures.
3. Training completion report.

## SECTION ~~C104~~C106
## FEES

~~C104.1~~C106.1 **Fees.** A permit shall not be ~~issued~~ valid until the fees prescribed ~~in Section C104.2~~by law have been paid~~.~~. Nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

~~C104.2~~C106.2 **Schedule of permit fees.** A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

**C106.3 Valuation of work.** The applicant for a permit shall provide an estimated value of the work for which the permit is being issued at the time of application. Such estimated valuations shall include the total value of the work, including materials and labor. Where, in the opinion of the *code official*, the valuation is underestimated, the permit shall be denied unless the applicant can show detailed estimates acceptable to the *code official*. The final valuation shall be *approved* by the *code official*.

~~C104.3~~C106.4 **Work commencing before permit issuance.** Any person who commences any work before obtaining the necessary permits shall be subject to ~~an additional~~a fee established by the *code official*, which shall be in addition to the required permit fees.

~~C104.4~~C106.5 **Related fees.** The payment of the fee for the construction, *alteration*, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

~~C104.5~~C106.6 **Refunds.** The *code official* is authorized to establish a refund policy.

## SECTION ~~C105~~C107
## INSPECTIONS

~~C105.1~~C107.1 **General.** Construction or work for which a permit is required shall be subject to inspection by the *code official,* his or her designated agent, or an *approved agency*, and such construction or work shall remain visible and able to be accessed for inspection purposes until *approved*. Approval as a result of an inspection shall not be construed to be an approval of a violation of the provisions of this code or of other ordinances of the jurisdiction. Inspections presuming to give authority to violate or cancel the provisions of this code or of other ordinances of the jurisdiction shall not be valid. It shall be the duty of the permit applicant to cause the work to remain visible and able to be accessed for inspection purposes. Neither the *code official* 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.

~~C105.2~~C107.2 **Required inspections.** The *code official,* his or her designated agent, or an approved agency, upon notification, shall make the inspections set forth in Sections ~~C104.2.1~~C107.2.1 through ~~C104.2.6~~C107.2.6.

~~C105.2.1~~C107.2.1 **Footing and foundation insulation.** Inspections shall verify footing and/or foundation insulation *R*-value, location, thickness, depth of burial and protection of insulation as required by the code, *approved* plans and specifications.

~~C105.2.2~~C107.2.2 ~~Thermal~~ Building thermal **envelope.** Inspections shall be made before application of interior finish and shall verify that envelope components with the ~~correct~~ type of insulation, ~~the~~ R-values, the

~~correct~~ location of insulation, thermal bridge mitigation, ~~the correct~~ fenestration, ~~the~~ U-factor, SHGC, VT, and that *air leakage* controls are ~~properly~~ installed, as required by the code, *approved* plans and specifications, including envelope components in future tenant spaces of multi-tenant buildings.

~~C105.2.3~~C107.2.3 **Plumbing system.** Inspections shall verify the type of insulation, the R-values, the protection required, controls, and heat traps as required by the code, approved plans and specifications.

~~C105.2.4~~C107.2.4 **Mechanical system.** Inspections shall verify the installed HVAC equipment for the ~~correct~~ type and size, controls, duct and piping insulation *R*-values, duct system and damper air leakage, minimum fan efficiency, energy recovery and economizer as required by the code, approved plans and specifications.

~~C105.2.5~~C107.2.5 **Electrical system.** Inspections shall verify lighting system controls, components, meters; motors and installation of an electric meter for each dwelling unit as required by the code, *approved* plans and specifications. Where an ESS area is required, inspections shall verify space availability and pathways to electrical service.

**Commented [DJ13]:** Is an ESS required anywhere?

~~C105.2.6~~C107.2.6 **Final inspection.** 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 in accordance with Section C408.

~~C105.3~~C107.3 **Reinspection.** A building shall be reinspected when determined necessary by the *code official*.

~~C105.4~~C107.4 **Approved inspection agencies.** The *code official* is authorized to accept reports of *approved* inspection agencies, provided such agencies satisfy the requirements as to qualifications and reliability relevant to the building components and systems they are inspecting.

~~C105.5~~C107.5 **Inspection requests.** It shall be the duty of the holder of the permit or their duly authorized agent to notify the *code official* when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this code.

~~C105.6~~C107.6 **Reinspection and testing.** Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made so as to achieve compliance with this code. The work or installation shall then be resubmitted to the *code official* for inspection and testing.

## SECTION ~~C106~~C108
## NOTICE OF APPROVAL

~~C106.1~~C108.1 **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*.

~~C106.2~~C108.2 **Revocation.** The *code official* 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 C107~~
~~VALIDITY~~

**Commented [BK(14]:** Now in Section C102

~~SECTION C108~~
~~REFERENCED STANDARDS~~

**Commented [BK(15]:** Now in Section C102

## SECTION ~~C110~~C109
## BOARD OF APPEALS

~~C110.1~~C109.1 **General.** In order to hear and decide appeals of orders, decisions or determinations made by the *code official* relative to the application and interpretation of this code, there shall be and is hereby created a board of appeals. ~~The *code official* shall be an ex officio member of said board but shall have no vote on any matter before the board.~~ The board of appeals shall be appointed by the governing ~~body~~ authority and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business, and shall render all decisions and findings in writing to the appellant with a duplicate copy to the *code official*.

~~C110.2~~C109.2 **Limitations on authority.** An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The board shall have no authority to waive requirements of this code.

~~C110.3~~C109.3 **Qualifications.** The board of appeals shall consist of members who are qualified by experience and training and are not employees of the jurisdiction.

**C109.4 Administration**. The *code official* shall take action in accordance with the decisions of the board.

## SECTION ~~C109~~C110
## STOP WORK ORDER

~~C109.1~~C110.1 **Authority.** Whenever the *code official* finds any work regulated by this code being performed in a manner contrary to the provisions of this code or dangerous or unsafe, the *code official* is authorized to issue a stop work order.

~~C109.2~~C110.2 **Issuance.** The stop work order shall be in writing and shall be given to the owner of the property, the owner's authorized agent, or the person performing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order, and the conditions under which the cited work is authorized to resume.

~~C109.3~~C110.3 **Emergencies.** Where an emergency exists, the *code official* shall not be required to give a written notice prior to stopping the work.

~~C109.4~~C110.4 **Failure to comply.** Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to fines established by the authority having jurisdiction.

## SECTION C111
## VIOLATIONS

It shall be unlawful for any person, firm, or corporation to erect or construct any building, or remodel or rehabilitate any existing building or structure in the state, or allow the same to be done, contrary to or in violation of any of the provisions of this code.

## SECTION C112
## LIABILITY

Nothing contained in this code is intended to be nor shall be construed to create or form the basis for any liability on the part of any city or county or its officers, employees or agents for any injury or damage resulting from the failure of a building to conform to the provisions of this code.

# CHAPTER 2 [CE]

# DEFINITIONS

## SECTION C201
## GENERAL

**C201.1 Scope.** Unless stated otherwise, the following words and terms in this code shall have the meanings indicated in this chapter.

**C201.2 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.

**C201.3 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*, *Uniform Plumbing Code* or the *International Residential Code* shall have the meanings ascribed to them in those codes.

**C201.4 Terms not defined.** Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies.

## SECTION C202
## GENERAL DEFINITIONS

**ABOVE-GRADE WALL.** That portion of a wall in the *building thermal envelope* that is not a below-grade wall. This includes between-floor spandrels, peripheral edges of floors, roof knee walls, dormer walls, gable end walls, walls enclosing a mansard roof, mechanical equipment penetrations and skylight shafts.

**ACCESS (TO).** That which enables a device, appliance or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel or similar obstruction.

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

**AIR BARRIER.** One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the building thermal envelope and its assemblies.

**AIR CURTAIN UNIT.** 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.

**AIR LEAKAGE.** The uncontrolled airflow through the *building thermal envelope* caused by pressure differences across the *building thermal envelope*. *Air leakage* can be inward (infiltration) or outward (exfiltration) through the *building thermal envelope*.

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

**ALTERNATING CURRENT-OUTPUT UNINTERRUPTIBLE POWER SUPPLY (AC-OUTPUT UPS).** A combination of convertors, switches and energy storage devices, such as batteries, constituting a power system for maintaining continuity of load power in case of input power failure. Input power failure occurs when voltage and frequency are outside rated steady state and transient tolerance bands or when distortion or interruptions are outside the limits specified for the uninterruptible power supply. An AC-output UPC is an uninterruptible power supply that supplies power with a continuous flow of electrical charge that periodically reversed direction.

**APPROVED.** Acceptable to the *code official*.

**APPROVED AGENCY.** An established and recognized agency regularly engaged in conducting tests or

furnishing inspection services, or furnishing product certification research reports, where such agency has been *approved* by the *code official*.

**APPROVED SOURCE.** An independent person, firm or corporation *approved* by the *code official*, who is competent and experienced in the application of engineering principles to materials, methods or systems analyses.

**ATTIC AND OTHER ROOFS.** Roofs other than roofs with insulation entirely above deck and metal building roofs, including roofs with insulation entirely below (inside of) the roof structure (i.e., attics, cathedral ceilings, and single-rafter ceilings), roofs with insulation both above and below the roof structure, and roofs without insulation.

**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").

**AUTOMATIC CONTROL DEVICE.** A device capable of automatically controlling equipment and devices without manual intervention.

**BELOW-GRADE WALL.** That portion of a wall in the *building thermal envelope* that is entirely below the finish grade and in contact with the ground.

**BEST EFFICIENCY POINT (BEP).** The pump hydraulic power operating point (consisting of both flow and head conditions) that results in the maximum efficiency.

**BIOGAS**. A mixture of hydrocarbons that is a gas at 60°F (15.5°C) and one atmosphere of pressure that is produced through the anaerobic digestion of organic matter.

~~**BIOMASS.** Nonfossilized and biodegradable organic material originating from plants, animals and/or micro-organisms, including products, by-products, residues and waste from agriculture, forestry and related industries as well as the nonfossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of nonfossilized and biodegradable organic material.~~

**BIOMASS WASTE.** Organic nonfossil material of biological origin that is a byproduct or a discarded product. *Biomass waste* includes municipal solid waste from biogenic sources; landfill gas; sludge waste; agricultural crop byproducts; straw; and other biomass solids, liquids and biogases, but excludes wood and wood-derived fuels (including black liquor), biofuel feedstock, biodiesel and fuel ethanol.

**BLOCK.** A generic concept used in energy simulation. It can include one or more thermal zones. It represents a whole building or portion of a building with the same use type served by the same HVAC system type.

**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 building systems have been installed, and function according to the approved construction documents.

**BUILDING ENTRANCE.** Any doorway, set of doors, revolving door, vestibule, or other form of portal (including elevator doors such as in parking garages) that is ordinarily used to gain access to the building or to exit from the building by its users and occupants. This does not include doors solely used to directly enter mechanical, electrical, and other building utility service equipment rooms, or doors for emergency egress only. Where buildings have separate one-way doors to enter or leave, any doors ordinarily used to leave the building are also deemed a building entrance.

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

**BUILDING THERMAL ENVELOPE.** The below-grade walls, above-grade walls, floors, ceilings, roofs, and any other building element assemblies that meet one or more of the following criteria:

1. Separates conditioned areas of all types from unconditioned or unenclosed areas.
2. Separates conditioned areas of differing types including elements between fully conditioned areas, low energy, semi-heated, greenhouse, and refrigerated areas.

***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)].

**CAPTIVE KEY DEVICE.** A lighting control that will not release the key that activates the override when the lighting is on.

**CAVITY INSULATION.** Insulating material located between framing members.

**CEILING FAN.** A nonportable device suspended from a ceiling or overhead structure for circulating air via the rotation of the blades. See also *large-diameter ceiling fan*.

**CERTIFIED COMMISSIONING PROFESSIONAL.** An individual who is certified by an ANSI/ISO/IEC 17024:2012 accredited organization to lead, plan, coordinate, and manage commissioning teams and implement the commissioning process.

**CHANGE OF OCCUPANCY.** A change in the use of a building or a portion of a building that results in any of the following:

1. A *change of occupancy* classification.
2. A change from one group to another group within an occupancy classification.
3. Any change in use within a group for which there is a change in the application of the requirements of this code.

**CHI-FACTOR (χ-FACTOR).** The heat loss factor for a single *thermal bridge* characterized as a point element of a *building thermal envelope* (Btu/h x °F) [W/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.

**CLEAN WATER PUMP.** A device that is designed for use in pumping water with a maximum nonabsorbent free solid content of 0.016 lb/ft3 (0.256 kg/m3) and with a maximum dissolved solid content of 3.1 lb/ft3 (49.66 kg/m3), provided that the total gas content of the water does not exceed the saturation volume, and disregarding any additives necessary to prevent the water from freezing at a minimum of 14°F (-10°C).

**CLERESTORY FENESTRATION.** See “Fenestration.”

**CLIMATE ZONE.** A geographical region based on climatic criteria as specified in this code.

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

**COEFFICIENT OF PERFORMANCE (COP) - COOLING.** The ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete 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 removal to 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 not included in the definition of "Residential buildings."

**COMMON AREAS.** All conditioned spaces within *Group R* occupancy buildings that are not *dwelling units* or *sleeping units*.

**COMMUNITY RENEWABLE ENERGY FACILITY.** A facility that produces energy harvested from *renewable energy resources* and is qualified as a community energy facility under applicable jurisdictional statutes and rules.

**COMMUNITY RENEWABLE ENERGY SYSTEM.** An off-site renewable energy system for which the owner has purchased or leased renewable energy capacity along with other subscribers.

**COMPRESSED AIR SYSTEM.** A system of at least one compressor providing compressed air at 40 psig or higher.

**COMPUTER ROOM.** A room whose primary function is to house equipment for the processing and storage of electronic data and that has a design total *information technology equipment (ITE)* equipment power density less than or equal to 20 watts per square foot (215 watts per $m^2$) of conditioned floor area or a design *ITE* equipment load less than or equal to 10 kW. See also *data center*.

**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 the building thermal envelope and that is directly heated or cooled or that is indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling. Elevator shafts, stair enclosures, enclosed corridors connecting conditioned spaces, and enclosed spaces through which conditioned air is intentionally transferred at a rate exceeding three air changes per hour are considered *contitioned spaces* for the purposes of the *building thermal envelope* requirements.

**CONGREGATE LIVING FACILITIES.** A *building* or part thereof that contains *sleeping units* where residents share bathroom or kitchen facilities, or both.

**CONSTRUCTION DOCUMENTS.** Written, graphic and pictorial documents prepared or assembled for describing the design, location and physical characteristics of the elements of a project necessary for obtaining a building permit.

**CONTINUOUS INSULATION (CI).** Insulating material that is continuous across all structural members without metal thermal bridges other than fasteners that have a total cross-sectional area not greater than 0.04 percent (0.12 percent where all metal thermal bridges are stainless steel) of the envelope surface through which they penetrate, and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the *building thermal envelope*.

**CONTROLLED PLANT GROWTH ENVIRONMENT.** Group F and U buildings or spaces that are used exclusively for and specifically controlled to facilitate and enhance plant growth and production by manipulating various indoor environmental conditions. Technologies include indoor agriculture, cannabis growing, hydroponics, aquaculture and aquaponics. Controlled indoor environment variables include, but are not limited to, temperature, air quality, humidity and carbon dioxide.

**CONTROLLED RECEPTACLE.** An electrical receptacle that is controlled by an *automatic control device*.

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

**DATA ACQUISITION SYSTEM.** An electronic system managed by the building owner to collect, tabulate and display metering information.

**DATA CENTER.** A room or series of rooms that share *Data Center Systems* whose primary function is to house equipment for the processing and storage of electronic data, which has a design total *information technology equipment (ITE)* equipment power density exceeding 20 watts per square foot (215 watts per $m^2$) of conditioned area and a total design ITE equipment load greater than 10 kW.

**DATA CENTER SYSTEMS.** HVAC systems, electrical systems, equipment, or portions thereof used to condition *ITE* or electrical systems in a *data center*.

**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.** The portion of the building interior floor area that is illuminated by natural daylight through sidelit and toplit fenestration.

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

**DEDICATED OUTDOOR AIR SYSTEM (DOAS)**. A ventilation system that supplies 100 percent outdoor air primarily for the purpose of *ventilation* ~~without requiring operation of a space-conditioning system fan for outdoor air delivery~~and that is a separate system from the *zone* space-conditioning system.

**DEHUMIDIFIER.** A self-contained, electrically operated and mechanically encased product with the sole purpose of dehumidifying the space consisting of the following:

1. A refrigerated surface (evaporator) that condenses moisture from the atmosphere.
2. A refrigerating system, including an electric motor.
3. An air-circulating fan.
4. A means for collecting or disposing of the condensate.

A dehumidifier does not include a portable air conditioner, room air conditioner or packaged terminal air conditioner.

**DEMAND CONTROL KITCHEN VENTILATION (DCKV)**. A system that provides *automatic*, continuous control over exhaust hood~~, where required,~~ and make-up air fan speed in response to ~~one or more~~ temperature, optical or infrared (IR) sensors that monitor cooking activity or through direct communication with cooking appliances.

**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 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.

**DEMAND RESPONSE SIGNAL**. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

**DEMAND RESPONSIVE CONTROL**. A control capable of receiving and automatically responding to a *demand response signal*.

**DESICCANT DEHUMIDIFICATION SYSTEM**. A mechanical dehumidification technology that uses a solid or liquid material to remove moisture from the air.

**DIRECT DIGITAL CONTROL (DDC).** A type of control where controlled and monitored analog or binary data such as temperature and contact closures are converted to digital format for manipulation and calculations by a digital computer or microprocessor, then converted back to analog or binary form to control physical devices.

**DIRECTLY OWNED OFF-SITE RENEWABLE ENERGY SYSTEM.** An off-site renewable energy system owned by the building project owner.

**DISTRICT ENERGY EFFICIENCY FACTOR.** Ratio of site energy input at the district plant required to produce a unit of heating or cooling at the project site on an annual basis, supported by calculations approved by the *code official*..

**DOOR, GARAGE.** Non-swinging doors rated by DASMA 105 with a single panel or horizontally-hinged sectional panels.

**DOOR, NONSWINGING.** Roll-up, tilt-up, metal coiling and sliding doors, access hatches, and all other doors that are not swinging doors or garage doors with less *than* or equal to 14 percent glazing.

**DOOR, SWINGING.** Doors that are hinged on one side and revolving doors.

**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.

**DX-DEDICATED OUTDOOR AIR SYSTEM UNIT~~S~~ (DX-DOAS UNIT~~S~~).** A type of air-cooled, water-cooled or water source factory-assembled product that dehumidifies 100 percent outdoor air to a low dew point and includes reheat that is capable of controlling the supply dry-bulb temperature of the dehumidified air to the designated supply air temperature. This conditioned outdoor air is then delivered directly or indirectly to the conditioned spaces. It may precondition outdoor air ~~by containing an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes, or other heat or mass transfer apparatus.~~with an *energy recovery ventilation system*.

**DYNAMIC GLAZING.** Any fenestration product that has the fully reversible ability to change its performance properties, including *U*-factor, SHGC, or VT.

**EAST-ORIENTED.** Facing within 45 degrees of true east to the south and within less than 22.5 degrees of true east to the north.

**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.

**EMITTANCE.** The ratio of the radiant heat flux emitted by a specimen measured on a scale from 0 to 1, where a value of 1 indicates perfect release of thermal radiation.

**ENCLOSED SPACE.** A volume surrounded by solid surfaces such as walls, floors, roofs, and openable devices such as doors and operable windows. Unconditioned crawlspaces, attics, and parking garages with natural or mechanical ventilation are not considered *enclosed spaces*.

**END USE CATEGORY.** A load or group of loads that consume energy in a common or similar manner.

**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, SERIES.** A three-step process in which the first step is to remove energy from a single airstream without the use of mechanical cooling. In the second step, the airstream is mechanically cooled for the purpose of dehumidification. In the third step, the energy removed in the first step is reintroduced to the airstream.

**ENERGY RECOVERY RATIO, SERIES (SERR).** The difference between the dry-bulb air temperatures leaving the *series energy recovery* unit and leaving the dehumidifying coil divided by the difference between 75°F (24°C) and the dry-bulb temperature of the air leaving the dehumidifying cooling coil.

**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.

**ENERGY SOURCE METER.** A meter placed at the source of the incoming energy that measures the energy delivered to the whole building or metered space.

**ENERGY STORAGE SYSTEM (ESS).** One or more devices, assembled together, capable of storing energy in order to supply electrical energy at a future time.

**ENERGY USE INTENSITY (EUI).** The metric indicating the total amount of energy consumed by a *building* in one year divided by the gross floor area of the *building*.

**ENTHALPY RECOVERY RATIO (ERR)**. Change in the enthalpy of the *outdoor air* supply divided by the difference between the *outdoor air* and entering exhaust air enthalpy, expressed as a percentage.

**ENTRANCE DOOR.** A vertical fenestration product used for occupant ingress, egress and access in nonresidential buildings including, but not limited to, exterior entrances utilizing latching hardware and *automatic* closers and containing over 50 percent glazing specifically designed to withstand heavy duty usage.

**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 below-grade walls.

~~**EXTERIOR WALL ENVELOPE.** A system or assembly of exterior wall components, including exterior wall finish materials, that provides protection of the building structural members, including framing and sheathing materials, and conditioned interior space from the detrimental effects of the exterior environment.~~

**FAN, EMBEDDED**. A fan that is part of a manufactured assembly where the assembly includes functions other than air movement.

**FAN ARRAY**. Multiple fans in parallel between two plenum sections in an air distribution system.

**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 ELECTRICAL INPUT POWER (FAN $kW_{DESIGN}$)**. The electrical input power in kilowatts required to operate an individual fan or *fan array* at design conditions. It includes the power consumption of motor controllers, ~~if~~ where present.

**FAN ENERGY INDEX (FEI)**. The ratio of the electric input power of a reference fan to the electric input power of the actual fan as calculated in accordance with AMCA 208.

**FAN SYSTEM**. Includes all the fans that contribute to the movement of air serving spaces that pass through a point of a common duct, plenum, or cabinet.

**FAN SYSTEM, COMPLEX**. A *fan system* that combines a *single-cabinet fan system* with other supply fans, exhaust fans ~~and/or other fans, or is not captured by other *fan system* types~~or both.

**FAN SYSTEM, EXHAUST~~/~~ OR RELIEF**. A *fan system* dedicated to the removal of air from interior spaces to the outdoors.

**FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV).** A *fan system* that serves three or more space-conditioning zones where airflow to each zone is individually controlled based on heating, cooling and/or ventilation requirements, indoor fan airflow varies as a function of load, and the sum of the minimum zone airflows is 40 percent or less of the fan system de-sign conditions.

**FAN SYSTEM, RETURN**. A *fan system* dedicated to removing air from interior where some or all the air is to be recirculated except during economizer operation.

**FAN SYSTEM, SINGLE-CABINET.** A *fan system* ~~where a~~that supplies air to a space and recirculates the air, wherein a single cabinet houses a single fan, a single *fan array*, a single set of fans operating in parallel, or fans or fan arrays in series ~~and embedded in the same cabinet, that both supplies air to a space and recirculates the air~~.

**FAN SYSTEM, SUPPLY-ONLY**. A *fan system* that provides supply air to interior spaces and does not recirculate the air.

**FAN SYSTEM, TRANSFER.** A *fan system* that exclusively moves air from one occupied space to another.

**FAN SYSTEM AIRFLOW (CFM).** The sum of the airflow of all fans with *fan electrical input power* greater than 1 kW at *fan system design conditions*, excluding the airflow that passes through downstream fans with fan in-put power less than 1 kW.

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

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

**FAN SYSTEM ELECTRICAL INPUT POWER** (**Fan $kW_{design}$, system**). The sum of the fan electrical input power

**Commented [DJ16]:** This phrase is not used anywhere in the code

**Commented [DJ17]:** I don't think this edit makes sense, nor does the whole definition.

(Fan $kW_{design}$) of all fans that are required to op-erate at fan system design conditions to supply air from the heating or cooling source to the conditioned spaces, return it to the source, exhaust it to the outdoors, or transfer it to another space.

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

**FAULT DETECTION AND DIAGNOSTICS (FDD) SYSTEM.** A software platform that utilizes building analytic algorithms to convert data provided by sensors and devices to automatically identify faults in building systems and pro-vide a prioritized list of actionable resolutions to those faults based on cost or energy avoidance, comfort and maintenance impact.

**FENESTRATION.** Products classified as either skylights or vertical fenestration.

**SKYLIGHTS.** Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (91.05 rad) from horizontal, including unit skylights, tubular daylighting devices and glazing materials in solariums, sunrooms, roofs, greenhouses, and sloped walls.

**VERTICAL FENESTRATION.** Windows that are fixed or operable, doors with no more than 50 percent glazed area and glazed block composed of glass or other transparent or translucent glazing materials and installed at a slope of not less than 60 degrees (91.05 rad) from horizontal. Opaque areas such as spandrel panels are not considered vertical fenestration.

**CLERESTORY FENESTRATION.** An upper region of vertical fenestration provided for the purpose of admitting daylight beyond the perimeter of a space. The entire clerestory fenestration assembly is installed at a height greater than 8 feet above the finished floor.

**FENESTRATION AREA.** Total area of the fenestration measured using the rough opening, and including the glazing, sash and frame.

**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.** A fenestration designed to be made up of field-glazed or field-assembled units using specific factory cut or otherwise factory-formed framing and glazing units. Examples of site-built fenestration include storefront systems, curtain walls, and atrium roof systems.

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

**FINANCIAL RENEWABLE ENERGY POWER PURCHASE AGREEMENT.** A financial arrangement between a renewable electricity generator and a purchaser wherein the purchaser pays or guarantees a price to the generator for the project's renewable generation. Also known as a "financial power purchase agreement" and "virtual power purchase agreement."

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

**FURNACE ELECTRICITY RATIO.** The ratio of furnace electricity use to total furnace energy computed as ratio .= (3.412 x $E_{AE}$)/1000 x $E_F$.+ 3.412 x $E_{AE}$) where $E_{AE}$ (average annual auxiliary electrical consumption) and $E_F$ (average annual fuel energy consumption) are defined in Appendix N to Subpart B of Part 430 of Title 10 of the Code of Federal Regulations and $E_F$ is expressed in millions of Btus per year.

**GENERAL LIGHTING.** Interior lighting that provides a substantially uniform level of illumination throughout a space. *General lighting* shall not include lighting that provides a dissimilar level of illumination to serve a specific application or decorative feature within such area.

**GREEN RETAIL TARIFF.** An electricity-rate structure qualified under applicable statutes or rules contracted by an electricity service provider to the building project *owner* to provide electricity generated with 100 percent *renewable energy resources* without the purchase of unbundled renewable energy certificates (RECs).

**GREENHOUSE.** A structure or a thermally isolated area of a *building* that maintains a specialized sunlit environment with a skylight roof ratio of 50 percent or more above the growing area used exclusively used for, and essential to, the cultivation, protection or maintenance of plants. Greenhouses are those that are erected for a period of 180 days or more.

**GROUP R.** Buildings or portions of buildings that contain any of the following occupancies as established in the *International Building Code*:

1. Group R-1.
2. Group R-2 where located more than three stories in height above grade plane or where *dwelling units* are accessed from interior corridors or other interior spaces.
3. ~~2.~~ Group R-4 where located more than three stories in height above grade plane.

**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.

**HEAT TRAP, PIPE CONFIGURED.** A pipe configured heat trap is either, as applicable:

1. A device specifically designed for the purpose or an arrangement of tubing that forms a loop of 360 degrees, or
2. Piping that from the point of connection to the water heater (inlet or outlet) includes a length of piping directed downward before connection to the vertical piping of the supply water or hot-water distribution system.

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

**HEATED WATER CIRCULATION SYSTEM.** A water distribution system having one or more recirculation pumps that pump water from a heated water source through a dedicated hot water circulation pipe or piping system.

**HIGH-CAPACITY GAS-FIRED WATER HEATER.** Gas-fired instantaneous *water heaters* with a rated input greater than 200,000 Btu/h (58.6 kW) and not less than 4,000 Btu/h per gallon (310 W per liter) of stored water. Also, gas-fired storage *water heaters* with a rated input both greater than 105,000 Btu/h (30.8 kW) and less than 4,000 Btu/h per gallon (310 W per liter) of stored water.

**HIGH-END TRIM.** A lighting control setting that limits the maximum power to individual luminaires or groups of luminaires in a space.

**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.

**HISTORIC BUILDINGS**. 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.

**HORTICULTURAL LIGHTING.** Electric lighting used for horticultural production, cultivation or maintenance.

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

**HUMIDISTATIC CONTROLS.** *Automatic* controls used to maintain humidity at a setpoint.

**HVAC TOTAL SYSTEM PERFORMANCE RATIO (HVAC TSPR).** The ratio of the sum of a building's annual heating and cooling load in thousands of Btus to the sum of annual carbon emissions in pounds from energy consumption of the building HVAC systems. Carbon emissions shall be calculated by multiplying site energy consumption by the carbon emission factors from Table C407.1.

**IEC DESIGN H MOTOR.** An electric motor that meets all of the following:

1. It is an induction motor designed for use with three-phase power.
2. It contains a cage rotor.
3. It is capable of direct-on-line starting.

**Commented [DJ18]:** This would indicate that the first three stories of a high-rise apartment building are NOT Group R

**Commented [BK(19]:** Adding this descriptor to correlate with the scoping change for Group R in the 2021 code.

**Commented [KA20R19]:** R-3 doesn't need to be here because it's not covered by the Comm energy code, right?

**Commented [BK(21R19]:** Correct

**Commented [DJ22]:** same

**Commented [DJ23]:** Instantaneous water heaters don't have any stored water, do they?

4. It has 4, 6 or 8 poles.
5. It is rated from 0.4 kW to 1600 kW at a frequency of 60 Hz.

**IEC DESIGN N MOTOR.** An electric motor that meets all of the following:

1. It is an inductor motor designed for use with three-phase power.
2. It contains a cage rotor.
3. It is capable of direct-on-line starting.
4. It has 2, 4, 6 or 8 poles.
5. It is rated from 0.4 kW to 1600 kW at a frequency of 60 Hz.

**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.

**INFORMATION TECHNOLOGY EQUIPMENT (ITE).** Items including computers, data storage, servers, network, and /communication equipment.

**INSULATION ENTIRELY ABOVE DECK.** A roof with all insulation:p

1. Installed above (outside of) the roof structure; and
2. Continuous (i.e., uninterrupted by framing members).

**INTEGRATED ENERGY EFFICIENCY RATIO (IEER).** A single-number figure of merit expressing cooling part-load EER efficiency for unitary air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

**INTEGRATED HVAC SYSTEM.** An HVAC system designed to handle both sensible and latent heat removal. *Integrated HVAC systems* ~~may~~ include, but are not limited to, HVAC systems with a sensible heat ration of 0.65 or less and the capability of providing cooling, dedicated outdoor air systems, single package air conditioners with at least one refrigerant circuit providing hot gas reheat, and ~~stand-alone~~ *dehumidifiers* modified to allow external heat rejection.

**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.

**INTEGRATED SEASONAL COEFFICIENT OF PERFORMANCE (ISCOP).** A seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the two COP values for the heating season of a DX-DOAS unit water or air source heat pump, expressed in W/W.

**INTEGRATED SEASONAL MOISTURE REMOVAL EFFICIENCY (ISMRE).** A seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the four dehumidification moisture removal efficiency (MRE) ratings required for DX-DOAS units, expressed in lb. of moisture/kWh.

**INTERNAL CURTAIN SYSTEM.** A system consisting of moveable panels of fabric or plastic film used to cover and uncover the space enclosed in a *greenhouse* on a daily basis.

**ISOLATION DEVICES.** Devices that isolate HVAC zones so they can be operated independently of one another. Isolation devices include separate systems, isolation dampers and controls providing shutoff at terminal boxes.

**LABELED.** Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, approved 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.

**LARGE-DIAMETER CEILING FAN**. A ceiling fan that is greater than ~~seven feet~~ or equal to 84.5 inches (~~2134 mm~~2.15 m) in diameter. These fans are sometimes referred to as High-Volume, Low-Speed (HVLS) fans.

**LARGEST NET CAPACITY INCREMENT**. The largest increase in capacity when switching between combinations of base compressors that is expected to occur under the *compressed air system* control scheme.

**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* 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-CARBON DISTRICT ENERGY EXCHANGE SYSTEM**. Any system serving multiple buildings providing energy in the form of a circulated fluid that can accept or reject heat from individual buildings. Energy can be indirectly con-verted to meet building heating or cooling loads by serving as the heat source or sink for heat-pump systems. Examples include, but are not limited to, low temperature condenser water, ground source con-denser water, or sewer heat recovery.

Low-carbon district energy exchange systems must demonstrate that 25 percent of the annual district-system-net-load-met (sum of heating and cooling energy provided to attached buildings) comes from heat recovery between connected buildings, waste heat, or *renewable energy resources* and no more than 25 percent of the annual heat input to the system comes from fossil fuel or electric-resistance sources.

**LOW-CARBON DISTRICT HEATING AND COOLING OR HEATING ONLY SYSTEM**. Any system serving multiple buildings providing energy in the form of direct heating and cooling, or heating only to a building. Energy can be directly converted to meet building heating or cooling loads through a heat exchanger. Examples include, but are not limited to, steam, hot water, and chilled water.

Low-carbon district systems must demonstrate the following:

1. Distribution losses must be accounted for and may not exceed 10 percent of the annual load delivered to buildings served by the system.
2. Twenty-five percent of the annual district-system-net-load-met (sum of heating and cooling energy provided to attached buildings) comes from heat recovery between connected buildings, waste heat or *renewable energy resources* and no more than 25 percent of the annual heat input to the system comes from fossil fuel or electric resistance sources; or
3. No more than 10 percent of the system annual heat input to the system comes from fossil fuel or electric resistance sources.

~~**LOW SLOPED ROOF**~~**LOW SLOPE.** A ~~roof having a~~ slope less than 2 units vertical in 12 units horizontal (17 percent slope) as applied to roofs.

**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.** A lighting system consisting of an isolating power supply, the low voltage luminaires, and associated equipment that are all identified for the use.

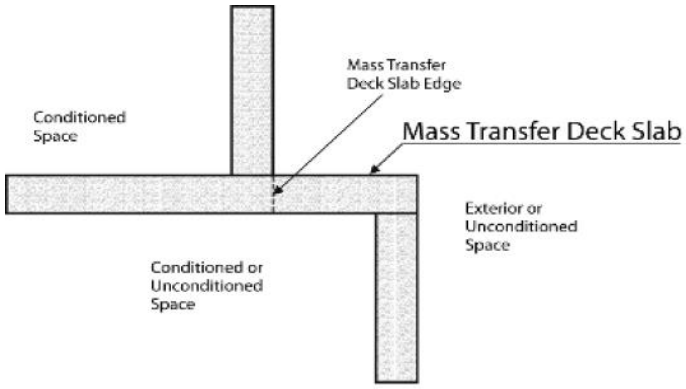
**LUMINAIRE.** A complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply.

**LUMINAIRE-LEVEL LIGHTING CONTROL.** A lighting system consisting of one or more *luminaires* where each *luminaire* has embedded lighting control logic, occupancy and ambient light sensors, and local override switching capability, where required. Each *luminaire* shall also have wireless networking capabilities to detect and share information with other *luminaires* to adjust to occupancy and/or daylight in the space.

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

**MASS TRANSFER DECK SLAB.** A concrete slab designed to transfer structural load from the building perimeter wall or column line above, laterally to an offset wall or column line below, and which has *conditioned* or *semi-heated space* on the inside of the upper wall and exterior or *unconditioned space* on the outside of the upper wall. The area of the slab edge shall be defined as the thickness of the slab multiplied by the length of the edge condition. Examples of this condition include, but are not limited to,

the transition from an above-grade structure to a below-grade structure or the transition from a tower to a podium. A cantilevered concrete balcony does not constitute a mass transfer deck slab.




**MECHANICAL COOLING.** Reducing the temperature of a gas or liquid by using vapor compression, absorption, desiccant dehumidification combined with evaporative cooling, or another energy-driven thermodynamic cycle. Indirect or direct evaporative cooling alone is not considered mechanical cooling.

**MECHANICAL HEATING.** Raising the temperature of a gas or liquid by use of fossil fuel burners, electric resistance heaters, heat pumps, or other systems that require energy to operate.

**MECHANICAL LOAD COEFFICIENT (MLC).** In a *data center*, the ratio of the cooling system's net use of energy to that of the *ITE*. The annual *MLC* is calculated using hourly weather data for the data center's location and equals the sum of all energy flowing into the cooling system to respond to that weather, minus any energy successfully recovered to avoid any new energy use, all divided by the energy flowing into the *ITE* during the same period.

**MECHANICAL ROOM.** A room or space in which mechanical equipment and appliances are located that has sufficient room for access and maintenance of the equipment or appliances with room energy doors closed.

**METAL BUILDING ROOF.** A roof that:

1. Is constructed with a metal, structural, weathering surface;
2. Has no ventilated cavity; and
3. Has the insulation entirely below deck (i.e., does not include composite concrete and metal deck construction nor a roof framing system that is separated from the superstructure by a wood substrate) and whose structure consists of one or more of the following configurations:
   a. Metal roofing in direct contact with the steel framing members;
   b. Metal roofing separated from the steel framing members by insulation;
   c. Insulated metal roofing panels installed as described in item a. or b.

**METER.** A device that measures the flow of energy.

**MICROCELL.** A wireless communication facility consisting of an antenna that is either: (a) Four (4) feet in height and with an area of not more than 580 square inches; or (b) if a tubular antenna, no more than four (4) inches in diameter and no more than six (6) feet in length; and the associated equipment cabinet that is six (6) feet or less in height and no more than 48 square feet in floor area.

**MULTI-PASS HEAT PUMP WATER HEATER.** A heat pump water heater control strategy requiring multiple passes of water through the heat pump to reach the final target storage water temperature.

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

**NEMA DESIGN A MOTOR.** A squirrel-cage motor that meets all of the following:

1. It is designed to withstand full-voltage starting and developing locked-rotor torque as shown in

paragraph 12.38.1 of NEMA MG 1.

2. It has pull-up torque not less than the values shown in paragraph 12.40.1 of NEMA MG 1.
3. It has breakdown torque not less than the values shown in paragraph 12.39.1 of NEMA MG 1.
4. It has a locked-rotor current higher than the values shown in paragraph 12.35.1 of NEMA MG 1 for 60 Hz and paragraph 12.35.2 of NEMA MG 1 for 50 Hz.
5. It has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

**NEMA DESIGN B MOTOR.** A squirrel-cage motor that meets all of the following:

1. It is designed to withstand full-voltage starting.
2. It develops locked-rotor, breakdown and pull-up torques adequate for general application as specified in Sections 12.38, 12.39 and 12.40 of NEMA MG 1.
3. It draws locked-rotor current not to exceed the values shown in paragraph 12.35.1 of NEMA MG 1 for 60 Hz and paragraph 12.35.2 of NEMA MG 1 for 50 Hz.
4. It has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

**NEMA DESIGN C MOTOR.** A squirrel-cage motor that meets all of the following:

1. It is designed to withstand full-voltage starting and developing locked-rotor torque for high-torque applications up to the values shown in paragraph 12.38.2 of NEMA MG 1 (incorporated by reference; see §431.15).
2. It has pull-up torque not less than the values shown in paragraph 12.40.2 of NEMA MG 1.
3. It has breakdown torque not less than the values shown in paragraph 12.39.2 of NEMA MG 1.
4. It has a locked-rotor current not to exceed the values shown in paragraph 12.35.1 of NEMA MG 1 for 60 Hz and paragraph 12.35.2 of NEMA MG 1 for 50 Hz.
5. It has a slip at rated load of less than 5 percent.

**NETWORKED GUEST ROOM CONTROL SYSTEM.** A control system, with access from the front desk or other central location associated with a Group R-1 building, that is capable of identifying the rented and unrented status of each guest room according to a timed schedule, and is capable of controlling HVAC in each hotel and motel guest room separately.

**NONSTANDARD PART LOAD VALUE (NPLV).** A single-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 conditions.

**NORTH-ORIENTED.** Facing within 67.5 degrees of true north.

**OCCUPANT SENSOR CONTROL.** An *automatic* control device or system that detects the presence or absence of people within an area and causes lighting, equipment or appliances to be regulated accordingly.

**OCCUPIED-STANDBY MODE.** Mode of operation when an HVAC *zone* is scheduled to be occupied and an occupant sensor indicates no occupants are within the *zone*.

**ON-SITE RENEWABLE ENERGY.** Energy from *renewable energy resources* harvested at the building site.

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

**OWNER.** Any person, agent, operator, entity, firm or corporation having any legal or equitable interest in the property; or recorded in the official records of the state, county or municipality as holding an interest or title to the property; or otherwise having possession or control of the property, including the guardian of the estate of any such person, and the executor or administrator of the estate of such person if ordered to take possession of real property by a court.

**PARKING AREA, EXTERIOR.** Parking spaces, drive aisles and ramps that are not located within a *building*, or that are located on a roof.

**PARKING AREA, INTERIOR.** Parking spaces, drive aisles and ramps located within a *building*.

**PARKING GARAGE SECTION.** A part of an enclosed parking garage that is separated from all other parts of the garage by full-height solid walls or operable openings that are intended to remain closed during normal operation and where vehicles cannot pass to other parts of the garage. A parking garage can have one or more *parking garage sections*, and *parking garage sections* can include multiple floors.

**PERSONAL WIRELESS SERVICE FACILITY.** A wireless communication facility (WCF), including a microcell, which is a facility for the transmission and/or reception of radio frequency signals and which may include antennas, equipment shelter or cabinet, transmission cables, a support structure to achieve the necessary elevation, and reception and/or transmission devices or antennas.

**PHOTOSYNTHETIC PHOTON EFFICACY (PPE).** Photosynthetic photon flux emitted by a light source divided by its electrical input ~~electric~~ power in units of micromoles per second per watt, or micromoles per joule (µmol/J) as defined by ANSI/ASABE S640.

**PHYSICAL RENEWABLE ENERGY POWER PURCHASE AGREEMENT.** A contract for the purchase of renewable electricity from a specific renewable electricity generator to a purchaser of renewable electricity.

**POWERED ROOF/WALL VENTILATORS.** A fan consisting 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.

**POWER-OVER-ETHERNET LIGHTING (POE).** Lighting sources powered by DC current utilizing Ethernet cables.

**PRIMARY STORAGE.** Compressed air storage located upstream of the distribution system and any pressure flow regulators

**PROCESS APPLICATION.** A manufacturing, industrial, or commercial procedure or activity where the primary purpose is other than conditioning spaces and maintaining comfort and amenities for the occupants of a *building*.

**PROPOSED DESIGN.** A description of the proposed building used to estimate annual energy use ~~and carbon emissions from energy consumption~~ for determining compliance based on ~~total~~ simulated building performance and *HVAC total performance ratio*.

**PSI-FACTOR (Ψ-FACTOR).** The heat loss factor per unit length of a *thermal bridge* characterized as a linear element of a *building thermal envelope* (Btu/h × ft × °F) [W/(m × K)].

**PUBLIC LAVATORY FAUCET.** A lavatory faucet that is not intended for private use as defined by the *Uniform Plumbing Code* and that is supplied with both potable cold and hot water.

**PUMP ENERGY INDEX (PEI).** The ratio of a pump's energy rating divided by the energy rating of a minimally compliant pump. For pumps with the constant load operating mode, the relevant PEI is $PEI_{CL}$. For pumps with the variable load operating mode, the relevant PEI is $PEI_{VL}$.

**PURCHASED ENERGY.** Energy or power purchased for consumption and delivered to the *building site*.

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

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

**REFRIGERANT DEW POINT.** The refrigerant vapor saturation temperature at a specified pressure.

**REFRIGERATED WAREHOUSE COOLER.** An enclosed storage space that has a total chilled storage area of 3,000 square feet or greater and is designed to maintain a temperature of greater than 32°F but less than 55°F.

**REFRIGERATED WAREHOUSE FREEZER.** An enclosed storage space that has a total chilled storage area of 3,000 $ft^2$ and is designed to maintain temperatures at or below 32°F.

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

**REFRIGERATION SYSTEM, MEDIUM TEMPERATURE.** 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.

**RENEWABLE ENERGY CERTIFICATE (REC).** A market-based instrument that represents and conveys the

**Commented [DJ24]:** I think these terms relate to a calculation in some other standard that should be defined somewhere.

environmental, social and other nonpower attributes of 1 megawatt hour of renewable electricity generation and could be sold separately from the underlying physical electricity associated with *renewable energy resources*, also known as energy attribute and energy attribute certificate (EAC).

**RENEWABLE ENERGY INVESTMENT FUND (REIF).** A fund established by a jurisdiction to accept payment from building project owners to construct or acquire interests in qualifying renewable energy systems, together with their associated RECs, on the building project owners' behalf.

**RENEWABLE ENERGY RESOURCES.** Energy derived from solar radiation, wind, waves, tides, ~~*biogas,*~~ *biomass waste*, or extracted from hot fluid or steam heated within the earth.

**RENEWABLE POWER PURCHASE AGREEMENT.** A power purchase agreement for off-site renewable energy where the owner agrees to purchase renewable energy output and the associated renewable energy certificates at a fixed price schedule.

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

**REPLACEMENT AIR.** Outdoor air that is used to replace air removed from a building through an exhaust system. Replacement air may be derived from one or more of the following: makeup air, supply air, transfer air and infiltration. However, the ultimate source of all replacement air is outdoor air. When replacement air exceeds exhaust, the result is exfiltration.

**REROOFING.** The process of recovering or replacing an existing roof covering. See "Roof Recover" and "Roof Replacement."

**RESIDENTIAL BUILDING.** For this code, the following building types are residential buildings:

1. Detached one- and two-family dwellings.
2. Multiple single-family dwellings (townhouses).
3. Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane whose *dwelling units* are accessed directly from the exterior.
4. Accessory structures to residential buildings.

Group R-2 buildings with *dwelling units* accessed from interior corridors or other interior spaces are not *residential buildings*.

**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. See also *attic and other roofs*, *metal building roof*, roof with *insulation entirely above deck* and *single-rafter roof*.

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

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

**ROOF REPLACEMENT**. ~~The process of removing the existing roof covering, repairing any damaged substrate and installing a new *roof covering*~~An *alteration* that includes the removal of all existing layers of *roof assembly* materials down to the roof deck and the installation of replacement materials above the existing roof deck.

**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 ($h \times ft^2 \times °F/Btu$) [$(m^2 \times K)/W$].

**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.

**SEMI-HEATED SPACE.** An enclosed space within a building, including adjacent connected spaces separated by an uninsulated component (e.g., basements, utility rooms, garages, corridors), which:

**Commented [DJ25]:** Seems like we need to leave "biomass" in this list separately from "biomass waste," since biomass includes wood and biomass waste doesn't. Also not sure why we're striking biogas.

**Commented [BK(26]:** Group R-4 was readopted after the 2021 code cycle.

1. Is heated but not cooled, and has an installed heating system output capacity greater than or equal to 3.4 Btu/(h-ft$^2$) but not greater than 8 Btu/(h-ft$^2$);
2. Is not a *walk-in cooler*, *walk-in freezer*, *refrigerated warehouse cooler* or *refrigerated warehouse freezer* space.

**SENSIBLE RECOVERY EFFECTIVENESS.** Change in the dry-bulb temperature of the outdoor air supply divided by the difference between the outdoor air and return air dry-bulb temperatures, expressed as a percentage, governed by AHRI Standard 1060.

**SERVICE WATER HEATING.** Heating water for domestic or commercial purposes other than space heating and process requirements.

**SIDELIT.** See Section C405.2.5.2.

**SIMULATED BUILDING PERFORMANCE.** A process in which the proposed building design is compared to a *standard reference design* for the purposes of estimating relative energy use against a baseline to determine code compliance.

**SINGLE-PASS HEAT PUMP WATER HEATER.** A heat pump water heater control strategy using variable flow or variable capacity to deliver water from the heat pump at the final target storage water temperature in a single-pass pump through the heat exchanger with variable incoming water temperatures.

**SINGLE-RAFTER ROOF.** A roof where the roof above and the ceiling below are both attached to the same wood rafter and where insulation is located in the space between these wood rafters.

**SKYLIGHT.** See "Fenestration."

**SLAB BELOW GRADE.** Any portion of a slab floor in contact with the ground which is more than 24 inches below the final elevation of the nearest exterior grade.

**SLAB-ON-GRADE FLOOR.** That portion of a slab floor of the *building thermal envelope* that is in contact with the ground and that is either above grade or is less than or equal to 24 inches below the final elevation of the nearest exterior grade.

**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 BUSINESS.** Any business entity (including a sole proprietorship, corporation, partnership or other legal entity) which is owned and operated independently from all other businesses, which has the purpose of making a profit, and which has fifty or fewer employees.

**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.

**SOLAR ZONE.** A clear area or areas reserved solely for current and future installation of photovoltaic or solar hot water systems.

**SOUTH-ORIENTED.** Facing within 45 degrees of true south.

**SPACE CONDITIONING CATEGORY.** Categories are based on the allowed peak space conditioning output capacity per square foot of *conditioned floor area*, or the design setpoint temperature, for a building or space. Space conditioning categories from lowest to highest include: low energy, semi-heated, conditioned, refrigerated walk-in and warehouse coolers, and refrigerated walk-in and warehouse freezers.

**STAND-ALONE DEHUMIDIFIER.** A product with the sole purpose of dehumidifying the space that does not include a portable air conditioner, room air conditioner, or packaged terminal air conditioner. Stand-alone dehumidifier is a self-contained, electrically operated, and mechanically encased assembly consisting of:

1. A refrigerated surface (evaporator) that condenses moisture from the atmosphere;
2. A refrigerating system, including an electric motor;
3. An air-circulating fan; and

4. A means for collecting or disposing of the condensate.

**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 and carbon emissions from energy consumption for compliance based on total simulated building performance and *HVAC total system performance ratio*.

**STEEL-FRAMED WALL.** A *wall* with a cavity (insulated or otherwise) whose exterior surfaces are separated by steel framing members (i.e., typical steel stud *walls* and curtain *wall systems*).

**STOREFRONT.** A 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, with or without mulled windows and doors.

**SUBSTANTIAL IMPROVEMENT.** Any *repair*, reconstruction, rehabilitation, *alteration*, *addition* or other improvement of a *building* or structure, the cost of which equals or is more than 50 percent of the market value of the structure before the improvement. Where the structure has sustained substantial damage, as defined in the *International Building Code*, any *repairs* are considered *substantial improvement* regardless of the actual *repair* work performed. *Substantial improvement* does not include the following:

1. Improvement of a *building* ordered by the code official to correct health, sanitary or safety code violations.
2. *Alteration* of a historic building where the *alteration* will not affect the designation as a historic building.

**SUBSYSTEM METER.** A meter placed downstream of the energy supply meter that measures the energy delivered to a load or a group of loads.

**SYSTEM.** A combination of equipment and auxiliary devices (e.g., controls, accessories, interconnection means and terminal elements) by which energy is transformed so it performs a specific function, such as HVAC, *service water heating* or lighting.

**TEMPERATURE MAINTENANCE.** The system used to maintain the temperature of the building service hot water delivery system, typically by circulation and reheating or by a heat trace system.

**TEMPORARY GROWING STRUCTURE.** A temporary growing structure has sides and roof covered with polyethylene, polyvinyl or similar flexible synthetic material and is used to provide plants with either frost protection or increased heat retention. Temporary structures are those that are erected for a period of less than 180 days.

**TESTING UNIT ENCLOSURE AREA.** The area sum of all the boundary surfaces that define the dwelling unit, sleeping unit, or ~~occupiable~~ conditioned enclosed space including top/ceiling, bottom/floor and all side walls. This does not include interior partition walls within the dwelling unit, sleeping unit, or ~~occupiable~~ conditioned enclosed space. Wall height shall be measured from the finished floor of the conditioned space to the finished floor or roof/ceiling air barrier above.

**THERMAL BLOCK.** A generic concept used in energy simulation. It can include one or more thermal zones. It represents a whole *building* or portion of a *building* with the same use type served by the same HVAC system type.

**THERMAL BRIDGE.** An element or interface of elements that has higher thermal conductivity than the surrounding *building thermal envelope*, which creates a path of least resistance for heat transfer.

**THERMAL DISTRIBUTION EFFICIENCY (TDE).** The resistance to changes in air heat as air is conveyed through a distance of air duct. TDE is a heat loss calculation evaluating the difference in the heat of the air between the air duct inlet and outlet caused by differences in temperatures between the air in the duct and the duct material. TDE is expressed as a percent difference between the inlet and outlet heat in the duct.

**THERMOSTAT.** An *automatic* control device used to maintain temperature at a fixed or adjustable setpoint.

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

**TOPLIT.** See Section C405.2.5.3

**TUBULAR DAYLIGHTING DEVICE (TDD).** A non-operable skylight device primarily designed to transmit daylight from a roof surface to an interior ceiling surface via a tubular conduit. The device consists of an exterior glazed weathering surface, a light transmitting tube with a reflective inside surface and an interior sealing device, such as a translucent ceiling panel.

***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 x $ft^2$ x°F) [W/($m^2$ x K)].

**UNCONDITIONED SPACE.** An enclosed space within a building that is not a *conditioned space* and that is not categorized under Section C402.1.1. Crawlspaces, attics and parking garages with natural or mechanical ventilation are not considered *enclosed spaces*.

**UNHEATED SLAB-ON-GRADE FLOOR.** A slab-on-grade floor that is not a heated slab-on-grade floor.

**UNIFORM ILLUMINATION.** A quality of illumination delivered by a lighting system typically comprised of similar fixtures mounted at a regular spacing interval. This lighting system provides a uniform contrast ratio of no greater that 5:1 maximum-to-minimum ratio throughout the entire area served, including task areas.

**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.

**VERTICAL FENESTRATION.** See "Fenestration."

**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. For skylights, VT shall be measured and rated in accordance with NFRC 202.

**VISIBLE TRANSMITTANCE – ANNUAL [VT-ANNUAL].** The ratio of visible light entering the space through the fenestration product assembly to the incident visible light during the course of a year, which includes the effects of glazing material, frame, and light well or tubular conduit, and is expressed as a number between 0 and 1. For tubular daylighting devices, VT-annual shall be measured and rated in accordance with NFRC 203.

**VOLTAGE DROP.** A decrease in voltage caused by losses in the wiring system that connect the power source to the load.

**WALK-IN COOLER.** An enclosed storage space capable of being refrigerated to temperatures above 32°F but less than 55°F 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 $ft^2$.

**WALK-IN FREEZER.** An enclosed storage space capable of being refrigerated to temperatures at or below 32°F that can be walked into, has a ceiling height of not less than 7 feet and has a total chilled storage area of less than 3,000 $ft^2$.

**WALL.** That portion of the *building thermal envelope*, including opaque area and *fenestration*, that is vertical or tilted at an angle of 60 degrees from horizontal or greater. This includes *above-grade walls* and *below-grade walls*, between floor spandrels, peripheral edges of floors, foundation *walls*, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof, mechanical equipment penetrations and skylight shafts.

**WALL, METAL BUILDING.** A *wall* whose structure consists of metal spanning members supported by steel

structural members (i.e., does not include spandrel glass or metal panels in curtain *wall systems*).

**WALL, WOOD-FRAMED AND OTHER.** All other *wall* types, including wood stud *walls*.

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

**WEST-ORIENTED.** Facing within 45 degrees of true west to the south and within less than 22.5 degrees of true west.

**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 [CE]

# GENERAL REQUIREMENTS

## SECTION C301
## CLIMATE ZONES

**C301.1 General.** Climate zones from Table C301.1 shall be used in determining the applicable requirements from Chapter 4.

### TABLE C301.1
### CLIMATE ZONES, MOISTURE REGIMES, AND WARM-HUMID DESIGNATIONS BY STATE AND COUNTY

Key: A – Moist, B - Dry, C - Marine
Absence of moisture designation indicates moisture regime is irrelevant

**WASHINGTON**

| | | |
|---|---|---|
| 5B Adams | 4C Grays Harbor | 4C Pierce |
| 5B Asotin | 4C Island | 4C San Juan |
| 5B Benton | 4C Jefferson | 4C Skagit |
| 5B Chelan | 4C King | 5B Skamania |
| 4C Clallam | 4C Kitsap | 4C Snohomish |
| 4C Clark | 5B Kittitas | 5B Spokane |
| 5B Columbia | 5B Klickitat | 5B Stevens |
| 4C Cowlitz | 4C Lewis | 4C Thurston |
| 5B Douglas | 5B Lincoln | 4C Wahkiakum |
| 5B Ferry | 4C Mason | 5B Walla Walla |
| 5B Franklin | 5B Okanogan | 4C Whatcom |
| 5B Garfield | 4C Pacific | 5B Whitman |
| 5B Grant | 5B Pend Oreille | 5B Yakima |

## SECTION C302
## DESIGN CONDITIONS

**C302.1 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.

**C302.2 Exterior design conditions.** The heating or cooling outdoor design temperatures shall be selected from Appendix C.

## SECTION C303
## MATERIALS, SYSTEMS AND EQUIPMENT

**C303.1 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.

**C303.1.1 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. Alternatively, 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. For insulated siding, the *R*-value shall be labeled on the product's package and shall be listed on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

**Exception**: For roof insulation installed above the deck, the R-value shall be labeled as required by the material standards specified in Table 1508.2 of the *International Building Code*.

**C303.1.1.1 Blown or sprayed roof/ceiling insulation.** The thickness of blown-in or sprayed fiberglass and cellulose roof/ceiling insulation shall be written in inches (mm) on markers for every 300 square feet (28 $m^2$) of attic area throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers of not less than 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed *R*-value shall be *listed* on certification provided by the insulation installer.

**C303.1.2 Insulation mark installation.** Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable upon inspection. For insulation materials that are installed without an observable manufacturer's *R*-value mark, such as blown or draped products, an insulation certificate complying with Section C303.1.1 shall be left immediately after installation by the installer, in a conspicuous location within the building, to certify the installed *R*-value of the insulation material.

**Exception**: For roof insulation installed above the deck, the *R*-value shall be *labeled* as specified by the material standards in Table 1508.2 of the *International Building Code*.

**C303.1.3 Fenestration product rating.** *U*-factors, solar heat gain coefficient (SHGC and visible transmittance (VT) of fenestration shall be determined as follows:

1. For windows, doors and skylights, U-factor, SHGC and VT ratings shall be determined in accordance with NFRC 100 and NFRC 200.

2. Where required for garage doors and rolling doors, U-factor ratings shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

*U*-factors, SHGC and VT shall be determined by an accredited, independent laboratory, and labeled and certified by the manufacturer with a label affixed to the product or a label certificate specific to the products in the project.

Products lacking such a labeled *U*-factor shall be assigned a default *U*-factor from Table C303.1.3(1), C303.1.3(2) or C303.1.3(4). ~~The solar heat gain coefficient (SHGC) and visible transmittance (VT) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer.~~ Products lacking such a labeled SHGC or VT shall be assigned a default SHGC or VT from Table C303.1.3(3). For tubular daylighting devices, $VT_{annual}$ shall be measured and rated in accordance with NFRC 203.

**Exception**: Units without NFRC ratings produced by a *small business* may be assigned default *U*-factors from Table C303.1.3(5) for vertical fenestration.

**TABLE C303.1.3(1)**
**DEFAULT GLAZED WINDOW, GLASS DOOR AND SKYLIGHT *U*-FACTORS**

| FRAME TYPE | Window and Glass Door | | SKYLIGHT |
|---|---|---|---|
| | SINGLE PANE | DOUBLE PANE | |
| Metal | 1.20 | 0.80 | See Table C303.1.3(4) |
| Metal with Thermal Break[a] | 1.10 | 0.65 | |
| Nonmetal or Metal Clad | 0.95 | 0.55 | |
| ~~Glazed~~ Glass Block | 0.60 | | |

[a] Metal Thermal Break .= A metal thermal break framed window shall incorporate the following minimum design characteristics:

1) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/$ft^2$/°F;
2) The thermal break material must produce a gap in the frame material of not less than 0.210 inches; and
3) All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in 1) and 2) above.

**TABLE C303.1.3(2)**
**DEFAULT OPAQUE DOOR *U*-FACTORS**

See Appendix A, Section A107

**TABLE C303.1.3(3)**
**DEFAULT GLAZED FENESTRATION**
**SHGC AND VT**

| | SINGLE GLAZED | | DOUBLE GLAZED | | GLAZED BLOCK |
|---|---|---|---|---|---|
| | Clear | Tinted | Clear | Tinted | |
| SHGC | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| VT | 0.6 | 0.3 | 0.6 | 0.3 | 0.6 |

**TABLE C303.1.3(4)**
**DEFAULT *U*-FACTORS FOR SKYLIGHTS**

| Fenestration Type | Frame Type | | | |
|---|---|---|---|---|
| | Aluminum Without Thermal Break | Aluminum With Thermal Break | Reinforced Vinyl/ Aluminum-Clad Wood or Vinyl | Wood or Vinyl-Clad Wood/ Vinyl without Reinforcing |
| Single Glazing | | | | |
| glass | U-1.58 | U-1.51 | U-1.40 | U-1.18 |
| acrylic/polycarb | U-1.52 | U-1.45 | U-1.34 | U-1.11 |
| Double Glazing | | | | |
| air | U-1.05 | U-0.89 | U-0.84 | U-0.67 |
| argon | U-1.02 | U-0.86 | U-0.80 | U-0.64 |
| Double Glazing, *e*=0.20 | | | | |
| air | U-0.96 | U-0.80 | U-0.75 | U-0.59 |
| argon | U-0.91 | U-0.75 | U-0.70 | U-0.54 |
| Double Glazing, *e*=0.10 | | | | |
| air | U-0.94 | U-0.79 | U-0.74 | U-0.58 |
| argon | U-0.89 | U-0.73 | U-0.68 | U-0.52 |
| Double Glazing, *e*=0.05 | | | | |
| air | U-0.93 | U-0.78 | U-0.73 | U-0.56 |
| argon | U-0.87 | U-0.71 | U-0.66 | U-0.50 |
| Triple Glazing | | | | |
| air | U-0.90 | U-0.70 | U-0.67 | U-0.51 |
| argon | U-0.87 | U-0.69 | U-0.64 | U-0.48 |
| Triple Glazing, *e*=0.20 | | | | |
| air | U-0.86 | U-0.68 | U-0.63 | U-0.47 |
| argon | U-0.82 | U-0.63 | U-0.59 | U-0.43 |
| Triple Glazing, *e*=0.20 on 2 surfaces | | | | |
| air | U-0.82 | U-0.64 | U-0.60 | U-0.44 |
| argon | U-0.79 | U-0.60 | U-0.56 | U-0.40 |
| Triple Glazing, *e*=0.10 on 2 surfaces | | | | |
| air | U-0.81 | U-0.62 | U-0.58 | U-0.42 |
| argon | U-0.77 | U-0.58 | U-0.54 | U-0.38 |
| Quadruple Glazing, *e*=0.10 on 2 surfaces | | | | |
| air | U-0.78 | U-0.59 | U-0.55 | U-0.39 |
| argon | U-0.74 | U-0.56 | U-0.52 | U-0.36 |
| krypton | U-0.70 | U-0.52 | U-0.48 | U-0.32 |

**Notes for Table C303.1.3(4)**

1. U-factors are applicable to both glass and plastic, flat and domed units, all spacers and gaps.
2. Emissivities shall be less than or equal to the value specified.
3. Gap fill shall be assumed to be air unless there is a minimum of 90% argon or krypton.

4. Aluminum frame with thermal break is as defined in footnote 1 to Table C303.1.3(1).

**TABLE C303.1.3(5)**
**SMALL BUSINESS COMPLIANCE TABLE**
**DEFAULT *U*-FACTORS FOR VERTICAL FENESTRATION**

| Vertical Fenestration Description | | | | Frame Type | | |
|---|---|---|---|---|---|---|
| | | | | Any Frame | Aluminum Thermal Break[2] | Wood/Vinyl/ Fiberglass |
| **Panes** | **Low-e[1]** | **Spacer** | **Fill** | | | |
| Double[3] | A | Any | Argon | 0.48 | 0.41 | 0.32 |
| | B | Any | Argon | 0.46 | 0.39 | 0.30 |
| | C | Any | Argon | 0.44 | 0.37 | 0.28 |
| | C | High Performance | Argon | 0.42 | 0.35 | Deemed to comply[5] |
| Triple[4] | A | Any | Air | 0.50 | 0.44 | 0.26 |
| | B | Any | Air | 0.45 | 0.39 | 0.22 |
| | C | Any | Air | 0.41 | 0.34 | 0.20 |
| | Any double low-e | Any | Air | 0.35 | 0.32 | 0.18 |

[1] Low-eA (emissivity) shall be 0.24 to 0.16.
Low-eB (emissivity) shall be 0.15 to 0.08.
Low-eC (emissivity) shall be 0.07 or less.

[2] Aluminum Thermal Break = An aluminum thermal break framed window shall incorporate the following minimum design characteristics:

a) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft$^2$/°F;

b) The thermal break material must produce a gap in the frame material of not less than 0.210 inches; and

c) All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in a) and b) above.

[3] A minimum air space of 0.375 inches between panes of glass is required for double glazing.

[4] A minimum air space of 0.25 inches between panes of glass is required for triple glazing.

[5] Deemed to comply glazing shall not be used for performance compliance.

**C303.1.4 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 (C.F.R. Title 16, Part 460) in units of h × ft$^2$ × °F/Btu at a mean temperature of 75°F (24°C).

**C303.1.4.1 Insulated siding.** The thermal resistance (*R*-value) shall be determined in accordance with ASTM C1363. Installation for testing shall be in accordance with the manufacturer's installation instructions.

**C303.1.5 Spandrel panels in glass curtain walls.** Table C303.1.5 provides default U-factors for the spandrel section of glass and other curtain wall systems. Design factors that affect performance are the type of framing, the type of spandrel panel and the R-value of insulation. Four framing conditions are considered in the table. The first is the common case where standard aluminum mullions are used. Standard mullions provide a thermal bridge through the insulation, reducing its effectiveness. The second case is for metal framing members that have a thermal break. A thermal break frame uses a urethane or other non-metallic element to separate the metal exposed to outside conditions from the metal that is exposed to interior conditions. The third case is for structural glazing or systems where there are no exposed mullions on the exterior. The fourth case is for the condition where there is no framing or the insulation is continuous and uninterrupted by

framing. The columns in the table can be used for any specified level of insulation between framing members installed in framed curtain walls or spandrel panels.

**Table C303.1.5**
**U-Factors for Spandrel Panels and Glass Curtain Walls**

| | | | Rated R-Value of Insulation Between Framing Members | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | None | R-4 | R-7 | R-10 | R-15 | R-20 | R-25 | R-30 |
| **Frame Type** | **Spandrel Panel** | | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** |
| Aluminum without Thermal Break | Single glass pane, stone or metal panel | 1 | 0.360 | 0.242 | 0.222 | 0.212 | 0.203 | 0.198 | 0.195 | 0.193 |
| | Double glass with no low-e coatings | 2 | 0.297 | 0.233 | 0.218 | 0.209 | 0.202 | 0.197 | 0.194 | 0.192 |
| | Triple or low-e glass | 3 | 0.267 | 0.226 | 0.214 | 0.207 | 0.200 | 0.196 | 0.194 | 0.192 |
| Aluminum with Thermal Break | Single glass pane, stone or metal panel | 4 | 0.350 | 0.211 | 0.186 | 0.173 | 0.162 | 0.155 | 0.151 | 0.149 |
| | Double glass with no low-e coatings | 5 | 0.278 | 0.200 | 0.180 | 0.170 | 0.160 | 0.154 | 0.151 | 0.148 |
| | Triple or low-e glass | 6 | 0.241 | 0.191 | 0.176 | 0.167 | 0.159 | 0.153 | 0.150 | 0.148 |
| Structural Glazing | Single glass pane, stone or metal panel | 7 | 0.354 | 0.195 | 0.163 | 0.147 | 0.132 | 0.123 | 0.118 | 0.114 |
| | Double glass with no low-e coatings | 8 | 0.274 | 0.180 | 0.156 | 0.142 | 0.129 | 0.122 | 0.117 | 0.114 |
| | Triple or low-e glass | 9 | 0.231 | 0.169 | 0.150 | 0.138 | 0.127 | 0.121 | 0.116 | 0.113 |
| No Framing, or Insulation is Continuous | Single glass pane, stone or metal panel | 10 | 0.360 | 0.148 | 0.102 | 0.078 | 0.056 | 0.044 | 0.036 | 0.031 |
| | Double glass with no low-e coatings | 11 | 0.297 | 0.136 | 0.097 | 0.075 | 0.054 | 0.043 | 0.035 | 0.030 |
| | Triple or low-e glass | 12 | 0.267 | 0.129 | 0.093 | 0.073 | 0.053 | 0.042 | 0.035 | 0.030 |

**C303.1.5.1 Window wall application**. Where “window wall” or similar assembly that is discontinuous at intermediate slab edges is used, the slab edge U-value shall be as listed in Appendix Table A103.3.7.1(3) or as determined using an approved calculation.

**303.1.5.2 Table value assumptions**. In addition to the spandrel panel assembly, the construction assembly U-factors assume an air gap between the spandrel panel (with an R-value of 1.39) and one layer of 5/8-inch gypsum board (with an R-value of 0.56) that provides the interior finish. The gypsum board is assumed to span between the window sill and a channel at the floor. For assemblies that differ from these assumptions, custom U-factors can be calculated to account for any amount of continuous insulation or for unusual construction assemblies using Equations 3-1, 3-2 or 3-3 where appropriate. Spandrel panel U-factors for assemblies other than those covered by this table or Equations 1-3 may be determined using an alternate approved methodology. Equations 3-1 through 3-3 do not calculate the value of any insulation inboard of the curtain wall assembly.

**Aluminum without Thermal Break** **(Equation 3-1)**

$$U_{overall} = \left[ \frac{1}{(R_{gypsum} + R_{airgap}) + \left[ \frac{1}{0.2798 + \left( \frac{0.8929}{R_{addedinsulation} + \left( \frac{1}{U_{centerofglass}} \right)} \right)} \right]} \right]$$

**Aluminum with Thermal Break** **(Equation 3-2)**

$$U_{overall} = \left[ \frac{1}{(R_{gypsum} + R_{airgap}) + \left[ \frac{1}{0.1808 + \left( \frac{0.8874}{R_{addedinsulation} + \left( \frac{1}{U_{centerofglass}} \right)} \right)} \right]} \right]$$

**Structural Glazing** **(Equation 3-3)**

$$U_{overall} = \left[ \frac{1}{(R_{gypsum} + R_{airgap}) + \left[ \frac{1}{0.1151 + \left( \frac{0.9487}{R_{addedinsulation} + \left( \frac{1}{U_{centerofglass}} \right)} \right)} \right]} \right]$$

**C303.2 Installation.** Materials, systems and equipment shall be installed in accordance with the manufacturer's instructions and the *International Building Code* or *International Residential Code*, as applicable.

**C303.2.1 Protection of exposed foundation insulation.** Insulation applied to the exterior of basement walls, crawlspace walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend not less than 6 inches (153 mm) below grade.

**C303.2.2 Multiple layers of continuous insulation.** 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 C303.2. 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.

# CHAPTER 4 [CE]

# COMMERCIAL ENERGY EFFICIENCY

## SECTION C401
## GENERAL

**C401.1 Scope.** The provisions in this chapter are applicable to commercial *buildings* and their *building sites*.

**C401.2 Application.** Commercial buildings shall comply with the fossil fuel compliance path according to Section C401.3, or with one of the following:

1. Prescriptive Compliance. The prescriptive compliance option requires compliance with Sections C402 through C406, and Sections C408, C409, C410, C411, and C412.
2. ~~*Total*~~ *Simulated Building Performance*. The ~~*total*~~ *Simulated Building Performance* option requires compliance with Section C407.
3. When adopted by the local jurisdiction, the requirements of Appendix F, Outcome-Based Energy Budget, Sections C408, C409, C410, C411, C412 and any specific section in Table C407.2 as determined by the local jurisdiction. The Proposed Total UA of the proposed building shall be no more than 20 percent higher than the Allowed Total UA as defined in Section C402.1.5.

**C401.2.1 Application to existing buildings.** Additions, alterations, repairs, and changes of space conditioning, occupancy, or use to existing buildings shall comply with Chapter 5.

**C401.2.2 Application to process equipment**. Energy using equipment used by a manufacturing, industrial, or commercial process other than for conditioning spaces or maintaining comfort and amenities for the occupants shall comply with Section C401.3.1 Item 2, Section C403.3.2, Tables C403.3.2(1) through (16) inclusive, Sections C403.3.4.1 through C403.3.4.3, C403.7.7, C403.9.2.1, C403.10.3, C403.11.2, C403.11.3, Table C404.2, and Sections C405.8, C410, and C412.

**C401.3 Fossil fuel compliance path.** Buildings complying with the fossil fuel compliance path shall comply with the prescriptive compliance path of this code as defined in Item 1 of Section C401.2, and as modified by this Section C401.3.

**C401.3.1 Modification of code requirements.** For use of this compliance path only, the following changes shall be made to this code:

1. **Section C403.1.4 - Space heating.** Strike the phrase "...or fossil fuel combustion..." from the first sentence of Section C403.1.4.
2. **Section C404.2.1 - Service water heating.** Revise the first sentence of Section C404.2.1 to read: "Service hot water shall be provided by fossil fuel water heating equipment, electric air-source heat pump water heating equipment, electric resistance water heating equipment, or a combination of these equipment types meeting the requirements of this section."
3. **Section C406.2.5 - Renewable energy.** When determining renewable energy credits in Equation 4-17 of Section C406.2.5, strike the phrase "...limited to 50 percent of the required credits in Section C406.1" in the definition of the factor $AEC_{RRa}$.
4. **Table C406.2 - Efficiency measure credits.** Use Table C406.2(2) credit values in place of Table C406.2(1) credit values.

**C401.3.2 Fossil fuel equipment.** Fossil fuel combustion appliances are permitted for HVAC heating, and shall comply with the applicable efficiency standards referenced in Section C403.3.3.2. Fossil fuel combustion appliances are permitted for service water heating, and shall comply with applicable efficiency standards referenced in Table C404.2.

**C401.3.3 Additional efficiency credits.** The number of additional efficiency credits required by Table C406.1 shall be increased by the number required in Table C401.3.3, modified as permitted in this section, and is in addition to the energy efficiency credits and load management credits required by Section C406.

**Exception:** The required number of space heating additional efficiency credits are permitted to be reduced

**Commented [KA27]:** Do you think we need to define fossil fuel?

**Commented [BK(28R27]:** ASHRAE 90.1 definition: ***Fossil fuel:*** *Fuel derived from a hydrocarbon deposit, such as petroleum, coal, or natural gas derived from living matter of a previous geologic time.*

in the following instances:

1. Low energy spaces in accordance with Section C402.1.1.1 and equipment buildings in accordance with Section C402.1.2 that are served by space heating systems shall comply with sufficient measures from Table C406.2(1) or Table C406.2(2) to achieve a minimum of 50 percent of the efficiency credits required for new construction by Table C401.3.3, modified as permitted in this section.
2. Building additions that have less than 1,000 square feet of conditioned floor area and that comply with sufficient measures from Table C406.2(1) or Table C406.2(2) to achieve a minimum of 50 percent of the additional efficiency credits required for additions by Table C401.3.3, modified as permitted in this section.
3. Semi-heated spaces in accordance with Section C402.1.1.2 that comply with sufficient measures from Table C406.2(1) or Table C406.2(2) to achieve a minimum of 50 percent of the space heating additional efficiency credits required by Table C401.3.3, modified as permitted in this section.
4. Unconditioned spaces, open parking garages and unheated enclosed parking garages are not required to achieve the additional efficiency credits for space heating required by Table C401.3.3.

**TABLE C401.3.3**
**ADDITIONAL CREDITS REQUIRED**

| Measure Title | Applicable Section | Occupancy Group | | | | | |
|---|---|---|---|---|---|---|---|
| | | Group R-1 | Group R-2 | Group B | Group E | Group M | All Other |
| New building - Additional efficiency credits required for space heating systems using the fossil fuel pathway | C401.3.3.1 | 7 | 24 | 101 | 38 | 111 | 56 |
| New building - Additional efficiency credits required for service water heating systems using the fossil fuel pathway | C401.3.3.2 | 198 | 212 | 27 | 17 | 79 | 107 |
| Building additions - Additional efficiency credits required for space heating systems using the fossil fuel pathway | C401.3.3.1 | 4 | 12 | 51 | 19 | 56 | 28 |
| Building additions - Additional efficiency credits required for service water heating systems using the fossil fuel pathway | C401.3.3.2 | 99 | 106 | 14 | 9 | 40 | 54 |

**C401.3.3.1 HVAC credit modification.** The number of HVAC heating energy efficiency credits required by Table C401.3.3 is permitted to be decreased according to ~~the following equation~~Equation 4-1:

$$CR = A \times (C - B)/D \quad \textbf{(Equation 4-1)}$$

Where:

CR = Additional credits required, rounded to the nearest whole number.

A = Baseline HVAC heating credits from Table C401.3.3.

B = Installed fossil fuel space heating capacity in kBTU/h of appliances that comply with any of the exceptions to Section C403.1.4.

C = Total installed fossil fuel space heating capacity in kBTU/h of all HVAC heating appliances.

D = Total capacity in kBTU/h of all types of space heating

appliances.

**C401.3.3.2 Service water heating credit modification.** The number of service water heating energy efficiency credits required by Table C401.3.3 is permitted to be decreased according to ~~the following equation~~Equation 4-2:

$$CR = A \times (C - B)/D \quad \textbf{(Equation 4-2)}$$

Where:

| | | |
|---|---|---|
| CR | = | Additional credits required, rounded to the nearest whole number. |
| A | = | Baseline credits from Table C401.3.3. |
| B | = | Installed service water heating appliances capacity in kBTU/h of service water heating appliances that comply with any of the exceptions to Section C404.2.1. |
| C | = | Total installed fossil fuel service water heating capacity in kBTU/h of all service water heating appliances. |
| D | = | Total capacity in kBTU/h of all types of service water heating appliances. |

**C401.3.4 Renewable energy credit limit.** No more than 80 percent of the efficiency credits required by Sections C401.3.3.1 and C401.3.3.2 are permitted to be renewable energy credits defined in Section C406.2.5.

**C401.3.5 Discrete area-weighting of additional required credits.** In addition to the area-weighted credit requirements in Section C406.1.2, where a building includes multiple occupancies, the additional required credits per Table C401.3.3 shall be determined separately for each occupancy group. Additional required credits shall be prorated on an area-weighted basis for each occupancy group in the same manner as required project credits per Section C406.1.

1. Where a single space heating or service water heating system serves multiple occupancies, the number of additional required credits shall be prorated on an area-weighted basis for each occupancy served.
2. Additional required credits for envelope systems shall be prorated on an area-weighted basis for all occupancies.
3. Occupancies are permitted to be subdivided into discrete areas, with required and achieved credits for each area prorated on an area-weighted basis as required for the occupancy group.

**C401.3.6 Electrification readiness.** Additionally, the following provisions shall be required for new construction for each fossil fuel space heating or service water heating appliance installed:

1. Provide a spare electrical branch circuit conduit to the location of a future replacement heat pump appliance to support an equivalent heating capacity.
2. Provide spare electrical service entrance conduits for the purpose of upgrading the main electrical service to support all heat pump appliances throughout the building.
3. The main electrical room has sufficient space to accommodate increasing the main electrical service's size to support all heat pump appliances throughout the building.
4. Additional accommodations for the equipment comprised of transformer(s) and other equipment necessary to support an electrical service upgrade. These accommodations shall include adequate space on the site. If the equipment is located in a transformer vault, that vault must include not only the space to support electrical service upgrade but also include accommodations for additional cooling for larger transformer(s).

**C401.4 ~~Thermal~~ Building thermal envelope certificate.** A permanent *building thermal envelope* certificate shall be completed by an *approved* party. Such certificate shall be posted on a wall in the space where the space conditioning equipment is located, a utility room or other *approved* location. If located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label, or other required labels. A copy of the certificate shall also be included in the construction files for the project. The certificate shall include:

1. *R*-values of insulation installed in or on ceilings, roofs, walls, foundations and slabs, crawlspace walls and floors, and ducts outside *conditioned spaces*.
2. *U*-factors and *solar heat gain coefficients* (SHGC) of fenestration.
3. Results from any *building thermal envelope* air leakage testing per-formed on the building.

Where there is more than one value for any component of the *building thermal envelope*, the certificate shall indicate the area-weighted average value where available. If the area-weighted average is not available, the certificate shall list each value that applies to 10 percent or more of the total component area.

## SECTION C402
## BUILDING THERMAL ENVELOPE REQUIREMENTS

**C402.1 General.** Building thermal envelope assemblies for buildings that are intended to comply with the code on a prescriptive basis, in accordance with the compliance path described in Item 1 of Section C401.2, shall comply with the following:

1. The opaque portions of the *building thermal envelope* shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of ~~either the R-value based method of~~ Section ~~C402.1.3~~C402.1.2, ~~the U-, C- and F-factor based method of Section C402.1.4~~C402.1.3, or ~~the component performance alternative of~~ Section ~~C402.1.5~~C402.1.4.
2. Fenestration in the *building thermal envelope* ~~assemblies~~ shall comply with Section C402.4, or the component performance alternative of Section ~~C402.1.5.~~C402.1.4.
3. Air leakage of *building thermal envelope* assemblies shall comply with Section C402.5.
4. Thermal bridges in above-grade walls shall comply with Section C402.7.
5. ~~3.~~ Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C410.

**C402.1.1 Low energy buildings, semi-heated buildings and greenhouses.** Low energy buildings shall comply with Section C402.1.1.1. Semi-heated buildings and spaces shall comply with Section C402.1.1.2, Greenhouses shall comply with Section C402.1.1.3. Equipment buildings shall comply with Section C402.1.1.4

**C402.1.1.1 Low energy buildings.** The following buildings, or enclosed portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this code shall be exempt from all thermal envelope provisions of this code:

1. Those that are heated and/or cooled with a peak design rate of energy usage less than 3.4 Btu/h × ft$^2$ (10.7 W/m$^2$) or 1.0 watt/ft$^2$ (10.7 W/m$^2$) of floor area for space conditioning purposes.
2. Those that do not contain conditioned space.
3. Unstaffed equipment shelters or cabinets used solely for personal wireless service facilities.

**C402.1.1.2 Semi-heated buildings and spaces.** The *building thermal envelope* of *semi-heated* buildings, or portions thereof, shall comply with the same requirements as that for conditioned spaces in Section C402, except as modified by this section. The total installed output capacity of mechanical space conditioning systems serving a *semi-heated* building or space shall comply with Section C202. *Building thermal envelope* assemblies separating conditioned space from semi-heated space shall comply with the exterior envelope insulation requirements. Semi-heated spaces are not required to comply with the opaque wall insulation provisions of Section C402.2.3 for walls that separate semi-heated spaces from the exterior or low energy spaces. Fenestration that forms part of the *building thermal envelope* enclosing semi-heated spaces shall comply with Section C402.4. Semi-heated spaces shall be calculated separately from other conditioned spaces for compliance purposes.

Opaque walls in semi-heated spaces shall be calculated as fully code compliant opaque walls for both the target and proposed for the Target UA calculations for the component performance alternative in Section C402.1.5, and for the Baseline Building Design for Total Building Performance compliance per Section C407. The capacity of heat trace temperature maintenance systems complying with Section C404.7.2 that are provided for freeze protection of piping and equipment only, shall not be included in the total installed output capacity of mechanical space conditioning systems.

**Exception:** Provided the total installed heating output capacity of mechanical space conditioning does not

exceed the criteria for semi-heated space as defined in Section C202, a semi-heated building or space may comply with this section when served by heat pumps without electric resistance back up and connected to a heating only thermostat.

**C402.1.1.3 Greenhouses.** *Greenhouse* structures or areas that comply with all of the following shall be exempt from the *building thermal envelope* requirements of this code:

1. Exterior opaque envelope assemblies complying with Sections C402.2 and C402.4.4.

   **Exception:** Low energy greenhouses that comply with Section C402.1.1.1.
2. Interior partition *building thermal envelope* assemblies that separate the *greenhouse* from conditioned space complying with Sections C402.2, C402.4.3 and C402.4.4.
3. Fenestration assemblies complying with the *building thermal envelope* requirements in Table C402.1.1.3. The U-factor for the skylight shall be for the roof assembly or a roof that includes the assembly and an internal curtain system.

   **Exception:** Unheated greenhouses.
4. No mechanical cooling is provided.
5. For heated greenhouses, heating is provided by a radiant heating system, a condensing natural gas-fired or condensing propane-fired heating system, or a heat pump with cooling capacity permanently disabled as pre-approved by the jurisdiction.

**TABLE C402.1.1.3**
**FENESTRATION BUILDING THERMAL ENVELOPE MAXIMUM REQUIREMENTS**

| Component | *U*-Factor BTU/h-ft$^2$-°F |
|---|---|
| Skylights | 0.5 |
| Vertical Fenestration | 0.6 |

~~C402.1.2~~C402.1.1.4 **Equipment buildings.** Buildings that comply with all of the following shall be exempt from the building thermal envelope provisions of this code:

1. Are separate buildings with floor area no more than 500 square feet (50 m$^2$).
2. Are intended to house electric equipment with installed equipment power totaling at least 7 watts per square foot (75 W/m$^2$) and not intended for human occupancy.
3. Are served by mechanical cooling and heating systems sized in accordance with Sections C403.1.2 and C403.3.1.
4. Have a heating system capacity not greater than 17,000 Btu/hr (5 kW) and a heating thermostat setpoint that is restricted to not more than 50°F (10°C).
5. Have an average wall and roof *U*-factor less than 0.200.

**Exception:** Where the cooling and heating system is a heat pump, the heating system capacity is allowed to exceed 17,000 Btu/h provided the heat pump cooling efficiency is at least 15 percent better than the requirements in Tables C403.3.2(2) and C403.3.2(14).

~~C402.1.2.1~~C402.1.1.4.1 **Standalone elevator hoistways.** Elevator hoistways that comply with all of the following shall be exempt from the building thermal envelope and envelope air barrier provisions of this code:

1. Are separate from any other conditioned spaces in the building (do not serve or open into any conditioned, semi-heated or indirectly conditioned space).
2. Have heating and/or cooling equipment sized only to serve the expected elevator loads with thermostat setpoints restricted to heating to no higher than 40° F and cooling to no lower than 95°F.
3. Have an area-weighted average wall, roof, and floor (where applicable) U-factor of less than or equal to 0.20. Calculations must include any floor-slab-edges that penetrate the hoistway and thus are considered part of the above-grade walls.

~~C402.1.4~~C402.1.2 **Assembly *U*-factor, *C*-factor or *F*-factor based method.** ~~*Building thermal envelope opaque assemblies shall meet the requirements of Section C402.2 based on the climate zone specified in Chapter 3.*~~ *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 ~~C402.1.4~~C402.1.2. 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 ~~C402.1.4~~C402.1.2. 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 ~~C402.1.4~~C402.1.2. The *U*-factors for typical construction assemblies are included in Appendix A. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Appendix A, values shall be calculated in accordance with the ASHRAE *Handbook of Fundamentals* using the framing factors listed in Appendix A where applicable and shall include the thermal bridging effects of framing materials.

**TABLE ~~C402.1.4~~C402.1.2**
**OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, f]**

| | CLIMATE ZONE 5 AND MARINE 4 | |
|---|---|---|
| | **All Other** | **Group R** |
| **Roofs** | | |
| Insulation entirely above deck | U-0.027 | U-0.027 |
| Metal buildings | U-0.031 | U-0.031 |
| Attic and other | U-0.021 | U-0.021 |
| Joist or single rafter | U-0.027 | U-0.027 |
| **Walls, Above Grade[k]** | | |
| Mass[g] | U-0.104[d] | U-0.078 |
| Mass transfer deck slab[j] | U-0.20 | U-0.20 |
| Metal building | U-0.050 | U-0.050 |
| Steel framed | U-0.055 | U-0.055 |
| Wood framed and other | U-0.051 | U-0.051 |
| **Walls, Below Grade** | | |
| Below-grade wall[b,g] | Same as above grade | Same as above grade |
| **Floors** | | |
| Mass[e] | U-0.031 | U-0.031 |
| Joist/framing | U-0.029 | U-0.029 |
| **Slab-on-Grade Floors** | | |
| Unheated slabs | F-0.54 | F-0.54 |
| Heated slabs[c] | F-0.55 | F-0.55 |
| **Opaque Doors** | | |
| Nonswinging door | U-0.31 | U-0.31 |
| Swinging door | U-0.37 | U-0.37 |
| Garage door <14% glazing | U-0.31 | U-0.31 |
| Garage door ≥14% glazing and <50% glazing[i] | U-0.34 | U-0.34 |

a. Use of opaque assembly *U*-factors, *C*-factors, and *F*-factors from Appendix A is required unless otherwise allowed

by Section C402.1.4.

b. Where heated slabs are below grade, they shall comply with the *F*-factor requirements for heated slabs.

c. Heated slab *F*-factors shall be determined specifically for heated slabs. Unheated slab factors shall not be used.

d. Exception: Integral insulated concrete block walls complying with ASTM C90 with all cores filled and meeting both of the following:
   1. At least 50 percent of cores must be filled with vermiculite or equivalent fill insulation; and
   2. The building thermal envelope encloses one or more of the following uses: Warehouse (storage and retail), gymnasium, auditorium, church chapel, arena, kennel, manufacturing plant, indoor swimming pool, pump station, water and waste water treatment facility, storage facility, storage area, motor vehicle service facility. Where additional uses not listed (such as office, retail, etc.) are contained within the building, the exterior walls that enclose these areas may not utilize this exception and must comply with the appropriate mass wall R-value from Table C402.1.3/U-factor from Table C402.1.4.

e. "Mass floors" shall ~~include floors weighing not less than~~be in accordance with Section C402.1.3.4.~~:~~
   ~~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.~~

f. 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 or subtracted from the original test design.

g. Peripheral edges of intermediate concrete floors are included in the above grade mass wall category and therefore must be insulated as above grade mass walls unless they meet the definition of Mass Transfer Deck Slab. The area of the peripheral edges of concrete floors shall be defined as the thickness of the slab multiplied by the perimeter length of the edge condition. See Table A103.3.7.2 for typical default u-factors for above grade slab edges and footnote c for typical conditions of above grade slab edges.

h. Swinging door *U*-factors shall be determined in accordance with NFRC-100.

i. Garage doors having a single row of fenestration shall have an assembly U-factor less than or equal to 0.44, provided that the fenestration area is not less than 14 percent and not more than 50 percent of the total door area.

j. Component performance in accordance with Section C402.1.5 shall be required for buildings with a mass transfer deck slab. A mass transfer deck, due to its configuration, is not insulated. The table value (U-0.20) shall be used as the baseline value for component performance or total building performance path calculations. For the proposed value, the appropriate value from Table A103.3.7.2 shall be used.

k. Through-wall mechanical equipment subject to Section C402.1.4.3 shall be calculated at the *U*-factor defined in Section C402.1.4.3. The area-weighted *U*-factor of the wall, including through-wall mechanical equipment, shall not exceed the value in the table.

~~**C402.1.4.1C402.1.2.1 Roof/ceiling assembly**~~**Methods of determining *U*-, *C*- and *F*-factors**. ~~The maximum roof/ceiling assembly *U*-factor shall not exceed that specified in Table C402.1.4 based on construction materials used in the roof/ceiling assembly.~~Where assembly *U*-factors, *C*-factors and *F*-factors and calculation procedures are established in ANSI/ASHRAE/IES 90.1 Appendix A for opaque assemblies, such opaque assemblies shall be a compliance alternative provided they meet the criteria of Table C402.1.2 and the construction, excluding cladding system on walls, complies with the applicable construction details from ANSI/ASHRAE/IES 90.1 Appendix A. Where U-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative provided they meet the criteria of Table C402.1.2. The *R-value of continuous insulation* shall be permitted to be added to or subtracted from the original tested design. Airspaces used for assembly evaluations shall comply with Section C402.2.7.

~~**C402.1.5.1C402.1.4.1 Component *U*-factors and *F*-factors.**~~ The *U*-factors and *F*-factors for typical construction assemblies are included in Chapter 3 and Appendix A. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Chapter 3 or Appendix A, values shall be calculated in accordance with the ASHRAE *Handbook of Fundamentals*, using the framing factors listed in Appendix A.

For envelope assemblies containing metal framing, the *U*-factor shall be determined by one of the following methods:

1. Results of laboratory measurements according to acceptable methods of test.
2. ASHRAE *Handbook of Fundamentals* where the metal framing is bonded on one or both sides to a metal skin or covering.
3. The zone method as provided in ASHRAE *Handbook of Fundamentals*.
4. Effective framing/cavity *R*-values as provided in Appendix A. When return air ceiling plenums are

**Commented [BK(29]:** Does this section need a reference to the WSEC Appendix A? Or should it default to the previous language under the UA method?

**Commented [KB30R29]:** **Duane Jonlin**
I don't see why we should make people go to ASHRAE 90.1. I'd suggest sticking with our Appendix A instead of this language.

**Commented [KA31]:** This sentence could make sense if Where is removed, 'are' is removed later in the sentence. SO it reads: "Assembly *U*-factors, *C*-factors and *F*-factors and calculation procedures established in ANSI/ASHRAE/IES 90.1 Appendix A for opaque assemblies shall be a compliance alternative provided they meet the criteria of Table C402.1.2 and the construction, excluding cladding system on walls, complies with the applicable construction details from ANSI/ASHRAE/IES 90.1 Appendix A.

employed, the roof/ceiling assembly shall:

a. For thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly; and
b. For gross area purposes, be based upon the interior face of the upper plenum surface.

5. Tables in ASHRAE 90.1 Normative Appendix A.
6. Calculation method for steel-framed walls in accordance with Section ~~C402.1.4.1~~C402.1.2.1.6 ~~and Table C402.1.4.1~~.

~~C402.1.4.1.1~~C402.1.2.1.1 **Suspended ceilings.** Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the assembly U-factor of the roof/ceiling construction.

C402.1.2.1.2 **Concrete masonry units, integral insulation.** In determining compliance with Table C402.1.2, the *U-factor* of concrete masonry units with integral insulation shall be permitted to be used.

C402.1.2.1.3 **Mass walls and floors.** Compliance with required maximum *U-factors* for mass walls and mass floors in accordance with Table C402.1.2 shall be permitted for assemblies complying with Section C402.1.3.4.

C402.1.2.1.4 **Area-weighted averaging of above-grade wall *U*-factors.** Where *above-grade walls* include more than one assembly type or a penetration of the opaque wall area, the area-weighted *U-factor* of the *above-grade wall* is permitted to be determined by an *approved* method.

~~C402.1.4.2~~C402.1.2.1.5 ~~**Thermal resistance of cold-formed steel stud walls**~~**Cold-formed steel assemblies.** ~~*U*-factors of walls with cold-formed steel studs shall be permitted to be determined in accordance with Equation 4-1:~~ *U*-factors for *building thermal envelopes* containing cold-formed steel-framed ceilings and walls are permitted to be determined in accordance with AISI S250 as modified herein.

~~*U* = 1/[*Rs* + (*ER*)] **(Equation 4-1)**~~

~~where:~~

~~*Rs* = The cumulative *R*-value of the wall components along the path of heat transfer, excluding the cavity insulation and steel studs.~~

~~*ER* = The effective *R*-value of the cavity insulation with steel studs as specified in Table C402.1.4.2.~~

1. Where the steel-framed wall contains no *cavity insulation*, and uses *continuous insulation* to satisfy the *U-factor* maximum, the steel-framed wall member spacing is permitted to be installed at any on-center spacing.
2. Where the steel-framed wall contains framing at 24 inches (610 mm) on center with no less than a 23 percent framing factor or framing at 16 inches (406 mm) on center with not less than a 25 percent framing factor, the next lower framing member spacing input values shall be used when calculating using AISI S250.
3. Where the steel-framed wall contains less than 23 percent framing factors, the **AISI S250** shall be used without any modifications.
4. Where the steel-framed wall contains other than standard C-shape framing members, the AISI S250 calculation option for other than standard C-shape framing is permitted to be used.

C402.1.2.1.6 **Spandrel panels.** *U-factors* of opaque assemblies within *fenestration* framing systems shall be determined in accordance with ~~the default values in Table C402.1.2.1.7, ASTM C1363 or ANSI/NFRC 100~~ Section C303.1.5.

~~C402.1.4.3~~C402.1.2.1.7 ~~**Thermal resistance of mechanical equipment penetrations**~~**Mechanical equipment penetrations.** ~~When the total area of penetrations from through-wall mechanical equipment or equipment listed in Table C403.3.2(4) exceeds 1 percent of the opaque *above-grade wall* area, the mechanical equipment penetration area shall be calculated as a separate wall assembly with a default *U*-factor of 0.5. Mechanical system ducts and louvers, including those for supply, exhaust and relief, and for condenser air intake and outlet, are not considered to be mechanical equipment for the purposes of this section~~Where the total area of through penetrations of mechanical equipment is greater than 1 percent of the opaque above-grade wall area, such area shall be calculated as a separate wall assembly, in accordance with either Section C402.1.2.1.4 or Section C402.1.4 using a published and approved U-

**Commented [BK(32]:** This is currently also in place as referenced in the section number. It is here for comparison with the new IECC language above.

**Commented [DJ33R32]:** I think our language is easier to follow

**Commented [BK(34]:** The IECC has moved Section C402.2.1.1, Tapered, above deck insulation based on thickness, to this location. This section was not adopted into the WSEC, as we refer instead to the tables in Appendix A, but incorporated the intent into an exception to C402.2.1.

**Commented [DJ35]:** Why is this used? CMU walls get a free pass in WA code, and don't have to use the real U-factors

**Commented [BK(36]:** This new section in the IECC is essentially the same as that in the WSEC Chapter 3. I did not include the IECC default table in the draft. The values in the WSEC table are different than the IECC values, but are the same as Title 24.

factor for that equipment or a default U-factor of 0.5.

**Exception**: Where mechanical equipment has been tested in accordance with *approved* testing standards, the mechanical equipment penetration area is permitted to be calculated as a separate wall assembly using the *U*-factor determined by such test.

**C402.1.3 Insulation component *R*-value method.** *Building thermal envelope* opaque assemblies shall comply with the requirements of Section C402.2 based on the climate zone specified in Chapter 3. For opaque portions of the *building thermal envelope* intended to comply on an insulation component *R*-value basis, the *R*-values for *cavity insulation* and *continuous insulation* shall not be less than that specified in Table C402.1.3. Where cavity insulation is installed in multiple layers, the cavity insulation *R*-values shall be summed to determine compliance with the cavity insulation *R*-value requirements. Where continuous insulation is installed in multiple layers, the continuous insulation *R*-values shall be summed to determine compliance with the continuous insulation *R*-value requirements. Cavity insulation *R*-values shall not be used to determine compliance with the continuous insulation *R*-value requirements in Table C402.1.3. Commercial *Group R* occupancy buildings or portions of *commercial buildings* enclosing *Group R* occupancies shall use the *R*-values from the "Group R" column of Table C402.1.3. *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 C402.1.3.

**TABLE C402.1.3**
**OPAQUE BUILDING THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD**[a, j, a,k,l]

| CLIMATE ZONE | 5 AND MARINE 4 | |
|---|---|---|
| | **All Other** | **Group R** |
| **Roofs** | | |
| Insulation entirely above deck | R-38ci | R-38ci |
| Metal buildings[b] | R-25 + R-22 LS | R-25 + R-22 LS |
| Attic and other | R-49 | R-49 |
| **Walls, Above Grade** | | |
| Mass[h]Mass[l] | R-9.5[c] ci | R-13.3ci |
| Mass transfer deck slab edge[g] | See Table C402.1.4C402.1.2 | See Table C402.1.4C402.1.2 |
| Metal building | R-13 + R-14ci | R-13 + R-14ci |
| Steel framed[h,l] | R-0 + R-15.2ci or R-13 + R-10ci or R-20 + R-9ci | R-19 + R-8.5ci |
| Wood framed and other[h,l] | R-0 + R-16ci std or R-13 + R-7.5ci std or R-20+R-3.8ci std or R-27 std | R-0 + R-16ci std or R-13 + R-7.5ci std or R-20 + R-3.8ci std or R-25R-27 std |
| **Walls, Below Grade** | | |
| Below-grade wall[d, h,l] | Same as above grade | Same as above grade |
| **Floors** | | |
| Mass[f] | R-30ci | R-30ci |
| Joist/framing | R-30[e] | R-30[e] |
| **Slab-on-Grade Floors** | | |

| CLIMATE ZONE | 5 AND MARINE 4 | |
|---|---|---|
| Unheated slabs | R-10 for 24" below | R-10 for 24" below |
| Heated slabs[d] | R-10 perimeter & under entire slab | R-10 perimeter & under entire slab |

For SI: 1 inch = 25.4 mm. ci = Continuous insulation. NR = No requirement. LS = Liner system

a. Assembly descriptions can be found in Chapter 2 and Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block with minimum thickness of ½ inch and minimum R-value of R-3.5 shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.

c. Exception: Integral insulated concrete block walls complying with ASTM C90 with all cores filled and meeting both of the following:
   1. ~~At least~~Not less than 50 percent of cores must be filled with vermiculite or equivalent fill insulation; and
   2. The building thermal envelope encloses one or more of the following uses: Warehouse (storage and retail), gymnasium, auditorium, church chapel, arena, kennel, manufacturing plant, indoor swimming pool, pump station, water and waste water treatment facility, storage facility, storage area, motor vehicle service facility. Where additional uses not listed (such as office, retail, etc.) are contained within the building, the exterior walls that enclose these areas may not utilize this exception and must comply with the appropriate mass wall R-value from Table C402.1.3/U-factor from Table C402.1.4.

d. Where heated slabs are below grade, they shall comply with the insulation requirements for heated slabs.

e. Steel floor joist systems shall be insulated to R-38 + R-10ci.

f. "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.

g. Component performance in accordance with Section C402.1.5 shall be required for buildings with a mass transfer deck slab.

h. The first value is cavity insulation; the second value is continuous insulation. Therefore, "R-0 + R16ci" means R-16 continuous insulation and no cavity insulation; "R-13 + R7.5ci" means R-13 cavity insulation and R-7.5 continuous insulation; "R-27" means R-27 cavity insulation and no continuous insulation. R-13, R-20 and R-27 cavity insulation, as used in this table, apply to a nominal 4-inch, 6-inch and 8-inch-deep wood or cold-formed steel stud cavities, respectively.

i. Where the required R-value in Table C402.1.3 is met by using continuous insulation such that cavity insulation is not required, the R-value is applicable to any wall spacing.

~~h.~~j. Peripheral edges of intermediate concrete floors are included in the above grade mass wall category and therefore must be insulated as above grade mass walls unless they meet the definition of Mass Transfer Deck Slab Edge. The area of the peripheral edges of concrete floors shall be defined as the thickness of the slab multiplied by the perimeter length of the edge condition. See Table A103.3.7.2 for typical default u-factors for above grade slab edges and footnote c for typical conditions of above grade slab edges.

~~i.~~k. Where the total area of through-wall mechanical equipment is greater than 1 percent of the opaque *above-grade wall area*, use of the *R*-value method is not permitted. See Section C402.1.4.3.

~~j.~~l. For roof, wall or floor assemblies where the proposed assembly would not be *continuous insulation*, alternate nominal *R*-value compliance options for assemblies with isolated metal fasteners that penetrate otherwise *continuous insulation* are shown in columns B and C of Table ~~C402.1.3(j)~~C402.1.3(l):

**TABLE ~~C402.1.3(j)~~C402.1.3(l)**
**CONTINUOUS INSULATION EQUIVALENTS**

| Column A | Column B | Column C |
|---|---|---|
| **Assemblies with continuous insulation (see definition)** | **Alternate option for assemblies with metal penetrations, greater than 0.04% but less than 0.08%** | **Alternate option for assemblies with metal penetrations, greater than or equal to 0.08% but less than 0.12%** |
| R-9.5ci | R-11.9ci | R-13ci |
| R-11.4ci | R-14.3ci | R-15.7ci |
| R-13.3ci | R-16.6ci | R-18.3ci |
| R-15.2ci | R-19ci | R-21ci |
| R-30ci | R-38ci | R-42ci |
| R-38ci | R-48ci | R-53ci |
| R-13 + R-7.5ci | R-13 + R-9.4ci | R-13 + R-10.3ci |
| R-13 + R-10ci | R-13 + R-12.5ci | R-13 + R-13.8ci |
| R-13 + R-12.5ci | R-13 + R-15.6ci | R-13 + R-17.2ci |

| | | |
|---|---|---|
| R-13 + R-13ci | R-13 + R-16.3ci | R-13 + R-17.9ci |
| R-19 + R-8.5ci | R-19 + R-10.6ci | R-19 + R-11.7ci |
| R-19 + R-14ci | R-19 + R-17.5ci | R-19 + R-19.2ci |
| R-19 + R-16ci | R-19 + R-20ci | R-19 + R-22ci |
| R-20 + R-3.8ci | R-20 + R-4.8ci | R-20 .+ R-5.3ci |
| R-21 + R-5ci | R-21 + R-6.3ci | R-21 + R-6.9ci |

**Notes for Table C402.1.3(j)**: These alternate nominal R-value compliance options are allowed for projects complying with all of the following:

1a. The ratio of the cross-sectional area, as measured in the plane of the surface, of metal penetrations of otherwise continuous insulation to the opaque surface area of the assembly is greater than 0.0004 (0.04%), but less than 0.0008 (0.08%), for use of Column B equivalents, and greater than or equal to 0.0008 (0.08%) but less than 0.0012 (0.12%) for use of Column C equivalents.

1b. Where all metal penetrations are stainless steel, Column B is permitted to be used for penetrations greater than 0.12% but less than 0.24% of opaque surface area, and Column C is permitted to be used for penetrations greater than or equal to 0.24% but less than 0.48% of opaque surface area.

2. The metal penetrations of otherwise continuous insulation are isolated or discontinuous (e.g., brick ties or other discontinuous metal attachments, offset brackets supporting shelf angles that allow insulation to go between the shelf angle and the primary portions of the wall structure). No continuous metal elements (e.g., metal studs, z-girts, z-channels, shelf angles) penetrate the otherwise continuous portion of the insulation.

3. Building permit drawings shall contain details showing the locations and dimensions of all the metal penetrations (e.g., brick ties or other discontinuous metal attachments, offset brackets, etc.) of otherwise continuous insulation. In addition, calculations shall be provided showing the ratio of the cross-sectional area of metal penetrations of otherwise continuous insulation to the overall opaque wall area.

For other cases where the proposed assembly is not continuous insulation, see Section C402.1.4 for determination of U-factors for assemblies that include metal other than screws and nails.

~~**TABLE C402.1.4.2**~~
~~**EFFECTIVE *R*-VALUES FOR STEEL STUD WALL ASSEMBLIES**~~

| ~~NOMINAL STUD DEPTH (inches)~~ | ~~SPACING OF FRAMING (inches)~~ | ~~CAVITY *R*-VALUE (insulation)~~ | ~~CORRECTION FACTOR (*Fc*)~~ | ~~EFFECTIVE *R*-VALUE (ER) (Cavity *R*-Value x *Fc*)~~ |
|---|---|---|---|---|
| ~~3 1/2~~ | ~~16~~ | ~~13~~ | ~~0.46~~ | ~~5.98~~ |
| | | ~~15~~ | ~~0.43~~ | ~~6.45~~ |
| ~~3 1/2~~ | ~~24~~ | ~~13~~ | ~~0.55~~ | ~~7.15~~ |
| | | ~~15~~ | ~~0.52~~ | ~~7.80~~ |
| ~~6~~ | ~~16~~ | ~~19~~ | ~~0.37~~ | ~~7.03~~ |
| | | ~~21~~ | ~~0.35~~ | ~~7.35~~ |
| ~~6~~ | ~~24~~ | ~~19~~ | ~~0.45~~ | ~~8.55~~ |
| | | ~~21~~ | ~~0.43~~ | ~~9.03~~ |
| ~~8~~ | ~~16~~ | ~~25~~ | ~~0.31~~ | ~~7.75~~ |
| | ~~24~~ | ~~25~~ | ~~0.38~~ | ~~9.50~~ |

**C402.1.3.1 *R*-value of multi-layered insulation components.** Where *cavity insulation* is installed in multiple layers, the *cavity insulation R*-values shall be summed to determine compliance with the *cavity insulation R-value* requirements. Where *continuous insulation* is installed in multiple layers, the *continuous insulation R*-values shall be summed to determine compliance with the *continuous insulation R-value* requirements. *Cavity insulation R*-values shall not be used to determine compliance with the *continuous insulation R-value* requirements in Table C402.1.3.

**C402.1.3.2 Area-weighted averaging of *R*-values.** Area-weighted averaging shall not be permitted for *R*-

*value* compliance.

**Exception:** For tapered above-deck roof insulation, compliance with the *R*-values required in Table C402.1.3 shall be permitted to be demonstrated by multiplying the rated *R-value* per inch of the insulation material by the average thickness of the roof insulation. The average thickness of the roof insulation shall equal the total volume of the roof insulation divided by the area of the roof.

~~C402.2.1.2~~C402.1.3.3 **Suspended ceilings.** Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the minimum thermal resistance (*R*-value) of roof insulation in roof/ceiling construction.

**C402.1.3.4 Mass walls and mass floors.** Compliance with required maximum *U-factors* for mass walls and mass floors in accordance with Table C402.1.2 and minimum *R*-values for insulation components applied to mass walls and mass floors in accordance with Table C402.1.3 shall be permitted for assemblies complying with the following:

1. Where used as a component of the *building thermal envelope*, mass walls shall comply with one of the following:
   1.1. Weigh not less than 35 pounds per square foot (171 kg/m2) of wall surface area.
   1.2. Weigh not less than 25 pounds per square foot (122 kg/m2 ) of wall surface area where the material weight is not more than 120 pounds per cubic foot (pcf) (1922 kg/m3).
   1.3. Have a heat capacity exceeding 7 Btu/ft2 × °F (144 kJ/m2 × K).
   1.4. Have a heat capacity exceeding 5 Btu/ft2 × °F (103 kJ/m2 × K) where the material weight is not more than 120 pcf (1922 kg/m3).
2. Where used as a component of the *building thermal envelope*, the minimum weight of mass floors shall comply with one of the following:
   2.1. Thirty-five pounds per square foot (171 kg/m2) of floor surface area.
   2.2. Twenty-five pounds per square foot (122 kg/m2) of floor surface area where the material weight is not more than 120 pcf (1922 kg/m3).

~~C402.1.5~~C402.1.4 **Component performance ~~alternative~~method.** *Building thermal envelope* values and fenestration areas determined in accordance with Equation ~~4-2~~4-3 shall be ~~permitted in lieu of~~ an alternate to compliance with the ~~*U*-factors and *F*-factors in~~ *U-*, *F-*, *psi-*, *chi-*, and *C*-factors in Table~~s C402.1.4 and C402.4~~C402.1.2, C402.1.2.7, C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1. Fenestration shall meet the applicable SHGC requirements of Section C402.4.3.

For buildings with more than one *space conditioning category*, component performance compliance shall be demonstrated separately for each space conditioning category. Interior partition ceilings, walls, fenestration and floors that separate space conditioning areas shall be applied to the component performance calculations for the space conditioning category with the highest level of space conditioning.

~~**Proposed Total UA ≤ Allowable Total UA** **(Equation 4-2)~~

~~Where:~~

| | | |
|---|---|---|
| ~~**Proposed Total UA**~~ | ~~=~~ | ~~UA-glaz-prop + UA sky-prop + UA-opaque-prop + FL-slab-prop~~ |
| ~~**Allowable Total UA**~~ | ~~=~~ | ~~UA-glaz-allow + UA-glaz-excess + UA sky-allow + UA-sky-excess + UA-opaque-allow + FL-slab-allow~~ |
| ~~**UA-glaz-prop**~~ | ~~=~~ | ~~Sum of (proposed U-factor × proposed area) for each distinct vertical fenestration type, up to code maximum area~~ |
| ~~**UA-sky-prop**~~ | ~~=~~ | ~~Sum of (proposed U-factor × proposed area) for each distinct skylight type, up to the code maximum area~~ |
| ~~**UA-opaque-prop**~~ | ~~=~~ | ~~Sum of (proposed U-factor × proposed area) for each distinct opaque thermal envelope type~~ |
| ~~**FL-slab-prop**~~ | ~~=~~ | ~~Sum of (proposed F-factor × proposed length) for each distinct slab on grade perimeter assembly~~ |
| ~~**UA-glaz-allow**~~ | ~~=~~ | ~~Sum of (code maximum vertical fenestration *U*-factor from Table C402.4, or Section C402.4.1.1.2 if applicable, × proposed area) for each distinct vertical fenestration type, not to exceed the code maximum area [1]~~ |
| ~~**UA-glaz-excess**~~ | ~~=~~ | ~~U-factor for the proposed wall type from Table C402.4[2] × vertical fenestration area in excess of the code maximum area~~ |

~~**UA-sky-allow** = Sum of (code maximum skylight *U*-factor from Table C402.4 × proposed area) for each distinct skylight type proposed, not to exceed the code maximum area~~

~~**UA-sky-excess** = U-factor for the proposed roof type from Table C402.4[3] × skylight area in excess of the code maximum area~~

~~**UA-opaque-allow** = Code maximum opaque envelope *U*-factor from Table C402.1.4 for each opaque door, wall, roof, and floor assembly × proposed area~~

~~**FL-slab-allow** = Code maximum *F*-factor for each slab-on-grade perimeter assembly × proposed length~~

~~**Notes**~~

~~1. Where multiple vertical fenestration types are proposed and the code maximum area is exceeded, the *U*-factor shall be the average Table C402.1.4 U-factor weighted by the proposed vertical fenestration area of each type.~~
~~2. Where multiple wall types are proposed the *U*-factor shall be the average Table C402.1.4 *U*-factor weighted by the proposed above grade wall area of each type.~~
~~3. Where multiple roof types are proposed the *U*-factor shall be the average Table C402.1.4 *U*-factor weighted by the proposed roof area of each type.~~

$$A_P + B_P + C_P + T_P \leq A_T + B_T + C_T + T_T - V_F - V_S \quad \textbf{(Equation 4-3)}$$

where:

$A_P$ = Sum of the (area × *U*-factor) for each proposed building thermal envelope assembly, other than slab-on-grade or below-grade wall assemblies.

$B_P$ = Sum of the (length × *F*-factor) for each proposed slab-on-grade edge condition.

$C_P$ = Sum of the (area × *C*-factor) for each proposed below-grade wall assembly.

$T_P$ = Sum of the ($\psi LP$) and ($\chi NP$) values for each type of thermal bridge condition of the building thermal envelope as identified in Section C402.7 in the proposed building. For the purposes of this section, the ($\psi LP$) and ($\chi NP$) values for thermal bridges caused by materials with a thermal conductivity less than or equal to 3.0 Btu × in/h × ft$^2$ × °F shall be assigned as zero.

$\psi LP$ = Psi-factor × length of the thermal bridge elements in the proposed building thermal envelope.

$\chi NP$ = Chi-factor × number of the thermal bridge point elements other than fasteners, ties or brackets in the proposed building thermal envelope.

$A_T$ = Sum of the (area × *U*-factor permitted by Tables C402.1.2 and C402.4) for each proposed building thermal envelope assembly, other than slab-on-grade or below-grade wall assemblies.

$B_T$ = Sum of the (length × *F*-factor permitted by Table C402.1.2) for each proposed slab-ongrade edge condition.

$C_T$ = Sum of the (area × *C*-factor permitted by Table C402.1.2) for each proposed below-grade wall assembly.

$T_T$ = Sum of the ($\psi LT$) and ($\chi NT$) values for each type of thermal bridge condition in the proposed building thermal envelope as identified in Section C402.6 with values specified as "compliant" in Table C402.1.4. For the purposes of this section, the ($\psi LT$) and ($\chi NT$) values for thermal bridges caused by materials with a thermal conductivity less than or equal to 3.0 Btu × in/h × ft$^2$ × °F shall be assigned as zero.

$\psi LT$ = (Psi-factor specified as "compliant" in Table C402.1.4) × length of the thermal bridge elements in the proposed building thermal envelope.

$\chi NT$ = (Chi-factor specified as "compliant" in Table C402.1.4) × number of the thermal bridge point elements other than fasteners, ties or brackets in the proposed building thermal envelope.

$P_F$ = Maximum vertical fenestration area allowable by Section C402.4.1, C402.4.1.1 or C402.4.1.2.

$Q_F$ = Proposed vertical fenestration area.

$R_F$ = $Q_F - P_F$, but not less than zero (excess vertical fenestration area).

$S_F$ = Area-weighted average *U*-factor permitted by Table C402.4 of all vertical fenestration assemblies

$T_F$ = Area-weighted average *U*-factor permitted by Table C402.1.2 of all exterior opaque wall assemblies.

$U_F$ = $S_F - T_F$ (excess *U*-factor for excess vertical fenestration area).

$V_F$ = $R_F \times U_F$ (excess $U \times A$ due to excess vertical fenestration area).

$P_S$ = Maximum skylight area allowable by Section C402.1.2.

$Q_S$ = Actual skylight area.

$R_S$ = $Q_S - P_S$, but not less than zero (excess skylight area).

$S_S$ = Area-weighted average *U*-factor permitted by Table C402.4 of all skylights.

$T_S$ = Area-weighted average *U*-factor permitted by Table C402.1.2 of all opaque roof assemblies.

$U_S$ = $S_S - T_S$ (excess *U*-factor for excess skylight area).

$V_S$ = $R_S \times U_S$ (excess $U \times A$ due to excess skylight area).

A proposed psi- or chi-factor for each thermal bridge shall comply with one of the following, as applicable:

1. Where the proposed mitigation of a thermal bridge is compliant with the requirements of Section C402.6, the "compliant" values in Table C402.1.4 shall be used for the proposed psi- or chi-factors.
2. Where a thermal bridge is not mitigated in a manner at least equivalent to Section C402.6, the "noncompliant" values in Table C402.1.4 shall be used for the proposed psi- or chi-factors.
3. Where the proposed mitigation of a thermal bridge provides a psi- or chi-factor ess than "compliant" values in Table C402.1.4, the proposed psi- or chi-factor shall be determined by thermal analysis, testing or other *approved* sources.

**TABLE C402.1.4**
**PSI- and CHI-FACTORS TO DETERMINE THERMAL BRIDGES FOR THE COMPONENT PERFORMANCE METHOD**

| THERMAL BRIDGE PER SECTION C402.6 | THERMAL BRIDGE COMPLIANT WITH SECTION C402.6 | | THERMAL BRIDGE NONCOMPLIANT WITH SECTION C402.6 | |
|---|---|---|---|---|
| | Psi-Factor (Btu/h × ft × °F) | Chi-Factor (Btu/h × °F) | Psi-Factor (Btu/h × ft × °F) | Chi-Factor (Btu/h × °F) |
| C402.7.1 Balconies and floor decks | 0.2 | N/A | 0.5 | N/A |
| C402.7.2 Cladding supports | 0.2 | N/A | 0.3 | N/A |
| C402.7.3 Structural beams and columns | N/A | 1.0 Carbon steel 0.3 Concrete | N/A | 2.0 Carbon steel 1.0 Concrete |
| C402.7.4 Vertical fenestration | 0.15 | N/A | 0.3 | N/A |
| C402.7.5 Parapets | 0.2 | N/A | 0.4 | N/A |

N/A = Not Applicable

~~C402.1.5.1~~C402.1.4.1 **Component *U*-factors and *F*-factors.** The *U*-factors and *F*-factors for typical construction assemblies are included in Chapter 3 and Appendix A. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Chapter 3 or Appendix A, values shall be calculated in accordance with the ASHRAE *Handbook of Fundamentals*, using the framing factors listed in Appendix A.

For envelope assemblies containing metal framing, the *U*-factor shall be determined by one of the following methods:

7. Results of laboratory measurements according to acceptable methods of test.
8. ASHRAE *Handbook of Fundamentals* where the metal framing is bonded on one or both sides to a metal skin or covering.
9. The zone method as provided in ASHRAE *Handbook of Fundamentals*.
10. Effective framing/cavity *R*-values as provided in Appendix A. When return air ceiling plenums are employed, the roof/ceiling assembly shall:
    a. For thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly; and
    b. For gross area purposes, be based upon the interior face of the upper plenum surface.
11. Tables in ASHRAE 90.1 Normative Appendix A.
12. Calculation method for steel-framed walls in accordance with Section ~~C402.1.4.1~~C402.1.2.1.6 ~~and Table C402.1.4.1~~.

~~**C402.1.5.2 SHGC rate calculations.** Solar heat gain coefficient shall comply with Table C402.4. The target $SHGCA_t$ and the proposed $SHGCA_p$ shall be calculated using Equations 4-3 and 4-4 and the corresponding areas and SHGCs from Table C402.4.~~

~~**Proposed Total SHGCxA ≤ Allowable Total SHGCxA (Equation 4-3)**~~

~~Where:~~

| | | |
|---|---|---|
| ~~**Proposed Total SHGCxA**~~ | = | ~~SHGCxA-glaz-prop + SHGCxA sky-prop~~ |
| ~~**Allowable Total SHGCxA**~~ | = | ~~SHGCxA-glaz-allow + SHGCxA-sky-allow~~ |
| ~~**SHGCxA-glaz-prop**~~ | = | ~~Sum of (proposed SHGC x proposed area) for each distinct vertical fenestration type~~ |
| ~~**SHGCxA-sky-prop**~~ | = | ~~Sum of (proposed SHGC x proposed area) for each distinct skylight type~~ |
| ~~**SHGCxA-glaz-allow**~~ | = | ~~Sum of (code maximum vertical fenestration SHGC from Table C402.4, or Section C402.4.1.3 if applicable, x proposed area) for each distinct vertical fenestration type, not to exceed the code maximum area~~ |
| ~~**SHGCxA-sky-allow**~~ | = | ~~Sum of (code maximum skylight SHGC from Table C402.4 x proposed area) for each distinct skylight type, not to exceed the code maximum area~~ |

~~If the proposed vertical fenestration area does not exceed the Vertical Fenestration Area allowed, the target area for each vertical fenestration type shall equal the proposed area. If the proposed vertical fenestration area exceeds the Vertical Fenestration Area allowed, the target area of each vertical fenestration element shall be reduced in the base envelope design by the same percentage and the net area of each above-grade wall type increased proportionately by the same percentage so that the total vertical fenestration area is exactly equal to the Vertical Fenestration Area allowed.~~

~~If the proposed skylight area does not exceed the Allowable Skylight Area from Section C402.4.1, the target area shall equal the proposed area. If the proposed skylight area exceeds the Allowable Skylight Area from Section C402.4.1, the area of each skylight element shall be reduced in the base envelope design by the same percentage and the net area of each roof type increased proportionately by the same percentage so that the total skylight area is exactly equal to the allowed percentage per Section C402.3.1 of the gross roof area.~~

~~C402.5.5~~C402.1.5 **Rooms containing fuel-burning appliances.** Where combustion air is supplied through openings in an exterior wall to a room or space containing a space conditioning fuel-burning appliance, one of the following shall apply:

1. The room or space containing the appliance shall be located outside of the building thermal envelope.
2. The room or space containing the appliance shall be enclosed and isolated from conditioned spaces inside the building thermal envelope. Such rooms shall comply with all of the following:
    2.1. The walls, floor and ceiling that separate the enclosed room or space from the conditioned spaces shall be insulated to be at least equivalent to the insulation requirement of below grade walls as specified in Table C402.1.3 or C402.1.4.
    2.2. The walls, floors and ceiling that separate the enclosed room or space from conditioned spaces

shall be sealed in accordance with Section C402.5.1.1

2.3. The doors into the enclosed room or space shall be fully gasketed.

2.4. ~~Water lines~~ Piping serving as part of a heating or cooling system and *ducts* in the enclosed room or space shall be insulated in accordance with Section C403. Service water piping shall be insulated in accordance with Section C404.

2.5. Where the air duct supplying combustion air to the enclosed room or space passes through conditioned space, the duct shall be insulated to an R-value of not less than R-16.

**Exception:** Fireplaces and stoves complying with Sections 901 through 905 of the *International Mechanical Code*, and Section 2111.14 of the *International Building Code*.

**C402.2 Specific ~~building thermal envelope~~ insulation and installation requirements.** Insulation in *building thermal envelope* opaque assemblies shall be installed in accordance with Section C303.2 and ~~comply with~~ Sections C402.2.1 through C402.2.9 ~~and Table C402.1.3~~.

Where this section refers to installing insulation levels as specified in Section C402.1.3, assemblies complying prescriptively with Section ~~C402.1.5~~C402.1.4 are allowed to install alternate levels of insulation so long as the *U*-factor of the insulated assembly is less than or equal to the *U*-factor required by the respective path.

**C402.2.1 ~~Roof assembly~~Roof-ceiling construction.** ~~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 C402.1.3, based on construction materials used in the roof assembly~~Insulation materials in the roof-ceiling construction shall be installed between the roof or ceiling framing, continuously below the ceiling framing, continuously above, below or within the roof deck or in an *approved* combination thereof. Insulation installed above the roof deck shall comply with Sections C402.2.1.1 through C402.2.1.3.

**Exceptions**:

1. Where tapered insulation is used with insulation entirely above deck, those roof assemblies shall show compliance on a *U*-factor basis per Section C402.1.4. The effective *U*-factor shall be determined through the use of Tables A102.2.6(1), A102.2.6(2) and A102.2.6(3).
2. Two layers of insulation are not required where insulation tapers to the roof deck, such as at roof drains. At roof drains, the immediate 24” x 24” plan area around each roof drain has a minimum insulation requirement of R-13, but otherwise is permitted to be excluded from roof insulation area-weighted calculations.

~~C402.1.4.1.2~~**C402.1.1 Joints staggered.** Continuous, above-deck insulation board located above the roof deck shall be installed in not less than two layers, and the edge joints between each layer of insulation shall be staggered, except where insulation tapers to the roof deck at a gutter edge, roof drain, or scupper.

~~C402.2.1.3~~**C402.2.1.2 Skylight curbs.** Skylight curbs shall be insulated to the level of the above-deck roofs ~~with~~ insulation ~~entirely above deck~~ or R-5, whichever is less.

**Exception**: Unit skylight curbs included as a component of skylight listed and labeled in accordance with NFRC 100 shall not be required to be insulated.

~~C402.2.1.4~~ **C402.2.1.3 Rooftop HVAC equipment curbs.** Structural curbs installed to support rooftop HVAC equipment are allowed to interrupt the above roof insulation. The area under the HVAC equipment inside of the equipment curb shall be insulated to a minimum of R-13 in all locations where there are not roof openings for ductwork. The annular space between the roof opening and the ductwork shall be sealed to maintain the building air barrier. The plan-view area of the HVAC equipment curb shall be excluded from the prescriptive roof insulation requirements or the area-weighted component performance calculations.

~~C402.2.1.1~~**C402.2.1.4 Minimum thickness~~~~, lowest point~~ of tapered insulation.** The ~~minimum~~ thickness of tapered above-deck roof insulation at its lowest point, gutter edge, roof drain or scupper, shall be not less than 1 inch (25 mm).

**C402.2.2 Above-grade walls.** ~~The minimum thermal resistance (*R*-value) of materials installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table C402.1.3, based on framing type and construction materials used in the wall assembly. The *R*-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table C402.1.3 except as otherwise noted in the table. In determining compliance with Table C402.1.4, the use of the U-factor of concrete masonry units with integral insulation shall be permitted.~~*Above-grade wall* insulation materials shall be installed between the wall framing, be integral to the wall assembly, be continuous on the wall assembly, or be any combination of these insulation methods. Where *continuous insulation* is layered on the

exterior side of a wall assembly, the joints shall be staggered.

"Mass walls" where used as a component in the thermal envelope of a building shall comply with one of the following:

1. Weigh not less than 35 psf (170 kg/m$^2$) of wall surface area.
2. Weigh not less than 25 psf (120 kg/m$^2$) of wall surface area where the material weight is not more than 120 pounds per cubic foot (pcf) (1,900 kg/m$^3$).
3. Have a heat capacity exceeding 7 Btu/ft$^2$ x °F (144 kJ/m$^2$ x K).
4. Have a heat capacity exceeding 5 Btu/ft$^2$ x° F (103 kJ/m$^2$ x K) where the material weight is not more than 120 pcf (1900 kg/m$^3$).

**C402.2.3 Floors over outdoor air or unconditioned space.** The thermal properties (component *R*-values or assembly *U*- or *F*-factors) of floor assemblies over outdoor air or unconditioned space shall be as specified in Table C402.1.3 or C402.1.4 based on the construction 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. Floor insulation shall be installed between floor framing, be integral to the floor assembly, be continuous on the floor assembly, or be any combination of these insulation methods. Where *continuous insulation* is layered on the exterior side of a floor assembly, the joints shall be staggered.

"Mass floors" where used as a component of the thermal envelope of a building shall provide one of the following weights:

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

**Exceptions**:

1. The floor framing cavity insulation or structural slab insulation shall be permitted to be installed 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 C402.1.3 for "Metal framed" or "Wood framed and other" values for "Walls, Above Grade" and extends from the bottom of the top of all perimeter floor framing or floor assembly members. Floor framing or structural slab members at the perimeter of the floor assembly shall be insulated vertically for their full depth with insulation equivalent to that required for the *above-grade wall* construction.
2. Insulation applied to the underside of concrete floor slabs shall be permitted an air space of not more than 1 inch where it turns up and is in contact with the underside of the floor under walls associated with the *building thermal envelope*.

**C402.2.4 Slabs-on-grade.** The minimum thermal resistance (*R*-value) of the insulation for unheated or heated slab-on-grade floors designed in accordance with the *R*-value method of Section C402.1.3 shall be as specified in Table C402.1.3. Where installed, the perimeter insulation for slab-on-grade shall be placed on the outside of the foundation or on the inside of the foundation wall. For installations complying with Table C402.1.3, the perimeter insulation shall extend downward from the top of the slab for the minimum distance shown in the table or to the top of the footing, whichever is less, or downward to not less than the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. Where installed, full slab insulation shall be continuous under the entire area of the slab-on-grade floor, except at structural column locations and service penetrations. Insulation required at the *heated slab* perimeter shall not be required to extend below the bottom of the heated slab and shall be continuous with the full slab insulation.

**Exception:** Where the slab-on-grade floor is greater than 24 inches (610 mm) below the finished exterior grade, perimeter insulation is not required at the slab.

**C402.2.4.1 Insulation installation.** Where installed, the perimeter insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The perimeter 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 not less than 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 a minimum of 10 inches (254 mm) of soil. Where installed, full slab insulation shall be

continuous under the entire area of the slab-on-grade floor, except at structural column locations and service penetrations. Insulation required at the heated slab perimeter shall not be required to extend below the bottom of the heated slab and shall be continuous with the full slab insulation.

**Exception:** Where the slab-on-grade floor is greater than 24 inches (61 mm) below the finished exterior grade, perimeter insulation is not required.

**C402.2.5 Below-grade walls.** The *R*-value of the insulating material installed in, or continuously on, the below-grade walls shall be in accordance with Table C402.1.3Below-grade wall insulation shall be installed between framing members, be integral to the wall assembly, be continuous on the wall assembly, or be any combination of these insulation methods. For installations complying with Section C401.2.1, insulation. The *U*-factor or *R*-value required shall extend to the level of the lowest floor of the conditioned space enclosed by the below-grade wall.

**C402.2.6 Insulation of radiant heating systems.** *Radiant heating system* panels and their associated components that are installed in interior or exterior assemblies shall be insulated to an R-value of not less than R-3.5 on all surfaces not facing the space being heated. Radiant heating system panels that are installed in the *building thermal envelope* shall be separated from the exterior of the building or unconditioned or exempt spaces by not less than the R-value of the insulation installed in the opaque assembly in which they are installed or the assembly shall comply with Section C402.1.4.

**Exception:** Heated slabs-on-grade insulated in accordance with Section C402.2.4.

**C402.2.7 Airspaces.** Where the *R*-value of an airspace is used for compliance in accordance with Section C402.1, the airspace shall be enclosed in an unventilated cavity constructed to minimize airflow into and out of the enclosed airspace. Airflow shall be deemed minimized where the enclosed airspace is located on the interior side of the continuous air barrier and is bounded on all sides by building componentsa cavity bounded on all sides by building components and constructed to minimize airflow into and out of the enclosed airspace. Airflow shall be deemed minimized where one of the following conditions occur:.

Commented [KA37]: Need connecting word

1. The enclosed airspace is unventilated.
1.2. The enclosed airspace is bounded on at least one side by an anchored masonry veneer, constructed in accordance with Chapter 14 of the *International Building Code* and vented by veneer weep holes located only at the bottom of the airspace and spaced not less than 15 inches (381 mm) on center with top of the cavity airspace closed.

**Exception:** The thermal resistance of airspaces located on the For ventilated cavities, the effect of the *ventilation* of airspaces located on the exterior side of the continuous air barrier and adjacent to and behind the exterior wall covering material shall be determined in accordance with ASTM C1363 modified with an airflow entering the bottom and exiting the top of the airspace at a minimum air movement rate of not less than 70 mm/sec.

**C402.2.8 Above-grade exterior concrete slabs.** Above-grade concrete slabs that penetrate the *building thermal envelope* including, but not limited to, decks and balconies, shall each include a minimum R-10 thermal break, aligned with the primary insulating layer in the ad-joining wall assemblies. Stainless steel (but not carbon steel) rein-forcing bars are permitted to penetrate the thermal break. If the total building performance path or the component performance alternative in Section C402.1.5 is utilized and the thermal break required by this section is not provided where concrete slabs penetrate the *building thermal envelope*, the sectional area of the penetration shall be as-signed the default *U*-factors from the "exposed concrete" row of Table A103.3.7.2.

**Exception**: *Mass transfer deck slabs*.

**C402.2.9 Vertical fenestration intersection with opaque walls.** Vertical fenestration shall comply with Items 1, 2, and 3, as applicable.

1. Where wall assemblies include continuous insulation, the exterior glazing layer of vertical fenestration and any required thermal break in the frame shall each be aligned within 2 inches laterally of either face of the continuous insulation layer.
2. Where wall assemblies do not include continuous insulation, the exterior glazing layer of vertical fenestration and any required thermal break in the frame shall each be aligned within the thickness of the wall insulation layer and not more than 2 inches laterally from the exterior face of the outermost insulation layer.

3. Where the exterior face of the vertical fenestration frame does not extend to the exterior face of the opaque wall rough opening, the exposed exterior portion of the rough opening shall be covered with either a material having an R-value not less than R-3, or with minimum 1.5-inch thickness wood.

**C402.3 Reserved.**

**C402.4 Fenestration.** Fenestration shall comply with Sections ~~C402.4~~ C402.4.1 through ~~C402.4.4~~C402.4.5 and Table C402.4. Daylight responsive controls shall comply with this section and Section ~~C405.2.5~~C405.2.4.

**TABLE C402.4**
**BUILDING THERMAL ENVELOPE FENESTRATION MAXIMUM *U*-FACTOR AND SHGC REQUIREMENTS**

| **CLIMATE ZONE** | **5 AND MARINE 4** | |
|---|---|---|
| ***U*-factor for Class AW windows rated in accordance with AAMA/CSA101/I.S.2/A440, vertical curtain walls and site-built fenestration products[a]** | | |
| Fixed[b] *U*-factor | U-0.34 | |
| Operable[c] *U*-factor | U-0.36 | |
| ***Entrance doors*[d]** | | |
| *U*-factor | U-0.60 | |
| U-factor for all other vertical fenestration | | |
| Fixed *U*-factor | U-0.26 | |
| Operable or mulled windows with fixed and operable sections *U*-factor | U-0.28 | |
| **SHGC for all vertical fenestration[f]** | | |
| | Fixed | Operable |
| **PF < 0.2** | 0.38 | 0.33 |
| **0.2 ≤ PF < 0.5** | 0.46 | 0.40 |
| **PF ≥ 0.5** | 0.61 | 0.53 |
| **Skylights** | | |
| ***U*-factor** | U-0.50 | |
| **SHGC** | 0.35 | |

a. U-factor and SHGC shall be rated in accordance with NFRC 100.
b. "Fixed" includes curtain wall, storefront, picture windows, and other fixed windows.
c. "Operable" includes openable fenestration products other than "entrance doors."
d. "Entrance door" includes glazed swinging entrance doors. Other doors which are not entrance doors, including sliding glass doors, are considered "operable."
e. Reserved.
f. Fenestration that is entirely within the conditioned space or is between conditioned and other enclosed space is exempt from solar heat gain coefficient requirements and not included in the SHGC calculation.

**C402.4.1 Maximum area.** The total building vertical fenestration area (not including opaque doors and opaque spandrel panels) shall not exceed 30 percent of the total building gross above-grade wall area. The skylight area shall not exceed 5 percent of the total building gross roof area (skylight-to-roof ratio).

For buildings with more than one *space conditioning category*, compliance with the maximum allowed window-to-wall ratio and skylight-to-roof ratio shall be demonstrated separately for each *space conditioning category*. Interior partition ceiling, wall, fenestration and floor areas that separate space conditioning areas shall not be applied to the window-to-wall ratio and skylight-to-roof ratio calculations.

**C402.4.1.1 Vertical fenestration maximum area with high performance alternates.** For buildings that comply with Section C402.4.1.1.1 or C402.4.1.1.2, the total building vertical fenestration area is permitted to exceed 30 percent but shall not exceed 40 percent of the gross above grade wall area for the purpose of prescriptive compliance with Section C402.1.4.

When determining compliance using the component performance alternative in accordance with Section C402.1.5, the total building vertical fenestration area allowed in Equation ~~4-2~~4-3 is 40 percent of the above grade wall area for buildings that comply with the vertical fenestration alternates described in this section.

**C402.4.1.1.1 Optimized daylighting.** All of the following requirements shall be met:

1. Not less than 50 percent of the total *conditioned floor area* in the building is within a primary sidelit

*daylight zone* or a toplit *daylight* zone that includes *daylight responsive controls* complying with Section C405.2.5.1.

2. Visible transmittance (VT) of all *vertical fenestration* in the building is greater than or equal to 1.1 times the required solar heat gain coefficient (SHGC) in accordance with Section C402.4, or 0.50, whichever is greater. It shall be permitted to demonstrate compliance based on the area weighted average *VT* being greater than or equal to the area weighted average of the minimum *VT* requirements.

**Exception**: Fenestration that is outside the scope of NFRC 200 is not required to comply with Item 2.

**C402.4.1.1.2 High-performance *fenestration*.** All of the following requirements shall be met:

1. All *vertical fenestration* in the building shall comply with the following U-factors:
   - 1.1. U-factor for Class AW windows rated in accordance with AAMA/CSA101/I.S.2/A440, vertical curtain walls and site-built fenestration products (fixed) = 0.31
   - 1.2. U-factor for Class AW windows rated in accordance with AAMA/CSA101/I.S.2/A440, vertical curtain walls and site-built fenestration products (operable) = 0.36
   - 1.3. Entrance doors = 0.60
   - 1.4. U-factor for all other vertical fenestration, fixed = 0.23
   - 1.5. U-factor for all other vertical fenestration, operable, or mulled windows with fixed and operable sections = 0.24
2. The SHGC of the vertical fenestration shall be no more than 0.9 times the maximum SHGC values listed in Table C402.4.

An area-weighted average shall be permitted to satisfy the U-factor requirement for each fenestration product category listed in Item 1 of this section. Individual fenestration products from different fenestration product categories shall not be combined in calculating the area-weighted average *U*-factor, except that fenestration from lines 1.1 and 1.2 are permitted to be combined.

**C402.4.2 Minimum skylight fenestration area.** Skylights shall be provided in enclosed spaces that meet all the following criteria:

1. Floor area of enclosed spaces is greater than 2,500 square feet (232 $m^2$).
2. Space is located directly under a roof and have a ceiling height greater than 15 feet (4572 mm) for no less than 75 percent of the ceiling area.
3. Space type is one of the following: office, lobby, atrium, concourse, corridor, gymnasium/exercise center, convention center, automotive service, manufacturing, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation, and workshop. Skylights in these spaces are required to provide a total toplit zone area not less than 50 percent of the floor area and shall provide one of the following:
   - 3.1. A minimum ratio of skylight area to *toplit daylight zone* area of not less than 3 percent where all skylights have a VT of at least 0.40, or $VT_{annual}$ of not less than 0.26, as determined in accordance with Section C303.1.3.
   - 3.2. A minimum skylight effective aperture, determined in accordance with Equation ~~4-5~~4-4, of:
     - 3.2.1. Not less than 1 percent using a skylight's VT rating; or
     - 3.2.2. Not less than 0.66 percent using a *tubular daylighting device*'s $VT_{annual}$ rating.

$$\text{Skylight Effective Aperture} = \frac{(0.85 \times \text{Skylight Area} \times \text{Skylight VT} \times \text{WF})}{\text{Toplit daylight zone}} \quad \textbf{(Equation ~~4-5~~4-4)}$$

where:

| | | |
|---|---|---|
| Skylight area | = | Total fenestration area of skylights. |
| Skylight VT | = | Area weighted average visible transmittance of skylights. |
| WF | = | Area weighted average well factor, where well factor is 0.9 if light well depth is less than 2 feet (610 mm), or 0.7 if light well depth is 2 feet (610 mm) or greater, or 1.0 for *tubular daylighting devices* with $VT_{annual}$ ratings measured according to NFRC 203. |
| Light well depth | = | Measure vertically from the underside of the lowest point of the skylight glazing to the ceiling plane under the skylight. |

**Exceptions:**

1. Skylights above daylight zones of enclosed spaces are not required in:
   - 1.1. Spaces designated as storm shelters complying with ICC 500.

1.2. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft$^2$ (5.4 W/m$^2$) and at least 10 percent lower than the lighting power allowance in Section C405.4.2.

1.3. Areas where it is documented that existing structures or natural objects block direct beam sunlight on at least half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.

1.4. Spaces where the daylight zone under rooftop monitors is greater than 50 percent of the enclosed space floor area.

1.5. Spaces where the total floor area minus the *sidelit daylight zone* area is less than 2,500 square feet (232 m$^2$), and where the lighting in the daylight zone is controlled in accordance with Section C405.2.4.1.

2. The skylight effective aperture, calculated in accordance with Equation ~~4-5~~4-4, is permitted to be 0.66 percent in lieu of one percent if the $VT_{annual}$ of the skylight or *TDD*, as measured by NFRC 203, is greater than 38 percent.

**C402.4.2.1 Lighting controls in daylight zones under skylights.** *Daylight responsive controls* shall be provided to control all electric lights within toplit daylight zones.

**C402.4.2.2 Haze factor.** Skylights in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store, and distribution/sorting area spaces shall have a glazing material or diffuser with a haze factor greater than 90 percent when tested in accordance with ASTM D 1003.

**Exception**: Skylights and *tubular daylighting devices* designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles, or the geometry of skylight and light well.

**C402.4.2.3 Daylight zones.** Daylight zones referenced in Sections C402.4.1.1 through C402.4.2.2 shall comply with Sections C405.2.5.2 and C405.2.5.3, as applicable. Daylight zones shall include *toplit daylight zones* and *sidelit* daylight *zones*.

**C402.4.3 Maximum *U*-factor and SHGC.** The maximum *U*-factor and solar heat gain coefficient (SHGC) for fenestration shall be as specified in Table C402.4.

The window projection factor shall be determined in accordance with Equation ~~4-6~~4-5.

$$PF = A/B \qquad \textbf{(Equation ~~4-6~~4-5)}$$

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 Reserved**~~

~~**C402.4.3.2 Reserved.**~~

~~**C402.4.3.3**~~**C402.4.3.1 Dynamic glazing.** Where *dynamic glazing* is intended to satisfy the SHGC and VT requirements of Table C402.4, 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 C402.4.

~~**C402.4.3.4**~~**C402.4.3.2 Area-weighted *U*-factor.** An area-weighted average shall be permitted to satisfy the *U*-factor requirements for each fenestration product category listed in Table C402.4. Individual fenestration products from different fenestration product categories listed in Table C402.4 shall not be combined in calculating area-weighted average *U*-factor.

**C402.4.4 Doors.** Opaque doors shall be considered part of the gross area of above grade walls that are part of the *building thermal envelope,* including the frame. Opaque doors shall comply with Table ~~C402.1.4~~C402.1.2. Other doors shall comply with the provisions of Section C402.4.3 for vertical fenestration.

**C402.5 Air leakage – building thermal envelope.** The *building thermal envelope* ~~of buildings~~ shall comply with Sections C402.5.1 through C402.5.8.

**C402.5.1 Air barriers.** A continuous air barrier shall be provided throughout the *building thermal envelope*. The ~~continuous~~ air barriers ~~shall~~ is permitted to be located at any combination of ~~on the~~ inside, ~~or~~ outside ~~of~~ or within the *building thermal envelope*~~, located within the assemblies composing the *building thermal envelope*, or any combination thereof~~. The air barrier shall comply with Sections C402.5.1.1 and C402.5.1.2. The air leakage performance of the *air barrier* shall be verified in accordance with Section C402.5.2.

**C402.5.1.1 Air barrier design and documentation requirements.** Design of the continuous *air barrier* shall be documented as follows:

1. Components comprising the continuous *air barrier* and their position within each *building thermal envelope* assembly shall be identified.
2. Joints, interconnections and penetrations of the continuous *air barrier* components shall be detailed.
3. The continuity of the *air barrier* building element assemblies that enclose *conditioned space* or provide a boundary between *conditioned space* and unconditioned space shall be identified.
4. Documentation of the continuous *air barrier* shall detail methods of sealing the *air barrier*, such as wrapping, caulking, gasketing, taping or other *approved* methods at the following locations:
   4.1. Joints around *fenestration* and door frames.
   4.2. Joints between walls and floors; between walls at building corners; between walls and roofs, including parapets and copings; where *above-grade walls* meet foundations; and at similar intersections.
   4.3. Penetrations or attachments through the continuous *air barrier*.
   4.4. Building assemblies used as *ducts* or plenums.
   4.5. Changes in continuous *air barrier* materials and assemblies.
5. Identify where testing will or will not be performed in accordance with Section C402.5.2. Where testing will not be performed, a plan for field inspections required by Section C402.5.2.3 shall be provided that includes the following:
   5.1. A schedule for periodic inspection.
   5.2. The continuous *air barrier* scope of work.
   5.3. A list of critical inspection items.
   5.4. Inspection documentation requirements.
   5.5. Provisions for corrective actions where needed.

~~C402.5.1.1~~**C402.5.1.2 Air barrier construction.** The *continuous air barrier* shall be constructed to comply with the following:

1. The air barrier shall be continuous for all assemblies that ~~are~~ comprise the *building 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. 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 differentials such as those 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. Sealing shall allow for expansion, contraction and mechanical vibration. ~~Joints and seams associated with penetrations shall be sealed in the same manner or taped.~~ Sealing materials shall be securely installed around the penetrations 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 fire sprinkler 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 ~~C402.5.8~~C402.5.1.2.1. Where similar objects are installed which penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

~~4.~~5. Electrical and communication boxes shall comply with Section C402.6.1.2.2.

~~5.~~6. Construction documents shall contain a diagram showing the building's pressure boundary in plan(s) and section(s) and a calculation of the area of the pressure boundary to be considered in the test.

~~**C402.5.10**~~**C402.6.1.2.1 Recessed lighting.** Recessed luminaires installed in the *building thermal envelope* shall be all of the following:

1. IC Rated.
2. *Labeled* as having an air leakage rate of not ~~more~~ greater than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E 283 at a 1.57 psf (75 Pa) pressure differential.
3. Sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

**C402.5.1.2.2 Electrical and communication boxes.** Electrical and communication boxes that penetrate the *air barrier* of the *building thermal envelope*, and that do not comply with Section C402.5.1.2.2.1, shall be caulked, taped, gasketed or otherwise sealed to the *air barrier* element being penetrated. All openings on the concealed portion of the box shall be sealed. Where present, insulation shall rest against all concealed portions of the box.

**C402.5.1.2.2.1 Air-sealed boxes.** Where air-sealed boxes are installed, they shall be marked in accordance with NEMA OS 4. Air-sealed boxes shall be installed in accordance with the manufacturer's instructions.

~~**C402.5.1.2**~~**C402.5.2 Air ~~barrier~~ leakage compliance.** ~~A continuous air barrier for the opaque building envelope shall comply with the following:~~

~~Group R dwelling units that are accessed directly from the outdoors shall meet the provisions of Section C402.5.2.~~

~~All other buildings or portions of buildings shall meet the provisions of Section C402.5.3.~~

*Air leakage* of the *building thermal envelope* shall be tested by an *approved* third party in accordance with Section C402.5.2.1. The measured *air leakage* shall not be greater than 0.25 cubic feet per minute per square foot (1.27 L/s x m2) of the *building thermal envelope area at a pressure differential of 0.3 inch water gauge (75 Pa) with the calculated building thermal envelope surface area being the sum of the above- and below-grade building thermal envelope.*

***Exceptions:***

1. *Where the measured air leakage rate is greater than 0.25 cfm/ft2 (1.27 L/s × m2)* ~~but is not greater than 0.45 cfm/ft2 (2.3 L/s × m2), the approved third party shall perform a diagnostic evaluation using a smoke tracer or infrared imaging. The evaluation shall be conducted while the building is pressurized or depressurized along with a visual inspection of the air barrier in accordance with ASTM E1186. All identified leaks shall be sealed where such sealing can be made without damaging existing building components. A report specifying the corrective actions taken to seal leaks shall be deemed to establish compliance with the requirements of this section where submitted to the *code official* and the building *owner*. Where the measured *air leakage* rate is greater than 0.45 cfm/ft2 (2.3 L/s × m2),~~ corrective actions must be made to the building and an additional testing completed until the required air leakage rating is achieved. Final passing of the air leakage test results shall be submitted to the *code official*.
2. ~~1.~~As an alternative, buildings or portions of buildings containing Group I-1 and R-2 occupancies shall be permitted to be tested by an approved third party in accordance with Section C402.5.2.2. ~~The reported air leakage of the *building thermal envelope* shall not be greater than 0.27 cfm/ft2 (1.4 L/s × m2) of the testing unit enclosure area at a pressure differential of 0.2.~~

~~**C402.5.3**~~**C402.5.2.1 ~~Building thermal envelope testing~~Whole building test method and reporting.** The *building thermal envelope* shall be tested by an *approved* third party in accordance with ~~ASTM E779, ANSI/RESNET/ICC 380,~~ ASTM E3158. ~~or ASTM E1827 or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.25 cfm/ft² (1.27 L/s × m²) of the *building thermal envelope* area at a pressure differential of 0.3 inch water gauge (75 Pa). Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:~~ A report that

**Commented [BK(38]:** Current state amendment. The IECC value is 0.35

**Commented [BK(39]:** Existing state language from C402.5.3

includes the tested surface area, floor area, air by volume, stories above grade, and *air leakage* rates shall be submitted to the *code official* and the building *owner*.

~~1. The entire envelope area of all stories that have any spaces directly under a roof.~~

~~2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.~~

~~3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.~~

~~1. Test shall be accomplished using either: a) both pressurization and depressurization, or b) pressurization alone, but not depressurization alone. The test results shall be plotted against the correct P for pressurization in accordance with Section 9.4 of ASTM E779.~~

**Exceptions:**

**1.** For *buildings* less than 10,000 square feet (929 $m^2$), the entire *building thermal envelope* shall be permitted to be tested in accordance with ASTM E779, ASTM E3158, ASTM E1827 or an equivalent *approved* method.

2. For *buildings* greater than 50,000 square feet (4645 m2), portions of the *building* shall be permitted to be tested and the measured *air leakage* shall be area weighted by the surface areas of the *building thermal envelope* in each portion. The weighted-average tested *air leakage* shall not be greater than the whole building *air leakage* limit. The following portions of the *building* shall be tested:

2.1. The entire *building thermal envelope* area of stories that have any *conditioned spaces* directly under a roof.

2.2. The entire *building thermal envelope* area of stories that have a *building entrance*, have a floor over unconditioned space, have a loading dock or that are below grade.

2.3. Representative above-grade portions of the building totaling not less than 25 percent of the wall area enclosing the remaining *conditioned space*.

~~C402.5.2~~C402.5.2.2 **Enclosure testing for dwelling and sleeping units accessed directly from the outdoors.** For dwelling units accessed directly from outdoors, the *building thermal envelope* shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 or an equivalent method approved by the *code official*. The measured air leakage shall not exceed 0.25 cfm/$ft^2$ (1.27 L/s $m^2$) of the *testing unit enclosure area* at a pressure differential of 0.2 inch water gauge (50 Pa). Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one *building thermal envelope* and are accessed directly from the outdoors, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each testing unit's enclosure area. Units shall be tested separately with an unguarded blower door test as follows:

1. Where buildings have fewer than eight testing units, each testing unit shall be tested.
2. For buildings with eight or more testing units, the greater of seven units or 20 percent of the testing units in the building shall be tested, including a top floor unit, a ground floor unit and a unit with the largest *testing unit enclosure area*. For each tested unit that exceeds the maximum air leakage rate, an additional two units shall be tested, including a mixture of testing unit types and locations.
3. Test shall be accomplished using either a) both pressurization and depressurization or b) pressurization alone, but not depressurization alone. The test results shall be plotted against the correct P for pressurization in accordance with Section 9.4 of ASTM E779.

Where the measured air leakage rate exceeds 0.25 cfm/$ft^2$ (2.0 L/s x $m^2$) corrective action shall be taken to seal leaks in the air barrier in all units exceeding the target value and all untested units. Post-corrective action testing and repeated corrective action measures will be taken until the required air leakage rating is achieved. Final passing air leakage test results shall be submitted to the *code official*.

---

C402.6.2.2 **Dwelling and sleeping unit enclosure ~~testing.~~ method and reporting.** The *building thermal envelope* shall be tested for *air leakage* in accordance with **ASTM E779**, **ANSI/RESNET/ICC 380**, **ASTM E1827** or an equivalent *approved* method ~~approved by the *code official*. The measured *air leakage* shall not exceed~~

**Commented [BK(40):]** The 2024 IECC does have some changes to the residential testing section, but they aren't compatible with the state amendment. See https://codes.iccsafe.org/content/IECC2024P1/chapter-4-ce-commercial-energy-efficiency#IECC2024P1_CE_Ch04_SecC402.6.2 along with shaded text below.

**Commented [KB41R40]: Duane Jonlin**
This might be worth checking to see if the IECC language is an improvement.

~~0.30 cfm/ft 2(1.5 L/s m2) of the *testing unit enclosure area* at a pressure differential of 0.2 inch water gauge (50 Pa).~~ Where multiple *dwelling units* or *sleeping units* or other ~~occupiable conditioned~~ spaces are contained within one *building thermal envelope*, each ~~unit~~ shall be considered an individual testing unit, and the *building air leakage* shall be the weighted average of all ~~testing~~ tested unit results, weighted by each *testing ~~unit's~~ unit enclosure area*. Units shall be tested ~~separately with an unguarded blower door test as follows:~~ without simultaneously testing adjacent units and shall be separately tested as follows:

1. Where buildings have ~~fewer~~ less than eight total ~~testing~~ dwelling or *sleeping units*, each testing unit shall be tested.
2. Where ~~For~~ buildings ~~with~~ have eight or more ~~testing~~ dwelling or *sleeping units*, the greater of seven units or 20 percent of the ~~testing~~ units in the building shall be tested, including a top floor unit, a middle floor unit, a ground floor unit and a unit with the largest *testing unit enclosure area*. For each tested unit that exceeds the maximum *air leakage* rate, an additional ~~two~~ three units shall be tested, including a mixture of testing unit types and locations.
3. *Enclosed spaces* with not less than one *exterior wall* in the *building thermal envelope* shall be tested in accordance with **Section C402.6.2.1**.

**Exception:** Corridors, stairwells, and *enclosed spaces* having a *conditioned floor area* not greater than 1,500 square feet (139 m2) shall be permitted to comply with **Section C402.6.2.3** and either **Section C402.6.2.3.1** or **Section C402.6.2.3.2**.

---

~~C402.5.4~~C402.5.2.3 **Building test for mixed-use buildings.** Where a building is three or fewer stories above grade plane and contains both commercial and residential uses, the air barrier of the R-2 and R-3 occupancy areas of the building is permitted to be separately tested according to Section R402.4.1.2. Alternatively, it is permissible to test the air barrier of the entire building according to Section C402.5.3, provided that the tested air leakage rate does not exceed the rate specified in Section C402.5.3.

~~C402.5.6~~C402.5.3 **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 shall be gasketed, weatherstripped or sealed.

**Exceptions**:

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

~~C402.5.7~~C402.5.4 **Air intakes, exhaust openings, stairways and shafts.** Stairway enclosures, elevator shaft vents and other outdoor air intake and exhaust openings integral to the *building thermal envelope* shall be provided with dampers in accordance with Section C403.7.8.

~~C402.5.8~~C402.5.5 **Loading dock weatherseals.** Cargo door openings and loading dock door openings shall be equipped with weatherseals that restrict ~~infiltration~~ air leakage and provide direct contact along the top and sides of vehicles that are parked in the doorway.

~~C402.5.9~~C402.5.6 **Vestibules.** All building entrances shall be protected with an enclosed vestibule~~, with all doors~~. Doors opening into and out of the vestibule shall be 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. The installation of one or more revolving doors in the building entrance shall not eliminate the requirement that a vestibule be provided on any doors adjacent to revolving doors. For the purposes of this section, “building entrances” shall include exit-only doors in buildings where separate doors for entering and exiting are provided.

Interior and exterior doors shall have a minimum distance between them of not less than 7 feet. The exterior envelope of conditioned vestibules shall comply with the requirements for a conditioned space. Either the interior or exterior envelope of unconditioned vestibules shall comply with the requirements for a conditioned space. The building lobby is not considered a vestibule.

**Exception:** Vestibules are not required for the following:

1. Doors not intended to be used as building entrances.
2. Unfinished ground-level space greater than 3,000 square feet (298 $m^2$) if a note is included on the permit documents at each exterior entrance to the space stating “Vestibule required at time of tenant

build-out if entrance serves a space greater than 3,000 square feet in area."

3. Doors opening directly from a *sleeping unit* or dwelling unit.
4. Doors between an enclosed space smaller than 3,000 square feet (298 m2) in area and the exterior of the building or the building entrance lobby, where those doors do not comprise one of the primary building entrance paths to the remainder of the building. The space must be enclosed and separated without transfer air paths from the primary building entrance paths. If there are doors between the space and the primary entrance path then the doors shall be equipped with self-closing devices so the space acts as a vestibule for the primary building entrance.
5. Revolving doors.
6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
7. In buildings less than three stories above grade or in spaces that do not directly connect with the building elevator lobby, doors that have an *air curtain unit* with a velocity of not less than 6.56 feet per second (2 m/s) at 6 inches (152 mm) above the floor that ~~have~~ has been tested in accordance with ANSI/AMCA 220 or ISO 27327-1 and installed in accordance with the manufacturer's instructions. *Manual* or *automatic* controls shall be provided that will operate the *air curtain unit* with the opening and closing of the door and comply with Section C403.4.1.5. *Air curtain~~s~~ units* and their controls shall comply with Section C408.2.3
8. Building entrances in buildings that are less than four stories above grade and less than 10,000 square feet in area.
9. Elevator doors in parking garages provided that the elevators have an enclosed lobby at each level of the garage.
10. Entrances to semi-heated spaces.
11. Doors that are used only to access outdoor seating areas that are separated from adjacent walking areas by a fence or other barrier.

**~~C402.5.11~~C402.5.7 ~~Operable openings interlocking~~Heating and cooling system controls for operable openings to the outdoors.** Where any operable openings to the outdoors are larger than 48 square feet (4.47 $m^2$) in area, such openings shall be interlocked with the heating and cooling system as required by Section ~~C403.4.1.6~~C403.4.1.7.

**Exceptions:**

1. Separately zoned areas associated with the preparation of food that contain appliances that contribute to the HVAC loads of a restaurant or similar type of occupancy.
2. Warehouses that utilize overhead doors for the function of the occupancy, where approved by the code official.
3. The outer entrance doors where located in the exterior wall and are part of a vestibule system.
4. Alterations to existing buildings.

**C402.6 Thermal bridges in above-grade walls.** *Thermal bridges* in *above-grade walls* shall comply with this section or an *approved* design.

**Exceptions:**

1. Any *thermal bridge* with a material thermal conductivity not greater than 3.0 Btu/h × ft × °F (5.19 W/m × K).
2. Blocking, coping, flashing and other similar materials for attachment of roof coverings.
3. *Thermal bridges* accounted for in the *U-factor* or *C-factor* for a *building thermal envelope*.

**C402.6.1 Balconies and floor decks.** Balconies and concrete floor decks shall not penetrate the *building thermal envelope*. Such assemblies shall be separately supported or shall be supported by structural attachments or elements that minimize thermal bridging through the *building thermal envelope*.

**Exceptions:** Balconies and concrete floor decks shall be permitted to penetrate the *building thermal envelope* where one of the following applies:

1. An area-weighted *U-factor* is used for *above-grade wall* compliance that includes a *U-factor* of 0.8 Btu/h × °F × ft2 (1.38 W/m × K) for the area of the *above-grade wall* penetrated by the concrete floor deck in accordance with Section C402.1.2.1.5.

**Commented [KA42]:** How does this relate to the thermal bridging in **TABLE C402.1.3(1) CONTINUOUS INSULATION EQUIVALENTS?**

2. An *approved* thermal break device with not less than R-10 insulation material is installed in accordance with the manufacturer's instructions.
3. An *approved* design where the *above-grade wall U-factor* used for compliance accounts for all balcony and concrete floor deck *thermal bridges*.

**C402.6.2 Cladding supports.** Linear elements supporting opaque cladding shall be offset from the structure with attachments that allow the *continuous insulation*, where present, to pass behind the cladding support element except at the point of attachment.

**Exceptions:**

1. An *approved* design where the *above-grade wall U-factor* used for compliance accounts for the cladding support element *thermal bridge*.
2. Anchoring for *curtain wall* and window wall systems where *curtain wall* and window wall systems comply with Section C402.6.4.

**C402.6.3 Structural beams and columns.** Structural steel and concrete beams and columns that project through the *building thermal envelope* shall be covered with not less than R-5 insulation for not less than 2 feet (610 mm) beyond the interior or exterior surface of an insulation component within the *building thermal envelope*.

**Exceptions:**

1. Where an *approved* thermal break device is installed in accordance with the manufacturer's instructions.
2. An *approved* design where the *above-grade wall U-factor* used to demonstrate compliance accounts for the beam or column *thermal bridge*.

**C402.6.4 Vertical fenestration.** Vertical *fenestration* intersections with *above-grade walls* shall comply with one or more of the following:

1. Where *above-grade walls* include *continuous insulation*, the plane of the exterior glazing layer or, for metal frame *fenestration*, a nonmetal thermal break in the frame shall be positioned within 2 inches (610 mm) of the interior or exterior surface of the *continuous insulation*.
2. Where *above-grade walls* do not include *continuous insulation*, the plane of the exterior glazing layer or, for metal frame *fenestration*, a nonmetal thermal break in the frame shall be positioned within the thickness of the integral or *cavity insulation*.
3. The surface of the rough opening, not covered by the *fenestration* frame, shall be insulated with insulation of not less than R-3 material or covered with a wood buck that is not less than 1.5 inches (38 mm) thick.
4. For the intersection between vertical *fenestration* and opaque spandrel in a shared framing system, manufacturer's data for the spandrel *U-factor* shall account for *thermal bridges*.

**Exceptions:**

1. Where an *approved* design for the *above-grade wall U-factor* used for compliance accounts for *thermal bridges* at the intersection with the vertical *fenestration*.
2. Doors.

**C402.6.5 Parapets.** Parapets shall comply with one or more of the following as applicable:

1. Where *continuous insulation* is installed on the exterior side of the *above-grade wall* and the roof is insulated with insulation entirely above deck, the *continuous insulation* shall extend up both sides of the parapet not less than 2 feet (610 mm) above the roof covering or to the top of the parapet, whichever is less. Parapets that are an integral part of a fire-resistance rated wall, and the exterior *continuous insulation* applied to the parapet, shall comply with the fire-resistance ratings of the *International Building Code*.
2. Where *continuous insulation* is installed on the exterior side of the *above-grade wall* and the roof insulation is below the roof deck, the *continuous insulation* shall extend up the exterior side of the parapet to not less than the height of the top surface of the *roof assembly*.
3. Where *continuous insulation* is not installed on the exterior side of the *above-grade wall* and the roof is insulated with insulation entirely above deck, the wall cavity or integral insulation shall extend into the

parapet up to the exterior face of the roof insulation or equivalent *R-value* insulation shall be installed not less than 2 feet (610 mm) horizontally inward on the underside of the roof deck.

4. Where *continuous insulation* is not installed on the exterior side of the *above-grade wall* and the roof insulation is below the roof deck, the wall and roof insulation components shall be adjacent to each other at the roof-ceiling-wall intersection.
5. Where a thermal break device with not less than R-10 insulation material aligned with the *above-grade wall* and roof insulation is installed in accordance with the manufacturer's instructions.

**Exception:** An *approved* design where the *above-grade wall U*-factor used for compliance accounts for the parapet *thermal bridge*.

## SECTION C403
## MECHANICAL SYSTEMS

**C403.1 General.** Mechanical systems and equipment serving heating, cooling, ventilating, and other needs shall comply with this section.

**Exceptions**:

1. Energy using equipment used by a manufacturing, industrial or commercial process other than for conditioning spaces or maintaining comfort and amenities for the occupants are exempt from all Section C403 subsections except for Section C403.3.2, Tables C403.3.2(1) through (16) inclusive, Sections C403.3.4.1, C403.3.4.2, C403.3.4.3. C403.7.7, C403.9.2.1, C403.10.3, C403.11.2, and C403.11.3. Data center and computer room HVAC equipment is not covered by this exception.
2. *Data center systems* ~~are exempt from Sections C403.4 and C403.5~~shall comply with Sections C403.1.2, C403.1.3 and C403.6.

**C403.1.1 HVAC total system performance ratio (*HVAC TSPR*).** For systems serving office (including medical office), retail, library and education occupancies and buildings, which are subject to the requirements of Section C403.3.5 without exceptions, and the dwelling units and residential common areas within Group R-2 multi-family buildings, the *HVAC total system performance ratio* (*HVAC TSPR*) of the *proposed design* HVAC system shall be greater than or equal to the *HVAC TSPR* of the *standard reference design* as calculated according to Appendix D, Calculation of HVAC Total System Performance Ratio.

**Exceptions:**

1. Buildings where the sum of the *conditioned floor area* of office, retail, education, library, and multifamily spaces is less than 5,000 square feet. Areas that are eligible for any of the exceptions below do not count towards the 5,000 square feet.
2. HVAC systems using district heating water, chilled water or steam.
3. HVAC systems connected to a *low-carbon district energy exchange system*.
4. HVAC systems not included in Table D601.10.1.
5. HVAC systems with chilled water supplied by absorption chillers, heat recovery chillers, water to water heat pumps, air to water heat pumps, or a combination of air and water cooled chillers on the same chilled water loop.
6. HVAC systems included in Table D601.10.1 with parameters in Table D601.10.2 not identified as applicable to that HVAC system type.
7. HVAC system served by heating water plants that include air to water or water to water heat pumps.
8. Underfloor air distribution and displacement ventilation HVAC systems.
9. Space conditioning systems that do not include *mechanical cooling*.
10. Alterations to existing buildings that do not substantially replace the entire HVAC system and are not serving initial build-out construction.
11. HVAC systems meeting all the requirements of the *standard reference design* HVAC system in Table D602.11, Standard Reference Design HVAC Systems.
12. Buildings or areas of medical office buildings that comply fully with ASHRAE Standard 170 including, but not limited to, surgical centers, or that are required by other applicable codes or standards to provide 24/7 air handling unit operation.
13. HVAC systems serving the following areas and spaces:
    - 13.1. Laundry rooms.
    - 13.2. Elevator machine rooms.
    - 13.3. Mechanical and electrical rooms.
    - 13.4. *Data centers* and *computer rooms*.
    - 13.5. Laboratories with fume hoods.
    - 13.6. Locker rooms with more than two showers.
    - 13.7. Natatoriums and rooms with saunas.
    - 13.8. Restaurants and commercial kitchens with total cooking capacity greater than 100,000 Btu/h.
    - 13.9. Areas of buildings with commercial refrigeration equipment exceeding 100 kW of power

**Commented [BK(43]:** The 2024 IECC contains a new Section C409, Calculation of the HVAC TSPR, that is a separate compliance pathway with a laundry list of systems not allowed to use the pathway.

**Commented [DJ44R43]:** We should establish a working group to examine the plusses and minuses of each version.

input.

13.10. Cafeterias and dining rooms.

**C403.1.2 Calculation of heating and cooling loads.** Design loads associated with heating, ventilating and air conditioning of the building shall be determined in accordance with the procedures described in ANSI/ASHRAE/ACCA Standard 183 or by an *approved* equivalent computational procedure, using the design parameters specified in Chapter 3. Heating and cooling loads shall be adjusted to account for load reductions that are achieved where energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook* by an *approved* equivalent computational procedure.

**C403.1.3 Data centers**. *Data center systems* shall comply with Sections 6 and 8 of ASHRAE ~~Standard~~ 90.4.

**C403.1.4 Use of electric resistance and fossil fuel-fired HVAC heating equipment.** HVAC heating energy shall not be provided by electric resistance or fossil fuel combustion appliances. For the purposes of this section, electric resistance HVAC heating appliances include, but are not limited to, electric baseboard, electric resistance fan coil and VAV electric resistance terminal reheat units and electric resistance boilers. For the purposes of this section, fossil fuel combustion HVAC heating appliances include, but are not limited to, appliances burning natural gas, heating oil, propane, or other fossil fuels.

**Exceptions:**

1. **Low heating capacity.** Buildings or areas of buildings, other than *dwelling units* or sleeping units, that meet the interior temperature requirements of Chapter 12 of the *International Building Code* with a total installed HVAC heating capacity no greater than 8.5 Btu/h (2.5 watts) per square foot of *conditioned space* are permitted to be heated using electric resistance appliances.
2. **Dwelling and sleeping units.** Dwelling or sleeping units are permitted to be heated using electric resistance appliances as long as the installed HVAC heating capacity in any separate space is not greater than:
   2.1. Seven hundred fifty (750) watts in Climate Zone 4, and 1000 watts in Climate Zone 5 in each habitable space with fenestration.
   2.2. One thousand (1,000) watts in Climate Zone 4, and 1300 watts in Climate Zone 5 for each habitable space that has two primary walls facing different cardinal directions, each with exterior fenestration. Bay windows and other minor offsets are not considered primary walls.
   2.3. Two hundred fifty (250) watts in spaces adjoining the *building thermal envelope* but without fenestration.

   For the purposes of this section, habitable space is as defined in the International Building Code. For buildings in locations with exterior design conditions below 4°F (-16°C), an additional 250 watts above that allowed for Climate Zone 5 is permitted in each space with fenestration.
3. **Small buildings.** Buildings with less than 2,500 square feet (232 $m^2$) of *conditioned floor area* are permitted to be heated using electric resistance appliances.
4. **Defrost.** Heat pumps are permitted to utilize electric resistance heating when a heat pump defrost cycle is required and is in operation.
5. **Air-to-air heat pumps.** Buildings are permitted to utilize electric resistance supplemental heating for air-to-air heat pumps that meet all of the following conditions:
   5.1. Internal electric resistance heaters have controls that prevent supplemental heater operation when the heating load can be met by the heat pump alone during both steady-state operation and setback recovery.
   5.2. The heat pump controls are configured to use the compressor as the first stage of heating down to an outdoor air temperature of 17°F (-8°C) or lower except when in defrost.

      **Exceptions to 5.2**:

      1. Packaged terminal heat pumps (PTHPs) that comply with the minimum heating efficiency requirements in Table C403.3.2(4) are exempt from heat pump controls capable of operating the compressor as the first stage of heating down to an outdoor air temperature of 17°F (-8°C) or lower.
      2. Heat pumps whose minimum efficiency is regulated by NAECA and whose ratings meet the requirements shown in Table C403.3.2(2) and include all usage of internal electric resistance heating are exempt from heat pump controls capable of operating the compressor as the first stage of heating down to an outdoor air temperature of 17°F (-8°C) or lower.

   5.3. The heat pump complies with one of the following:

5.3.1. Controlled by a digital or electronic thermostat designed for heat pump use that energizes the supplemental heat only when the heat pump has insufficient capacity to maintain setpoint or to warm up the space at a sufficient rate.
5.3.2. Controlled by a multistage space thermostat and an outdoor air thermostat wired to energize supplemental heat only on the last stage of the space thermostat and when outdoor air temperature is less than 32°F (0°C) except when in defrost.
5.3.3. The minimum efficiency of the heat pump is regulated by NAECA, its rating meets the requirements shown in Table C403.3.2(2), and its rating includes all usage of internal electric resistance heating.

5.4. The heat pump rated heating capacity is sized to meet the heating load at an outdoor air temperature of 32°F (0°C) or lower and has a rated heating capacity at 47°F (8°C) no less than 2 times greater than supplemental heating capacity in Climate Zone 4 and no less than the supplemental heating capacity in Climate Zone 5, or utilizes the smallest available factory-available internal electric resistance heater.

6. **Air-to-water heat pumps.** Buildings are permitted to utilize electric resistance (for Climate Zone 4 or 5) or fossil fuel-fired (for Climate Zone 5) auxiliary heating to supplement heat pump heating for hydronic heating systems that meet all of the following conditions:
   6.1. Controls for the auxiliary heating sources are configured to lock out the supplemental heat when the outside air temperature is above 36°F (2°C), unless the hot water supply temperature setpoint to the building heat coils cannot be maintained for 20 minutes.
   6.2. The heat pump controls are configured to use the compressor as the first stage of heating down to the lowest exterior design temperature for which the equipment is rated except during startup or defrost operation.
   6.3. The heat pump rated heating capacity at 47°F (8°C) is no less than 75 percent of the design heating load at 29°F (-2°C).
7. **Ground source heat pumps.** Buildings are permitted to utilize electric resistance supplemental heating for heat pump heating for hydronic heating systems with ground source heat pump equipment that meets all of the following conditions:
   7.1. Controls for the auxiliary heating sources are configured to lock out the supplemental heat when the equipment source-side entering water temperature is above 42°F (6°C), unless the hot water supply temperature setpoint to the building heat coils cannot be maintained for 20 minutes.
   7.2. The heat pump controls are configured to use the compressor as the first stage of heating.
   7.3. The ground source heat exchanger shall be sized so that the heat pump annual heating output is no less than 70 percent of the total annual heating output in the final year of a 30-year simulation using IGSHPA listed simulation software.
8. **Small systems.** Buildings in which electric resistance or fossil fuel appliances, including decorative appliances, either provide less than 5 percent of the total building HVAC system heating capacity or serve less than 5 percent of the *conditioned floor area*.
9. **Specific conditions.** Portions of buildings that require fossil fuel or electric resistance space heating for specific conditions *approved* by the *code official* for research, health care, process or other specific needs that cannot practicably be served by heat pump or other space heating systems. This does not constitute a blanket exception for any occupancy type.
10. **Kitchen make-up air.** Make-up air for commercial kitchen exhaust systems required to be tempered by Section 508.1.1 of the *International Mechanical Code* is permitted to be heated by using fossil fuel in Climate Zone 5 or electric resistance in Climate Zone 4 or 5.
11. **District energy.** Steam or hot water district energy systems that utilize fossil fuels as their primary source of heat energy, that serve multiple buildings, and that were already in existence prior to the effective date of this code, including more energy-efficient upgrades to such existing systems, are permitted to serve as the primary heating energy source.
12. **Heat tape.** Heat tape is permitted where it protects water-filled equipment and piping located outside of the *building thermal envelope*, provided that it is configured and controlled to be automatically turned off when the outside air temperature is above 40°F (4°C).
13. **Temporary systems.** Temporary electric resistance heating systems are permitted where serving future tenant spaces that are unfinished and unoccupied, provided that the heating equipment is sized and controlled to achieve interior space temperatures no higher than 40°F (4°C).

14. **Pasteurization.** Electric resistance heat controls are permitted to reset the supply water temperature of hydronic heating systems that serve service water heating heat exchangers during pasteurization cycles of the service hot water storage volume. The hydronic heating system supply water temperature shall be configured to be 145°F (63°C) or lower during the pasteurization cycle.
15. **Freeze protection.** Heating systems sized for spaces with indoor design conditions of 45°F (7°C) and intended for freeze protection are permitted to use electric resistance. The *building thermal envelope* of any such space shall be insulated in compliance with Section C402.1.
16. **DOAS ERV auxiliary heat.** Dedicated outdoor air systems with energy recovery ventilation are permitted to utilize fossil fuel for Climate Zone 5 or electric resistance in Climate Zone 4 or 5 for auxiliary heating to preheat outdoor air for defrost or as auxiliary supplemental heat to temper supply air to 55°F (13°C) or lower for buildings or portions of buildings that do not have hydronic heating systems.
17. **Low-carbon district energy systems.** Low-carbon district energy systems that meet the definitions of *low-carbon district energy exchange system* or *low-carbon district heating and cooling or heating only systems*.
18. **Essential facilities.** Groups I-2 and I-3 occupancies that by regulation are required to have in place redundant emergency backup systems.

**C403.2 System design.** Mechanical systems shall be designed to comply with Sections C403.2.1 through C403.2.4. Where elements of a building's mechanical systems are addressed in Sections C403.3 through C403.13, such elements shall comply with the applicable provisions of those sections.

**C403.2.1 Zone isolation required.** HVAC systems, DOAS and exhaust systems serving areas that are intended to operate or be occupied nonsimultaneously shall be divided into separate isolation areas. *Zones* intended to be occupied simultaneously may be grouped into a single isolation area provided the combined total area does not exceed 25,000 square feet (2323 $m^2$) of *conditioned floor area* and does not include more than one floor. Each isolation area shall be equipped with isolation devices and controls configured to automatically shut off the supply of conditioned 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 C403.4.2.2. 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 isolation 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.
3. Isolation areas intended to operate continuously or intended to be inoperative only when all other isolation areas in a *zone* are inoperative.

**C403.2.2 Ventilation and exhaust.**

**C403.2.2.1 Ventilation.** Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *International Mechanical Code*. Where mechanical ventilation is provided, the system shall be configured to provide no greater than 150 percent of the minimum outdoor air required by Chapter 4 of the *International Mechanical Code* or other applicable code or standard, whichever is greater.

**Exceptions:**

1. The mechanical system may supply outdoor air at rates higher than the limit above when it is used for particulate or VOC dilution, economizing or night flushing, dehumidification, pressurization, exhaust make-up, or other process air delivery. Outdoor air shall be reduced to the minimum ventilation rates when not required for the preceding uses.
2. Air systems supplying dwelling or sleeping units within Group R-1, R-2 or I-2 occupancies.
3. Alterations that replace less than half of the total heating and cooling capacity of the system.
4. Systems with energy recovery complying with the requirements of Section C403.7.6 that utilize sensible only active chilled beams for space cooling without any additional zonal fan power. Active chilled beams shall be permitted to utilize the increased outdoor airflow to increase space

sensible capacity and to maintain space latent cooling loads without additional controls to reduce the outdoor airflow to each *zone*.

5. Systems that include energy recovery ventilation with an 80 percent minimum sensible recovery effectiveness in accordance with Section C403.3.5.1 and with controls capable and configured to lock-out the use of supplemental heat may provide ventilation up to a maximum of 200 percent of the minimum outdoor air required.

**C403.2.2.2 Exhaust.** Exhaust shall be provided in accordance with Chapters 4 and 5 of the *International Mechanical Code*. Where exhaust is provided, the system shall be configured to provide no greater than 150 percent of the minimum exhaust air required by Chapters 4 and 5 of the *International Mechanical Code* or other applicable code or standard, whichever is greater.

**Exceptions:**

1. The mechanical system may exhaust air at rates higher than the limit above when it is used for particulate or VOC dilution, economizer, night flushing, dehumidification, pressure equalization, relief, or other process exhaust air requirements. Outdoor air and exhaust air shall be reduced to the minimum exhaust rates when not required for the preceding uses.
2. Domestic range hood exhaust in Group R occupancies.
3. Exhaust for Group I occupancies.

**C403.2.3 Fault detection and diagnostics.** ~~New buildings~~ Buildings with ~~an HVAC system serving~~ a gross conditioned floor area of not less than100,000 square feet (9290 $m^2$) ~~or larger~~ served by one or more HVAC systems that are controlled by a *direct digital* control (DDC) system shall include a fault detection and diagnostics (FDD) system to monitor the HVAC system's performance and automatically identify faults. The FDD system shall:

1. Include permanently installed sensors and devices to monitor ~~the~~ HVAC system~~'s~~ performance.
2. Sample ~~the~~ HVAC system~~'s~~ performance at least once every 15 minutes.
3. Automatically identify and report HVAC system faults.
4. Automatically notify authorized personnel of identified HVAC system faults.
5. Automatically provide prioritized recommendations for repair of identified faults based on analysis of data collected from the sampling of HVAC system performance.
6. Be capable of transmitting the prioritized fault repair recommendations to remotely located authorized personnel.

**Exception:** Group R-1 and R-2 occupancies.

**C403.2.4 Variable flow capacity.** For fan and pump motors 5.0 hp and greater including motors in or serving custom and packaged air handlers serving variable air volume fan systems, constant volume fans, heating and cooling hydronic pumping systems, pool and service water pumping systems, domestic water pressure-booster systems, cooling tower fan, and other pump or fan motors where variable flows are required, there shall be:

1. Variable speed drives; or
2. Other controls and devices that will result in fan and pump motor demand of no more than 30 percent of design wattage at 50 percent of design air volume for fans when static pressure setpoint equals 1/3 the total design static pressure, and 50 percent of design water flow for pumps, based on manufacturer's certified test data. Variable inlet vanes, throttling valves (dampers), scroll dampers or bypass circuits shall not be allowed.

**Exception:** Variable speed devices are not required for motors that serve:

1. Fans or pumps in packaged equipment where variable speed drives are not available as a factory option from the equipment manufacturer.
2. Fans or pumps that are required to operate only for emergency fire-life-safety events (e.g., stairwell pressurization fans, elevator pressurization fans, fire pumps, etc.).

**C403.3 Equipment selection.** Heating and cooling equipment installed in mechanical systems shall be sized in accordance with Section C403.3.1 and shall be not less efficient in the use of energy than as specified in Section C403.3.2.

**C403.3.1 Equipment and system sizing.** The output capacity of heating and cooling equipment shall be not

greater than that of the smallest available equipment size that exceeds the loads calculated in accordance with Section C403.1.2. A single piece of equipment providing both heating and cooling shall 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 are configured to sequence the operation of each unit based on load.

**C403.3.2 HVAC equipment performance requirements.** Equipment shall meet the minimum efficiency requirements of Tables C403.3.2(1) through C403.3.2(16) when tested and rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of AHRI 400. The efficiency shall be verified through certification and listed under an *approved* certification program or, if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

**TABLE C403.3.2(1)**
**MINIMUM EFFICIENCY REQUIREMENTS—**
**ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS[c,d]**

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| Air conditioners, air cooled | < 65,000 Btu/h[b] | All | Split System, three phase and applications outside U.S. single phase[b] | 13.4 SEER2 | AHRI 201210/240-2023 |
| | | | Single package, three phase and applications outside U.S. single phase[b] | 13.4 SEER2 | |
| Space constrained, air cooled | ≤ 30,000 Btu/h[b] | All | Split System, three phase and applications outside U.S. single phase[b] | 11.7 SEER2 | |
| | | | Single package, three phase and applications outside U.S. single phase[b] | 11.7 SEER2 | |
| Small duct, high velocity, air cooled | ≤ 65,000 Btu/h[b] | All | Split System, three phase and applications outside U.S. single phase[b] | 12.112.0 SEER2 | |
| Air conditioners, air cooled | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 11.2 EER 14.8 IEER | AHRI 340/360 |
| | | All other | Split System and Single Package | 11.0 EER 14.6 IEER | |
| | ≥ 135,000 Btu/h | Electric | Split System and | 11.0 EER | |

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| | and<br>< 240,000 Btu/h | Resistance (or None) | Single Package | 14.2 IEER | |
| | | All other | Split System and Single Package | ~~10.8 EER~~<br>14.0 IEER | |
| | ≥ 240,000 Btu/h and < 760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | ~~10.0 EER~~<br>13.2 IEER | |
| | | All other | Split System and Single Package | ~~9.8 EER~~<br>13.0 IEER | |
| | ≥ 760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | ~~9.7 EER~~<br>12.5 IEER | |
| | | All other | Split System and Single Package | ~~9.5 EER~~<br>12.3 IEER | |
| Air conditioners, water cooled | < 65,000 Btu/h[b] | All | Split System and Single Package | 12.1 EER<br>12.3 IEER | AHRI 210/240 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 12.1 EER<br>13.9 IEER | AHRI 340/360 |
| | | All other | Split System and Single Package | 11.9 EER<br>13.7 IEER | |
| Air conditioners, water cooled (continued) | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 12.5 EER<br>13.9 IEER | AHRI 340/360 |
| | | All other | Split System and Single Package | 12.3 EER<br>13.7 IEER | |
| | ≥ 240,000 Btu/h and < 760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 12.4 EER<br>13.6 IEER | |
| | | All other | Split System and Single Package | 12.2 EER<br>13.4 IEER | |
| | ≥ 760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 12.2 EER<br>13.5 IEER | |
| | | All other | Split System and Single Package | 12.0 EER<br>13.3 IEER | |
| Air conditioners, evaporatively cooled | < 65,000 Btu/h[b] | All | Split System and Single Package | 12.1 EER<br>12.3 IEER | AHRI 210/240 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 12.1 EER<br>12.3 IEER | AHRI 340/360 |
| | | All other | Split System and Single Package | 11.9 EER<br>12.1 IEER | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 12.0 EER<br>12.2 IEER | |
| | | All other | Split System and Single Package | 11.8 EER<br>12.0 IEER | |
| | ≥ 240,000 Btu/h and < 760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 11.9 EER<br>12.1 IEER | |
| | | All other | Split System and Single Package | 11.7 EER<br>11.9 IEER | |
| | ≥ 760,000 Btu/h | Electric | Split System and | 11.7 EER | |

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| | | Resistance (or None) | Single Package | 11.9 IEER | |
| | | All other | Split System and Single Package | 11.5 EER<br>11.7 IEER | |
| Condensing units, air cooled | ≥ 135,000 Btu/h | -- | -- | 10.5 EER<br>11.8 IEER | AHRI 365 |
| Condensing units, water cooled | ≥ 135,000 Btu/h | -- | -- | 13.5 EER<br>14.0 IEER | |
| Condensing units, evaporatively cooled | ≥ 135,000 Btu/h | -- | -- | 13.5 EER<br>14.0 IEER | |

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

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, U.S. air-cooled air conditioners less than 65,000 Btu/h are regulated as consumer products by the U.S. Department of Energy Code of Federal Regulations DOE 10 C.F.R. 430. SEER and SEER2 values for single-phase products are set by the U.S. Department of Energy.

c. DOE 10 C.F.R. 430 Subpart B Appendix MI includes the test procedure updates effective 1/1/2023 that will be incorporated in AHRI 210/240-2023.

~~d. This table is a replica of ASHRAE 90.1 Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(2)**
**ELECTRICALLY OPERATED AIR-COOLED UNITARY HEAT PUMPS—**
**MINIMUM EFFICIENCY REQUIREMENTS~~c~~**

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| Air cooled (cooling mode) | < 65,000 Btu/h | All | Split System, three phase and applications outside U.S. single phase[b] | 14.3 SEER2 | AHRI ~~201~~210/240-2023 |
| | | | Single Package, three phase and applications outside U.S. single phase[b] | 13.4 SEER2 | |
| Space constrained, air cooled (cooling mode) | ≤ 30,000 Btu/h | All | Split System, three phase and applications outside U.S. single phase[b] | 11.7 SEER2 | |
| | | | Single Package, three phase and applications outside U.S. single phase[b] | 11.7 SEER2 | |
| ~~Single~~ Small duct high velocity, air cooled (cooling mode) | ≤ 65,000 Btu/h | All | Split System, three phase and applications outside U.S. single phase[b] | 12.0 SEER2 | |
| Air cooled (cooling mode) | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | ~~11.0 EER~~<br>14.1 IEER | AHRI 340/360 |

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| | | All other | Split System and Single Package | ~~10.8 EER~~ 13.9 IEER | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | ~~10.6 EER~~ 13.5 IEER | |
| | | All other | Split System and Single Package | ~~10.4 EER~~ 13.3 IEER | |
| | ≥ 240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | ~~9.5 EER~~ 12.5 IEER | |
| | | All other | Split System and Single Package | ~~9.3 EER~~ 12.3 IEER | |
| Air cooled (heating mode) | < 65,000 Btu/h (Cooling capacity)[b] | - | Split System, three phase and applications outside U.S. single phase[b] | 7.5 HSPF2 | AHRI ~~201~~210/240-2023 |
| | | - | Single Package, three phase and applications outside U.S. single phase[b] | 6.7 HSPF2 | |
| Space constrained, air cooled (heating mode) | ≤ 30,000 Btu/h (cooling capacity) | - | Split System, three phase and applications outside U.S. single phase[b] | 6.3 HSPF2 | |
| | | - | Single Package, three phase and applications outside U.S. single phase[b] | 6.3 HSPF2 | |
| Small-duct high velocity, air cooled (heating mode) | < 65,000 Btu/h | - | Split System, three phase and applications outside U.S. single phase[b] | 6.1 HSPF2 | |
| Air cooled (heating mode) | ≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity) | - | 47ºF db/43ºF wb Outdoor Air | 3.40 $COP_H$ | AHRI 340/360 |
| | | | 17ºF db/15ºF wb Outdoor Air | 2.25 $COP_H$ | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity) | - | 47ºF db/43ºF wb Outdoor Air | 3.30 ~~$COP_H$~~$SOP_H$ | |
| | | | 17ºF db/15ºF wb Outdoor Air | 2.05 $COP_H$ | |
| | ≥ 240,000 Btu/h (cooling capacity) | | 47ºF db/43ºF wb Outdoor Air | 3.20 $COP_H$ | |
| | | | 17ºF db/15ºF wb Outdoor Air | 2.05 $COP_H$ | |

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 standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, U.S. air-cooled heat pumps less than 65,000 Btu/h are regulated as consumer products by the U.S. Department of Energy Code of Federal Regulations DOE 10 C.F.R. 430. SEER, SEER2, and HSPF values for single-phase products are set by the U.S. Department of Energy.

c. DOE 10 C.F.R. 430 Subpart B Appendix MI includes the test procedure updates effective 1/1/2023 that will be incorporated into AHRI 210/240-2023.

~~d. This table is a replica of ASHRAE 90.1 Table 6.8.1-2 Electrically Operated Air-Cooled Unitary Heat Pumps—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(3)**
**~~WATER~~ LIQUID-CHILLING PACKAGES—MINIMUM EFFICIENCY REQUIREMENTS[a,b,e,f]**

| Equipment Type | Size Category | Units | Path A | | Path B | | Test Procedure[c] |
|---|---|---|---|---|---|---|---|
| | | | FL | IPLV.IP | FL | IPLV.IP | |
| Air-cooled ~~chillers~~ | < 150 tons | EER(Btu/Wh) | ≥ 10.100 | ≥ 13.700 | ≥ 9.700 | ≥ 15.800 | AHRI 550/590 |
| | ≥ 150 tons | EER(Btu/Wh) | ≥ 10.100 | ≥ 14.000 | ≥ 9.700 | ≥ 16.100 | |
| Air cooled without condenser, electrically operated | All capacities | EER(Btu/Wh) | Air-cooled ~~chillers~~ without condensers ~~shall~~ must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements | | | | |
| ~~Water~~ Liquid-cooled, electrically operated, positive displacement | < 75 tons | kW/ton | ≤ 0.750 | ≤ 0.600 | ≤ 0.780 | ≤ 0.500 | |
| | ≥ 75 tons and < 150 tons | kW/ton | ≤ 0.720 | ≤ 0.560 | ≤ 0.750 | ≤ 0.490 | |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.660 | ≤ 0.540 | ≤ 0.680 | ≤ 0.440 | |
| | ≥ 300 tons and < 600 tons | kW/ton | ≤ 0.610 | ≤ 0.520 | ≤ 0.625 | ≤ 0.410 | |
| | ≥ 600 tons | kW/ton | ≤ 0.560 | ≤ 0.500 | ≤ 0.585 | ≤ 0.380 | |
| ~~Water~~ Liquid-cooled, electrically operated, centrifugal | < 150 tons | kW/ton | ≤ 0.610 | ≤ 0.550 | ≤ 0.695 | ≤ 0.440 | |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.610 | ≤ 0.550 | ≤ ~~0.695~~0.635 | ≤ 0.400 | |
| | ≥ 300 tons and < 400 tons | kW/ton | ≤ 0.560 | ≤ 0.520 | ≤ 0.595 | ≤ 0.390 | |
| | ≥ 400 tons and < 600 tons | kW/ton | ≤ 0.560 | ≤ 0.500 | ≤ 0.585 | ≤ 0.380 | |
| | ≥ 600 tons | kW/ton | ≤ 0.560 | ≤ 0.500 | ≤ 0.585 | ≤ 0.380 | |
| Air cooled absorption, single effect | All capacities | COP(W/W) | ≥ 0.600 | NR | NA[d] | NA[d] | AHRI 560 |
| ~~Water~~ Liquid-cooled absorption, single effect | All capacities | COP(W/W) | ≥ 0.700 | NR | NA[d] | NA[d] | |
| Absorption double effect, indirect fired | All capacities | COP(W/W) | ≥ 1.000 | ≥ 1.050 | NA[d] | NA[d] | |
| Absorption double effect, direct fired | All capacities | COP(W/W) | ≥ 1.000 | ≥ 1.000 | NA[d] | NA[d] | |

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.
NR = No requirement.

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

b. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions per Section C403.3.2.4 and are applicable only for the range of conditions listed there. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the referenced test procedure.

c. Both the full load and IPLV.IP requirements must be met or exceeded to comply with this standard. When there is a Path B, compliance can be with either Path A or Path B for any application.

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

e. FL is the full-load performance requirements, and IPLV.IP is for the part-load performance requirements.

~~f. This table is a replica of ASHRAE 90.1 Table 6.8.1-3 Water-Chilling Packages—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(4)**
**ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS, SINGLE-PACKAGE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[e]**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency[d] | Test Procedure[a] |
|---|---|---|---|---|
| PTAC (cooling mode) Standard size | < 7,000 Btu/h | 95°F db/75°F wb outdoor air[c] | 11.9 EER | AHRI 310/380 |
| | ≥ 7,000 Btu/h and ≤ 15,000 Btu/h | | 14.0 - (0.300 × Cap/1000) EER[d] | |
| | >15,000 Btu/h | | 9.5 EER | |
| PTAC (cooling mode) Nonstandard size[a] | < 7,000 Btu/h | 95°F db/75°F wb outdoor air[c] | 9.4 EER | AHRI 310/380 |
| | ≥ 7,000 Btu/h and ≤ 15,000 Btu/h | | 10.9 - (0.213 × Cap/1000) EER[d] | |
| | >15,000 Btu/h | | 7.7 EER | |
| PTHP (cooling mode) Standard size | < 7,000 Btu/h | 95°F db/75°F wb outdoor air[c] | 11.9 EER | AHRI 310/380 |
| | ≥ 7,000 Btu/h and ≤ 15,000 Btu/h | | 14.0 - (0.300 × Cap/1000) EER[d] | |
| | > 15,000 Btu/h | | 9.5 EER | |
| PTHP (cooling mode) Nonstandard size[b] | < 7,000 Btu/h | 95°F db/75°F wb outdoor air[c] | 9.3 EER | AHRI 310/380 |
| | ≥ 7,000 Btu/h and ≤ 15,000 Btu/h | | 10.8 - (0.213 × Cap/1000) EER[d] | |
| | >15,000 Btu/h | | 7.6 EER | |
| PTHP (heating mode) Standard size | < 7,000 Btu/h | 47°F db/43°F wb outdoor air | 3.3 $COP_H$ | AHRI 310/380 |
| | ≥ 7,000 Btu/h and ≤ 15,000 Btu/h | | 3.7 - (0.052 × Cap/1000) $COP_H$[d] | |
| | >15,000 Btu/h | | 2.90 $COP_H$ | |
| PTHP (heating mode) Nonstandard size[b] | < 7,000 Btu/h | 47°F db/43°F wb outdoor air | 2.7 $COP_H$ | AHRI 310/380 |
| | ≥ 7,000 Btu/h and ≤ 15,000 Btu/h | | 2.9 - (0.026 × Cap/1000) $COP_H$[d] | |
| | >15,000 Btu/h | | 2.5 $COP_H$ | |
| SPVAC (cooling mode) single and three phase | < 65,000 Btu/h | 95°F db/75°F wb outdoor air[c] | 11.0 EER | AHRI 390 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | | 10.0 EER | |
| | ≥ 135,000 Btu/h and ≤ 240,000 Btu/h | | 10.0 EER | |
| SPVHP (cooling mode) | < 65,000 Btu/h | 95°F db/75°F wb outdoor air[c] | 11.0 EER | AHRI 390 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | | 10.0 EER | |
| | ≥ 135,000 Btu/h and ≤ 240,000 Btu/h | | 10.0 EER | |
| SPVHP (heating mode) | <65,000 Btu/h | 47°F db/43°F wb outdoor air | 3.3 $COP_H$ | AHRI 390 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | | 3.0 $COP_H$ | |
| | ≥ 135,000 Btu/h and ≤ 240,000 Btu/h | | 3.0 $COP_H$ | |
| Room air conditioners without reverse cycle with | < 6,000 Btu/h | - | 11.0 CEER | ANSI/AHAM RAC-1 |
| | ≥ 6,000 Btu/h and < 8,000 Btu/h | - | 11.0 CEER | |

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency[d] | Test Procedure[a] |
|---|---|---|---|---|
| louvered sides for applications outside U.S.[d] | ≥ 8,000 Btu/h and < 14,000 Btu/h | - | 10.9 CEER | |
| | ≥ 14,000 Btu/h and < 20,000 Btu/h | - | 10.7 CEER | |
| | ≥ 20,000 Btu/h and < 28,000 Btu/h | - | 9.4 CEER | |
| | ≥ 28,000 Btu/h | - | 9.0 CEER | |
| Room air conditioners without louvered sides | < 6,000 Btu/h | - | 10.0 CEER | ANSI/AHAM RAC-1 |
| | ≥ 6,000 Btu/h and < 8,000 Btu/h | - | 10.0 CEER | |
| | ≥ 8,000 Btu/h and < 11,000 Btu/h | - | 9.6 CEER | |
| | ≥ 11,000 Btu/h and < 14,000 Btu/h | - | 9.5 CEER | |
| | ≥ 14,000 Btu/h and < 20,000 Btu/h | - | 9.3 CEER | |
| | ≥ 20,000 Btu/h | - | 9.4 CEER | |
| Room air conditioners with reverse cycle, with louvered sides for applications outside U.S.[d] | < 20,000 Btu/h | - | 9.8 CEER | ANSI/AHAM RAC-1 |
| | ≥ 20,000 Btu/h | - | 9.3 CEER | |
| Room air conditioners with reverse cycle without louvered sides for applications outside U.S.[d] | < 14,000 Btu/h | - | 9.3 CEER | ANSI/AHAM RAC-1 |
| | ≥ 14,000 Btu/h | - | 8.7 CEER | |
| Room air conditioners, casement only for applications outside U.S.[d] | All capacities | - | 9.5 CEER | ANSI/AHAM RAC-1 |
| Room air conditioners, casement-slider for application outside U.S.[d] | All capacities | - | 10.4 CEER | ANSI/AHAM RAC-1 |

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.
"Cap" = The rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.

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

b. Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW STANDARD PROJECTS." Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external wall opening of less than 16 inches (406 mm) high or less than 42 inches (1067 mm) wide and having a cross-sectional area less than 670 square inches (0.43 $m^2$).

c. The cooling-mode wet bulb temperature requirement only applies for units that reject condensate to the condenser coil.

d. Room air conditioners are rated as consumer products by 10 CFR 430. For US applications of room air conditioners, refer to informative appendix F, Table F-3, for the US DOE minimum efficiency requirements for US applications.

~~d.~~e. "Cap" in EER and COPH equations for PTACs and PTHPs means cooling capacity in Btu/h at 95°F outdoor dry-bulb temperature.

~~e.~~f. This table is a replica of ASHRAE 90.1 Table 6.8.1-4 Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air-Conditioner Heat Pumps—Minimum Efficiency Requirements.

**Commented [DJ45]:** This note is irrelevant, isn't it?

~~TABLE C403.3.2(5)~~
~~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 furnace, gas fired for application outside the U.S.~~ | ~~< 225,000 Btu/h~~ | ~~Maximum capacity[c]~~ | ~~80% AFUE (nonweatherized) or 1% AFUE (weatherized) or 80% $E_t$[b,d]~~ | ~~DOE 10 C.F.R. 430 Appendix N or Section 2.39, Thermal Efficiency, ANSI Z21.47~~ |
| ~~Warm-air furnace, gas fired~~ | ~~< 225,000 Btu/h~~ | ~~Maximum capacity[c]~~ | ~~80% $E_t$[b,d] before 1/1/2023 81% $E_t$[d] after 1/1/2023~~ | ~~Section 2.39, Thermal Efficiency, ANSI Z21.47~~ |
| ~~Warm-air furnace, oil fired~~ | ~~< 225,000 Btu/h~~ | ~~Maximum capacity[c]~~ | ~~83% AFUE (nonweatherized) or 78% AFUE (weatherized) or 80% $E_t$[b,d]~~ | ~~DOE 10 C.F.R. 430 Appendix N or Section 42, Combustion UL 727~~ |
| ~~Warm-air furnace, oil fired~~ | ~~< 225,000 Btu/h~~ | ~~Maximum capacity[c]~~ | ~~80% $E_t$ before 1/1/2023 82% $E_t$[d] after 1/1/2023~~ | ~~Section 42, Combustion UL 727~~ |
| ~~Electric furnaces for applications outside the U.S.~~ | ~~< 225,000 Btu/h~~ | ~~All~~ | ~~96% AFUE~~ | ~~DOE 10 C.F.R. 430 Appendix N~~ |
| ~~Warm air duct furnaces, gas fired~~ | ~~All capacities~~ | ~~Maximum capacity[c]~~ | ~~80% $E_c$[e]~~ | ~~Section 2.10, Efficiency, ANSI Z83.8~~ |
| ~~Warm air unit heaters, gas fired~~ | ~~All capacities~~ | ~~Maximum capacity[c]~~ | ~~80% $E_c$[e,f]~~ | ~~Section 2.10, Efficiency, ANSI Z83.8~~ |
| ~~Warm air unit heaters, oil fired~~ | ~~All capacities~~ | ~~Maximum capacity[c]~~ | ~~80% $E_c$[e,f]~~ | ~~Section 40, Combustion, UL 731~~ |

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

~~a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the referenced year version of the test procedure.~~

~~b. Combination units (i.e., furnaces contained within the same cabinet as an air conditioner) not covered by DOE 10 C.F.R. 430 (i.e., 3-phase power or with cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating. All other units greater than 225,000 Btu/h sold in the U.S. must meet the AFUE standards for consumer products and testing using U.S. DOE's AFUE test procedure at DOE 10 C.F.R. 430 Subpart B, Appendix N.~~

~~c. Compliance of multiple firing rate units shall be at the maximum firing rate.~~

~~d. $E_t$ = Thermal efficiency. Units must also include an interrupted or intermittent ignition device (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.~~

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

~~f. Units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper.~~

~~g. This table is a replica of ASHRAE 90.1 Table 6.8.1-5 Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(5)**
**WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS—MINIMUM EFFICIENCY REQUIREMENTS[g]**

| Description | Fuel | Electric Power Phase | Application Location | Heating Capacity (InputP Btu/h[b] | Combo-Unit Cooling Capacity, Btu/h | Subtype | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|---|---|---|
| Warm-air furnace | Gas | 1 | Inside US | < 225,000 | < 65,000 | See Informative Appendix F, Table F-4[f] | | |
| Warm-air furnace | Gas | 1 | Inside US | < 225,000 | ≥ 65,000 | Nonweatherized | 80% AFUE | Appendix N[g] |
| | | | | | | Weatherized | 81% AFUE or 80% $E_t$[c] | Appendix N[g] ANSI Z21.47 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Warm-air furnace | Gas | 1 | Outside US | < 225,000 | All | Nonweatherized | 80% AFUE | Appendix N[g] |
| | | | | | | Weatherized | 81% AFUE or 80% $E_t$[c] | Appendix N[g] |
| | | | | | | | | ANSI Z21.47 |
| Warm-air furnace | Gas | 3 | All | < 225,000 | All | Nonweatherized | 80% AFUE | Appendix N[g] |
| | | | | | | Weatherized | 81% AFUE or 80% $E_t$[c] | Appendix N[g] |
| | | | | | | | | ANSI Z21.47 |
| Warm-air furnace | Gas | All | All | ≥ 225,000 and ≤ 400,000 | All | All | 81% $E_t$[c] | ANSI Z21.47 |
| Warm-air furnace | Gas | All | Inside US | > 400,000 | All | All | 80% $E_t$[c,b]efore 1/1/23 81% $E_t$[c] after 1/1/23 | ANSI Z21.47 |
| Warm-air furnace | Gas | All | Outside US | > 400,000 | All | All | 80% $E_t$[c,b]efore 1/1/23 81% $E_t$[c] after 1/1/23 | ANSI Z21.47 or ANSI Z83.8 |
| Warm-air furnace | Oil | 1 | Inside US | < 225,000 | < 65,000 | See Informative Appendix F, Table F-4[f] | | |
| Warm-air furnace | Oil | 1 | Inside US | < 225,000 | ≥ 65,000 | Nonweatherized | 83% AFUE | Appendix N[g] |
| | | | | | | Weatherized | 78% AFUE or 80% $E_t$[d] | Appendix N[g] |
| | | | | | | | | Section 42 UL 727 |
| Warm-air furnace | Oil | 1 | Outside US | < 225,000 | All | Nonweatherized | 83% AFUE | Appendix N[g] |
| | | | | | | Weatherized | 78% AFUE or 80% $E_t$[d] | Appendix N[g] |
| | | | | | | | | Section 42 UL 727 |
| Warm-air furnace | Oil | 3 | All | <225,000 | All | Nonweatherized | 83% AFUE | Appendix N[g] |
| | | | | | | Weatherized | 78% AFUE or 80% $E_t$[d] | Appendix N[g] |
| | | | | | | | | Section 42 UL 727 |
| Warm-air furnace | Oil | All | All | ≥225,000 | All | All | 82% $E_t$[d] | Section 42 UL 727 |
| Warm-air furnace | Electric | 1 | Inside US | <225,000 | < 65,000 | See Informative Appendix F, Table F-4[f] | | |
| Warm-air furnace | Electric | 1 | Inside US | <225,000 | ≥ 65,000 | All | 96% AFUE | Appendix N[g] |
| Warm-air furnace | Electric | 1 | Outside US | <225,000 | All | All | 96% AFUE | Appendix N[g] |
| Warm-air furnace | Electric | 3 | All | <225,000 | All | All | 96% AFUE | Appendix N[g] |
| Warm-air duct furnaces | Gas | All | All | All | All | All | 80% $E_c$[d] | ANSI Z83.8 |
| Warm-air unit heaters | Gas | All | All | All | All | All | 80% $E_c$[d,e] | ANSI Z83.8 |
| Warm-air unit heaters | Oil | All | All | All | All | All | 80% $E_c$[d,e] | Section 40 UL 731 |

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

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure. For this table, the following applies:
   - Appendix N = 10 CFR 430 Appendix N
   - ANSI Z21.47 = Section 2.39, Thermal Efficiency, ANSI Z21.47
   - ANSI Z83.3 = Section 2.10, Efficiency, ANSI Z83.3
   - UL 727 = Section 42, Combustion, UL 727

- UL 731 = Section 40, Combustion, UL 731

b. Compliance of multiple firing rate units shall be at the maximum firing rate.

c. $E_t$ = thermal efficiency. Units must also include an interrupted or intermittent ignition device (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.

d. $E_c$ = combustion efficiency (100 percent less flue losses). See test procedure for detailed discussion.

e. Units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an *automatic* flue damper.

f. Includes combination units with cooling capacity < 65,000 Btu/h. For US applications of federally covered < 225,000 Btu/h products, see Informative Appendix F, Table F-4.

g. 10 CFR 430 is limited to-single phase equipment that is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu/h but for the test and rating procedures are not impacted for three-phase and can be used for AFUE ratings for ASHRAE/IES Standard 90.1 three-phase products and single-phase products with a cooling capacity greater than 65,000 Btu/h.

**TABLE C403.3.2(6)**
**GAS- AND OIL-FIRED BOILERS—MINIMUM EFFICIENCY REQUIREMENTS**

| Equipment ~~Type[a]~~Type[b] | Subcategory or Rating Condition | Size Category (Input) | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|
| Boilers, hot water | Gas-fired | < 300,000 Btu/h[g,h] for applications outside the U.S. | ~~82~~84% AFUE | DOE 10 C.F.R. 430 Appendix N |
| | | ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e] | 84% $E_t$[d] | DOE 10 C.F.R. 431.86 |
| | | > 2,500,000 Btu/h[b] and ≤ 10,000,000 Btu/h[b] | ~~85~~82% ~~$E_t$[d]~~$E_c$[c] | |
| | | > 10,000,000 Btu/h[b] | 82% $E_c$[c] | |
| | Oil-fired[f] | < 300,000 Btu/h[g,h] | ~~84~~86% AFUE | DOE 10 C.F.R. 430 Appendix N |
| | | ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e] | ~~87~~82% $E_t$[d] | DOE 10 C.F.R. 431.86 |
| | | > 2,500,000 Btu/h[b] and ≤ 10,000,000 Btu/h[b] | ~~88~~84% $E_c$[c] | |
| | | > 10,000,000 Btu/h[b] | 84% ~~$E_t$[d]~~$E_c$[c] | |
| Boilers, steam | Gas-fired | < 300,000 Btu/h[g] For applications outside the US | ~~81~~82% AFUE | DOE 10 C.F.R. 430 Appendix N |
| | Gas-fired - all, except natural draft | ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b][e] | ~~82~~79% $E_t$[d] | DOE 10 C.F.R. 431.86 |
| | | > 2,500,000 Btu/h[a][b] ≤; 10,000,000 Btu/h[b] | 79% $E_t$[d] | |
| | | ≤; 10,000,000 Btu/h[b] | 79% $E_t$[d] | |
| | Gas-fired - natural draft | ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b][e] | ~~81~~79% $E_t$[d] | |
| | | > 2,500,000 Btu/h[a][b] ~~≤; 10,000,000 Btu/h[b]~~ | ~~82~~79% $E_t$[d] | |
| | | ~~> 10,000,000 Btu/h[b]~~ | ~~79% $E_t$[d]~~ | |
| | Oil-fired[f] | < 300,000 Btu/h[g] For applications outside the US | 82% AFUE | DOE 10 C.F.R. 430 Appendix N |
| | | ≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b][e] | 84% $E_t$[d] | DOE 10 C.F.R. 431.86 |
| | | >2,500,000 Btu/h[b] ≤10,000,000 Btu/h[b] | ~~85~~81% $E_t$[d] | |
| | | ~~≤~~>10,000,000 Btu/h[b] | 81% $E_t$[d] | |

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

**Commented [KA46]:** It appears the efficiency is going down because the test standard was modified?

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. 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.
c. $E_c$ = Combustion efficiency (100 percent less flue losses).
d. $E_t$ = Thermal efficiency.
e. Maximum capacity – Minimum and maximum ratings as provided for and allowed by the unit's controls.
f. Includes oil-fired (residual).
g. Boilers shall not be equipped with a constant burning pilot light.
h. A boiler not equipped with a tankless domestic water heating coil shall be equipped with an automatic means for adjusting the temperature of the water such that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of the water supplied.
~~i. This table is a replica of ASHRAE 90.1 Table 6.8.1-6 Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(7)**
**PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT—MINIMUM EFFICIENCY REQUIREMENTS[i]**

| Equipment Type[a] | Total System Heat Rejection Capacity at Rated Conditions | Subcategory or Rating Condition[h] | Performance Required[a,b,c,~~d~~,f,g] | Test ~~Procedure~~[e]Procedure[d,e] |
|---|---|---|---|---|
| Propeller or axial fan open-circuit cooling towers | All | 95°F Entering Water<br>85°F Leaving Water<br>75°F Entering wb | ≥ 40.2 gpm/hp | CTI ATC-105 and CTI STD-201 RS |
| Centrifugal fan open circuit cooling towers | All | 95°F Entering Water<br>85°F Leaving Water<br>75°F Entering wb | ≥ 20.0 gpm/hp | CTI ATC-105 and CTI STD-201 RS |
| Propeller or axial fan closed-circuit cooling towers | All | 102°F Entering Water<br>90°F Leaving Water<br>75°F Entering wb | ≥ 16.1 gpm/hp | CTI ATC-105S and CTI STD-201 RS |
| Centrifugal fan closed-circuit cooling towers | All | 102°F Entering Water<br>90°F Leaving Water<br>75°F Entering wb | ≥ 7.0 gpm/hp | CTI ATC-105S and CTI STD-201 RS |
| Propeller or axial fan dry coolers (air-cooled fluid coolers) | All | 115°F Entering Water<br>105°F Leaving Water<br>95°F Entering wb | ≥ 4.5 gpm/hp | CTI ATC-~~106~~105DS |
| Propeller or axial fan evaporative condensers | All | R-448A Test Fluid<br>165°F Entering Gas Temperature<br>105°F Condensing Temperature<br>75°F Entering wb | ≥ 160,000 Btu/h • hp | CTI ATC-106 |
| Propeller or axial fan evaporative condensers | All | Ammonia Test Fluid<br>140°F Entering Gas Temperature<br>96.3°F Condensing Temperature<br>75°F Entering wb | ≥ 134,000 Btu/h • hp | CTI ATC-106 |
| Centrifugal fan evaporative condensers | All | R-448A Test Fluid<br>165°F Entering Gas Temperature<br>105°F Condensing Temperature<br>75°F Entering wb | ≥ 137,000 Btu/h • hp | CTI ATC-106 |
| Centrifugal fan evaporative condensers | All | Ammonia Test Fluid<br>140°F Entering Gas Temperature<br>96.3°F Condensing Temperature | ≥ 110,000 Btu/h • hp | CTI ATC-106 |

| Equipment Type[a] | Total System Heat Rejection Capacity at Rated Conditions | Subcategory or Rating Condition[h] | Performance Required[a,b,c,d,f,g] | Test Procedure[a] Procedure[d,e] |
|---|---|---|---|---|
| | | 75°F Entering wb | | |
| Air cooled condensers | All | 125°F Condensing Temperature R-22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering db | ≥ 176,000 Btu/h • hp | 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. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b.a. 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 the table divided by the fan motor nameplate power.

c.b. 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 divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.

d.c. For purposes of this table, dry-cooler performance is defined as the process water-flow rating of the unit at the thermal rating condition listed in the table divided by the total fan motor nameplate power of the unit, and air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the total fan motor nameplate power of the unit.

d. ASHRAE 90.1 Section 13 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

e. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections. The certification requirements do not apply to field-erected cooling towers.

f. All 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.

g. 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.

h. Requirements for evaporative condensers are listed with ammonia (R-717) and R-448A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-448A must meet the minimum efficiency requirements listed above with R-448A as the test fluid. For ammonia, the condensing temperature is defined as the saturation temperature corresponding to the refrigerant pressure at the condenser entrance. For R-448A, which is a zeotropic refrigerant, the condensing temperature is defined as the arithmetic average of the dew point and the bubble point temperatures corresponding to the refrigerant pressure at the condenser entrance.

i. This table is a replica of ASHRAE 90.1 Table 6.8.1-7 Performance Requirements for Heat Rejection Equipment—Minimum Efficiency Requirements.

**TABLE C403.3.2(8)**
**ELECTRICALLY OPERATED VARIABLE VARIABLE-REFRIGERANT- FLOW AIR CONDITIONERS—MINIMUM EFFICIENCY REQUIREMENTS[b]**

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| VRF Air Conditioners, Air Cooled | < 65,000 Btu/h Three-phase for applications in the US and single-phase and three-phase for applications outside the US | All | VRF Multi-Split System | 13.0 SEER | AHRI 210/240 |

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System | ~~11.2~~10.5 EER 15.5 IEER | AHRI 1230 |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System | ~~11.0~~10.3 EER 14.9 IEER | AHRI 1230 |
| | ≥ 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System | ~~10.0~~9.5 EER 13.9 IEER | |

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

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

~~b. This table is a replica of ASHRAE 90.1 Table 6.8.1-8 Electrically Operated Variable-Refrigerant-Flow Air Conditioners—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(9)**
**ELECTRICALLY OPERATED VARIABLE-~~REFRIGERANT~~ REFRIGERANT-FLOW ~~AIR-TO-AIR~~ AND APPLIED HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS~~[b]~~**

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| VRF Air Cooled (cooling mode) | < 65,000 Btu/h three-phase for applications in the US and single- and three-phase for applications outside the US | All | VRF Multi-Split System | ~~13.0~~13.4 SEER2 | AHRI ~~1230~~210/240 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System | ~~11.0~~ 10.3 EER 14.6 IEER | AHRI 1230 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System with Heat Recovery | ~~10.8~~ 10.1 EER 14.4 IEER | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System | ~~10.6~~9.9 EER ~~13.9~~14.4 IEER | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System with Heat Recovery | ~~10.4~~9.7 EER ~~13.7~~13.9 IEER | |
| | ≥ 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System | ~~9.5~~9.1 EER 12.7 IEER | |
| | ≥ 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split System with Heat Recovery | ~~9.3~~8.9 EER 12.5 IEER | |
| VRF Water Source (cooling mode) | < 65,000 Btu/h | All | VRF Multi-Split System 86ºF entering water | 12.0 EER 16.0 IEER | AHRI 1230 |
| | < 65,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 86ºF entering water | 11.8 EER 15.8 IEER | |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | All | VRF Multi-Split System 86ºF entering water | 12.0 EER 16.0 IEER | |

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 86ºF entering water | 11.8 EER 15.8 IEER | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | All | VRF Multi-Split System 86ºF entering water | 10.0 EER 14.0 IEER | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 86ºF entering water | 9.8 EER 13.8 IEER | |
| | ≥ 240,000 Btu/h | All | VRF Multi-Split System 86ºF entering water | 10.0 EER 12.0 IEER | |
| | ≥ 240,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 86ºF entering water | 9.8 EER 11.8 IEER | |
| VRF Groundwater Source (cooling mode) | < 135,000 Btu/h | All | VRF Multi-Split System 59ºF entering water | 16.2 EER | AHRI 1230 |
| | < 135,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 59ºF entering water | 16.0 EER | |
| | ≥ 135,000 Btu/h | All | VRF Multi-Split System 59ºF entering water | 13.8 EER | |
| | ≥ 135,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 59ºF entering water | 13.6 EER | |
| VRF Ground Source (cooling mode) | < 135,000 Btu/h | All | VRF Multi-Split System 77ºF entering water | 13.4 EER | AHRI 1230 |
| | < 135,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 77ºF entering water | 13.2 EER | |
| | ≥ 135,000 Btu/h | All | VRF Multi-Split System 77ºF entering water | 11.0 EER | |
| | ≥ 135,000 Btu/h | All | VRF Multi-Split System with Heat Recovery 77ºF entering water | 10.8 EER | |
| VRF Air Cooled (heating mode) | < 65,000 Btu/h (cooling capacity) three-phase for applications in the US and single- and three-phase for applications outside the US | | VRF Multi-Split System | ~~7.7~~7.5 HSPF2 | AHRI ~~1230~~210/240 |
| | ≥ 65,000 Btu/h and < 135,000 | | VRF Multi-Split System | 3.3 $COP_H$ | AHRI 1230 |

**Commented [DJ47]:** Irrelevant for WA code

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| | Btu/h (cooling capacity) | | 47ºF db/43ºF wb outdoor air 17ºF db/15ºF wb outdoor air | 2.25 $COP_H$ | AHRI 1230 |
| | ≥ 135,000 Btu/h (cooling capacity) | | VRF Multi-Split System 47ºF db/43ºF wb outdoor air 17ºF db/15ºF wb outdoor air | 3.2 $COP_H$ 2.05 $COP_H$ | |
| VRF Water Source (heating mode) | < 65,000 Btu/h (cooling capacity) | | VRF Multi-Split System 68ºF entering water | 4.3 $COP_H$ | AHRI 1230 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity) | | VRF Multi-Split System 68ºF entering water | 4.3 $COP_H$ | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity) | | VRF Multi-Split System 68ºF entering water | 4.0 $COP_H$ | |
| | ≥ 240,000 Btu/h (cooling capacity) | | VRF Multi-Split System 68ºF entering water | 3.9 $COP_H$ | |
| VRF Groundwater Source (heating mode) | < 135,000 Btu/h (cooling capacity) | | VRF Multi-Split System 50ºF entering water | 3.6 $COP_H$ | AHRI 1230 |
| | ≥ 135,000 Btu/h (cooling capacity) | | VRF Multi-Split System 50ºF entering water | 3.3 $COP_H$ | |
| VRF Ground Source (heating mode) | < 135,000 Btu/h (cooling capacity) | | VRF Multi-Split System 32ºF entering water | 3.1 $COP_H$ | AHRI 1230 |
| | ≥ 135,000 Btu/h (cooling capacity) | | VRF Multi-Split System 32ºF entering water | 2.8 $COP_H$ | |

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

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

~~b. This table is a replica of ASHRAE 90.1 Table 6.8.1-9 Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(10)**
**FLOOR-MOUNTED AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS—MINIMUM EFFICIENCY REQUIREMENTS~~[b]~~**

| Equipment Type | Standard Model | Net Sensible Cooling Capacity | Minimum Net Sensible COP | Rating Conditions Return Air (dry bulb/dew point) | Test Procedure[a] |
|---|---|---|---|---|---|
| Air cooled | Downflow | < 80,000 Btu/h | 2.70 | 85°F/52°F (Class 2) | AHRI 1360 |
| | | ≥ 80,000 Btu/h and < 295,000 | 2.58 | | |

| Equipment Type | Standard Model | Net Sensible Cooling Capacity | Minimum Net Sensible COP | Rating Conditions Return Air (dry bulb/dew point) | Test Procedure[a] |
|---|---|---|---|---|---|
| | | Btu/h | | | |
| | | ≥ 295,000 Btu/h | 2.36 | | |
| | | < 80,000 Btu/h | 2.67 | | |
| | Upflow - Ducted | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.55 | | |
| | | ≥ 295,000 Btu/h | 2.33 | | |
| | | < 65,000 Btu/h | 2.16 | | |
| | Upflow - Nonducted | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.04 | 75°F/52°F (Class 1) | |
| | | ≥ 240,000 Btu/h | 1.89 | | |
| | | < 65,000 Btu/h | 2.65 | | |
| | Horizontal | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.55 | 95°F/52°F (Class 3) | |
| | | ≥ 240,000 Btu/h | 2.47 | | |
| | | < 80,000 Btu/h | 2.70 | | |
| | Downflow | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.58 | | |
| | | ≥ 295,000 Btu/h | 2.36 | 85°F/52°F (Class 1) | |
| | | < 80,000 Btu/h | 2.67 | | |
| Air cooled with fluid economizer | Upflow - Ducted | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.55 | | AHRI 1360 |
| | | ≥ 295,000 Btu/h | 2.33 | | |
| | | < 65,000 Btu/h | 2.09 | | |
| | Upflow - Nonducted | ≥ 65,000 Btu/h and < 240,000 Btu/h | 1.99 | 75°F/52°F (Class 1) | |
| | | ≥ 240,000 Btu/h | 1.81 | | |
| | | > 65,000 Btu/h | 2.65 | | |
| | Horizontal | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.55 | 95°F/52°F (Class 3) | |
| | | ≥ 240,000 Btu/h | 2.47 | | |
| | | < 80,000 Btu/h | 2.82 | | |
| | Downflow | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.73 | | |
| | | ≥ 295,000 Btu/h | 2.67 | 85°F/52°F (Class 1) | |
| | | < 80,000 Btu/h | 2.79 | | |
| Water cooled | Upflow - Ducted | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.70 | | AHRI 1360 |
| | | ≥ 295,000 Btu/h | 2.64 | | |
| | Upflow - Nonducted | < 65,000 Btu/h | 2.43 | 75°F/52°F (Class 1) | |
| | | ≥ 65,000 Btu/h and < 240,000 | 2.32 | | |

| Equipment Type | Standard Model | Net Sensible Cooling Capacity | Minimum Net Sensible COP | Rating Conditions Return Air (dry bulb/dew point) | Test Procedure[a] |
|---|---|---|---|---|---|
| | | Btu/h | | | |
| | | ≥ 240,000 Btu/h | 2.20 | | |
| | Horizontal | < 65,000 Btu/h | 2.79 | 95°F/52°F (Class 3) | |
| | | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.68 | | |
| | | ≥ 240,000 Btu/h | 2.60 | | |
| Water cooled with fluid economizer | Downflow | < 80,000 Btu/h | 2.77 | 85°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.68 | | |
| | | ≥ 295,000 Btu/h | 2.61 | | |
| | Upflow - Ducted | < 80,000 Btu/h | 2.74 | | |
| | | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.65 | | |
| | | ≥ 295,000 Btu/h | 2.58 | | |
| | Upflow - Nonducted | < 65,000 Btu/h | 2.35 | 75°F/52°F (Class 1) | |
| | | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.24 | | |
| | | ≥ 240,000 Btu/h | 2.12 | | |
| | Horizontal | < 65,000 Btu/h | 2.71 | 95°F/52°F (Class 3) | |
| | | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.60 | | |
| | | ≥ 240,000 Btu/h | 2.54 | | |
| Glycol cooled | Downflow | < 80,000 Btu/h | 2.56 | 85°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.24 | | |
| | | ≥ 295,000 Btu/h | 2.21 | | |
| | Upflow - Ducted | < 80,000 Btu/h | 2.53 | | |
| | | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.21 | | |
| | | ≥ 295,000 Btu/h | 2.18 | | |
| | Upflow - Nonducted | < 65,000 Btu/h | 2.08 | 75°F/52°F (Class 1) | |
| | | ≥ 65,000 Btu/h and < 240,000 Btu/h | 1.90 | | |
| | | ≥ 240,000 Btu/h | 1.81 | | |
| | Horizontal | < 65,000 Btu/h | 2.48 | 95°F/52°F (Class 3) | |
| | | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.18 | | |
| | | ≥ 240,000 Btu/h | 2.18 | | |
| Glycol cooled with fluid | Downflow | < 80,000 Btu/h | 2.51 | 85°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 80,000 Btu/h and < 295,000 | 2.19 | | |

| Equipment Type | Standard Model | Net Sensible Cooling Capacity | Minimum Net Sensible COP | Rating Conditions Return Air (dry bulb/dew point) | Test Procedure[a] |
|---|---|---|---|---|---|
| economizer | | Btu/h | | | |
| | Upflow - Ducted | ≥ 295,000 Btu/h | 2.15 | | |
| | | < 80,000 Btu/h | 2.48 | | |
| | | ≥ 80,000 Btu/h and < 295,000 Btu/h | 2.16 | | |
| | | ≥ 295,000 Btu/h | 2.12 | | |
| | Upflow - Nonducted | < 65,000 Btu/h | 2.00 | 75°F/52°F (Class 1) | |
| | | ≥ 65,000 Btu/h and < 240,000 Btu/h | 1.82 | | |
| | | ≥ 240,000 Btu/h | 1.73 | | |
| | Horizontal | < 65,000 Btu/h | 2.44 | 95°F/52°F (Class 3) | |
| | | ≥ 65,000 Btu/h and < 240,000 Btu/h | 2.10 | | |
| | | ≥ 240,000 Btu/h | 2.10 | | |

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 standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-10 Floor-Mounted Air Conditioners and Condensing Units Serving Computer Rooms—Minimum Efficiency Requirements.

**TABLE C403.3.2(11)**
**VAPOR-COMPRESSION-BASED INDOOR POOL DEHUMIDIFIERS—MINIMUM EFFICIENCY REQUIREMENTS[b]**

| Equipment Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|
| Single package indoor (with or without economizer) | Rating Conditions: A or C | 3.5 MRE | AHRI 910 |
| Single package indoor water-cooled (with or without economizer) | Rating Conditions: A, B or C | 3.5 MRE | |
| Single package indoor air-cooled (with or without economizer) | Rating Conditions: A, B or C | 3.5 MRE | |
| Split system indoor air-cooled (with or without economizer) | Rating Conditions: A, B or C | 3.5 MRE | |

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-11 Vapor-Compressor-Based Indoor Pool Dehumidifiers—Minimum Efficiency Requirements.

**TABLE C403.3.2(12)**
**ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITHOUT ENERGY RECOVERY—MINIMUM EFFICIENCY REQUIREMENTS[b]**

| Equipment Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|
| Air cooled (dehumidification mode) | -- | 4.03.8 ISMRE2 | AHRI 920 |
| Air- source heat pumps (dehumidification mode) | -- | 4.03.8 ISMRE2 | AHRI 920 |
| Water cooled (dehumidification mode) | Cooling tower condenser water | 4.94.7 ISMRE2 | AHRI 920 |
| | Chilled water | 6.0 ISMRE | |
| Air Air-source heat pump (heating mode) | -- | 2.72.05 ISCOP2 | AHRI 920 |
| Water- source heat pump (dehumidification mode) | Ground source, closed and open loop[b] | 4.84.6 ISMRE2 | AHRI 920 |
| | Ground water source | 5.0 ISMRE | |
| | Water source | 4.03.8 ISMRE2 | |
| Water- source heat pump (heating mode) | Ground source, closed and open loop[b] | 2.02.13 ISCOP2 | AHRI 920 |
| | Ground water source | 3.2 ISCOP | |
| | Water source | 3.52.13 ISCOP2 | |

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-13 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without Energy Recovery—Minimum Efficiency RequirementsOpen-loop systems are rated using closed-loop test conditions.

**TABLE C403.3.2(13)**
**ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITH ENERGY RECOVERY—MINIMUM EFFICIENCY REQUIREMENTS[b]**

| Equipment Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|
| Air cooled (dehumidification mode) | -- | 5.25.0 ISMRE2 | AHRI 920 |
| Air- source heat pumps (dehumidification mode) | -- | 5.25.0 ISMRE2 | AHRI 920 |
| Water cooled (dehumidification mode) | Cooling tower condenser water | 5.35.1 ISMRE2 | AHRI 920 |
| | Chilled water | 6.6 ISMRE | |
| Air- source heat pump (heating mode) | -- | 3.33.2 ISCOP2 | AHRI 920 |
| Water- source heat pump (dehumidification mode) | Ground source, closed and open loop[b] | 5.25.0 ISMRE2 | AHRI 920 |
| | Ground water source | 5.8 ISMRE | |
| | Water source | 4.84.6 ISMRE2 | |
| Water Water-source heat pump (heating mode) | Ground source, closed and open loop[b] | 3.83.5 ISCOP2 | AHRI 920 |
| | Ground water source | 4.0 ISCOP | |
| | Water source | 4.84.04 ISCOP2 | |

[a] Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

[b] This table is a replica of ASHRAE 90.1 Table 6.8.1-14 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, with Energy Recovery—Minimum Efficiency Requirements Open-loop systems are rated using closed-loop test conditions.

**TABLE C403.3.2(14)**
**ELECTRICALLY OPERATED ~~WATER~~ WATER-SOURCE HEAT PUMPS—MINIMUM EFFICIENCY ~~REQUIREMENTS[c]~~ REQUIREMENTS[b]**

| Equipment Type | Size Category[b] | Heating Section Type | Subcategory or Rating Condition | Minimum Efficiency | Test Procedure[a] |
|---|---|---|---|---|---|
| ~~Water~~ Water-~~to~~ to-air, water loop (cooling mode) | < 17,000 Btu/h | All | 86°F entering water | 12.2 EER | ISO 13256-1 |
| | ≥ 17,000 Btu/h and < 65,000 Btu/h | All | 86°F entering water | 13.0 EER | |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | All | 86°F entering water | 13.0 EER | |
| ~~Water~~ Water-~~to~~ to-air, ground water (cooling mode) | < 135,000 Btu/h | All | 59°F entering water | 18.0 EER | ISO 13256-1 |
| ~~Brine~~ Brine-~~to~~ to-air, ground loop (cooling mode) | < 135,000 Btu/h | All | 77°F entering water | 14.1 EER | ISO 13256-1 |
| Water-~~ to~~ to-water, water loop (cooling mode) | < 135,000 Btu/h | All | 86°F entering water | 10.6 EER | ISO 13256-2 |
| ~~Water~~ Water-~~to~~ to-water, ground water (cooling mode) | < 135,000 Btu/h | All | 59°F entering water | 16.3 EER | |
| ~~Brine~~ Brine-~~to~~ to-water, ground loop (cooling mode) | < 135,000 Btu/h | All | 77°F entering fluid | 12.1 EER | |
| ~~Water~~ Water-~~to~~ to-air, water loop (heating mode) | < 135,000 Btu/h (cooling capacity) | -- | 68°F entering water | 4.3 $COP_H$ | ISO 13256-1 |
| ~~Water~~ Water-~~to~~ to-air, ground water (heating mode) | < 135,000 Btu/h (cooling capacity) | -- | 50°F entering water | 3.7 $COP_H$ | |
| ~~Brine~~ Brine-~~to~~ to-air, ground loop (heating mode) | < 135,000 Btu/h (cooling capacity) | -- | 32°F entering ~~fluid~~water | 3.2 $COP_H$ | |
| ~~Water~~ Water-~~to~~ to-water, water loop (heating mode) | < 135,000 Btu/h (cooling capacity) | -- | 68°F entering water | 3.7 $COP_H$ | ISO 13256-1 |
| ~~Water~~ Water-~~to~~ to-water, ground water (heating mode) | < 135,000 Btu/h (cooling capacity) | -- | 50°F entering water | 3.1 $COP_H$ | ISO 13256-2 |
| ~~Brine~~ Brine-~~to~~ to-water, ground loop (heating mode) | < 135,000 Btu/h (cooling capacity) | -- | 32°F entering ~~fluid~~water | 2.5 $COP_H$ | ISO 13256-2 |

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 standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, U.S. air-cooled heat pumps less than ~~19 kW~~65,000 Btu/h are regulated as consumer produces by DOE 10 C.F.R. 430. ~~SCOPC, SCOP2C, SCOPH and SCOP2H~~SEER, SEER2, HPSF, HPSF2 values for single-phase products are set by the U.S. DOE.

~~c. This table is a replica of ASHRAE 90.1 Table 6.8.1-15 Electrically Operated Water-Source Heat Pumps—Minimum Efficiency Requirements.~~

**TABLE C403.3.2(15)**
**HEAT-PUMP AND HEAT RECOVERY CHILLER PACKAGES—MINIMUM EFFICIENCY REQUIREMENTS[g,h,I,j,k]**

| HEATING OPERATION | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equipment Type | Size Category, ton[n] | Cooling-Only Operation Cooling Efficiency[a] Air-Source EER (FL/IPLV), Btu/W×h Water-Source Power Input per Capacity (FL/IPLV), kW/ton[n] | | Heating Source Conditions (entering/leaving water) or OAT (db/wb), °F | Heat-Pump Heating Full-Load Efficiency ($COP_H$)[b], W/W | | | | Heat Recovery Chiller Full-Load Efficiency ($COP_{HR}$)[c,d], W/W Simultaneous Cooling and Heating Full-Load Efficiency ($COP_{SHC}$)[e], W/W | | | | Test Procedure[a] |
| | | | | | Leaving Heating Water Temperature | | | | Leaving Heating Water Temperature | | | | |
| | | | | | Low | Medium | High | Boost | Low | Medium | High | Boost | |
| | | Path A | Path B | | 105°F | 120°F | 140°F | 140°F | 105°F | 120°F | 140°F | 140°F | |
| Air source | All sizes | ≥9.595 FL ≥13.02 IPLV.IP | ≥9.215 FL ≥15.01 IPLV.IP | 47 db 43 wb[a] | ≥3.290 | ≥2.770 | ≥2.310 | NA | NA | NA | NA | NA | AHRI 550/590 |
| | | ≥9.595 FL ≥13.30 IPLV.IP | ≥9.215 FL ≥15.30 IPLV.IP | 17 db 15 wb[a] | ≥2.230 | ≥1.950 | ≥1.630 | NA | NA | NA | NA | NA | |
| Water-source electrically operated positive displacement | < 75 | ≥0.7885 FL ≥0.6316 IPLV.IP | ≥0.7875 FL ≥0.5145 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | |
| | ≥ 75 and < 150 | ≥0.7579 FL ≥0.5895 IPLV.IP | ≥0.7140 FL ≥0.4620 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | |
| | ≥ 150 and < 300 | ≥0.6947 FL ≥0.5684 IPLV.IP | ≥0.7140 FL ≥0.4620 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | |
| | ≥ 300 and < 600 | ≥0.6421 FL ≥0.5474 IPLV.IP | ≥0.6563 FL ≥0.4305 IPLV.IP | 54/44[f] | ≥4.930 | ≥3.960 | ≥2.970 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.990 | NA | NA | NA | ≥6.850 | |
| | ≥ 600 | ≥0.5895 FL ≥0.5263 IPLV.IP | ≥0.6143 FL ≥0.3990 IPLV.IP | 54/44[f] | ≥4.930 | ≥3.960 | ≥2.970 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.990 | NA | NA | NA | ≥6.850 | |
| Water-source electrically operated centrifugal | < 75 | ≥0.6421 FL ≥0.5789 IPLV.IP | ≥0.7316 FL ≥0.4632 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | |
| | ≥ 75 and < 150 | ≥0.5895 FL ≥0.5474 IPLV.IP | ≥0.6684 FL ≥0.4211 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | |
| | ≥ 150 and < 300 | ≥0.5895 FL ≥0.5263 IPLV.IP | ≥0.6263 FL ≥0.4105 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | |
| | ≥ 300 and < 600 | ≥0.5895 FL ≥0.5263 IPLV.IP | ≥0.6158 FL ≥0.4000 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.990 | NA | NA | NA | ≥6.850 | |
| | ≥ 600 | ≥0.5895 FL ≥0.5263 IPLV.IP | ≥0.6158 FL ≥0.400 IPLV.IP | 54/44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | |
| | | | | 75/65[f] | NA | NA | NA | ≥3.990 | NA | NA | NA | ≥6.850 | |

## TABLE C403.3.2(15)
## HEAT-PUMP AND HEAT RECOVERY CHILLER PACKAGES—MINIMUM EFFICIENCY REQUIREMENTS[g,o]

| HEATING OPERATION[b,e,j] | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equipment Type | Size Category, Refrigerating Capacity[h], $ton_R$ | Cooling Operation Efficiency[a,d,e,j] Air-Source EER (FL/IPLV), Btu/W×h Liquid-Source Power Input per Capacity (FL/IPLV), kW/$ton_R$ | | Heating Source Conditions (leaving liquid) or Outdoor Air Temp. (db/wb), °F | Heat-Pump Heating Full-Load Heating Efficiency ($COP_H$)[f,h,k], W/W | | | | Simultaneous Cooling and Heating Full-Load Efficiency ($COP_{SHC}$)[b,i], W/W | | | | Heat Recovery Heating Full-Load Efficiency ($COP_{HR}$)[c,j], W/W | | | | Test Procedure[a] |
| | | | | | Entering/Leaving Heating Liquid Temperature | | | | Entering/Leaving Heating Liquid Temperature | | | | Entering/Leaving Heating Liquid Temperature | | | | |
| | | | | | Low | Medium | High | Boost | Low | Medium | High | Boost | Low | Med | Hot Water 1 | Hot Water 2 | |
| | | Path A | Path B | | 95°F/ 105°F | 105°F/ 120°F | 120°F/ 140°F | 120°F/ 140°F | 95°F/ 105°F | 105°F/ 120°F | 120°F/ 140°F | 95°F/ 105°F | 95°F/ 105°F | 105°F/ 120°F | 90°F/ 140°F | 120°F/ 140°F | |
| Air source | <150.0 | ≥9.595 FL ≥13.02 IPLV.IP | ≥9.215 FL ≥15.01 IPLV.IP | 47 db 43 wb[l] | ≥3.290 | ≥2.770 | ≥2.310 | NA | NA | NA | NA | NA | NA | NA | NA | NA | AHRI 550/590 |
| | | | | 17 db 15 wb[l] | ≥2.029 | ≥1.775 | ≥1.483 | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| | ≥150.0 | ≥9.595 FL ≥13.30 IPLV.IP | ≥9.215 FL ≥15.30 IPLV.IP | 47 db 43 wb[l] | ≥3.290 | ≥2.770 | ≥2.310 | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| | | | | 17 db 15 wb[l] | ≥2.029 | ≥1.775 | ≥1.483 | NA | NA | NA | NA | NA | NA | NA | NA | NA | |
| Liquid-source electrically operated positive displacement | ≥ 11.25[p] and < 150 | ≥0.7895 FL ≥0.6316 IPLV.IP | ≥0.8211 FL ≥0.5263 IPLV.IP | 44[m] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | ≥8.330 | ≥6.410 | ≥4.862 | ≥4.420 | |
| | | | | 65[m] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | NA | NA | NA | NA | |
| | ≥ 150 and < 300 | ≥0.7579 FL ≥0.5895 IPLV.IP | ≥0.7140 FL ≥0.4620 IPLV.IP | 44[m] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | ≥8.330 | ≥6.410 | ≥4.862 | ≥4.420 | |
| | | | | 65[m] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | NA | NA | NA | NA | |
| | ≥ 300 and < 400 | ≥0.6947 FL ≥0.5684 IPLV.IP | ≥0.7140 FL ≥0.4620 IPLV.IP | 44[m] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | ≥8.330 | ≥6.410 | ≥4.862 | ≥4.420 | |
| | | | | 65[m] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | NA | NA | NA | NA | |
| | ≥ 400 and < 600 | ≥0.6421 FL ≥0.5474 IPLV.IP | ≥0.6563 FL ≥0.4305 IPLV.IP | 44[m] | ≥4.930 | ≥3.960 | ≥2.970 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | ≥8.900 | ≥6.980 | ≥5.500 | ≥5.000 | |
| | | | | 65[m] | NA | NA | NA | ≥3.900 | NA | NA | NA | ≥6.850 | NA | NA | NA | NA | |
| | ≥ 600 | ≥0.5895 FL ≥0.5263 IPLV.IP | ≥0.6143 FL ≥0.3990 IPLV.IP | 44[m] | ≥4.930 | ≥3.960 | ≥2.970 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | ≥8.900 | ≥6.980 | ≥5.500 | ≥5.000 | |
| | | | | 65[m] | NA | NA | NA | ≥3.900 | NA | NA | NA | ≥6.850 | NA | NA | NA | NA | |
| Water-source electrically operated centrifugal | ≥ 11.25[p] and < 150 | ≥0.6421 FL ≥0.5789 IPLV.IP | ≥0.7316 FL ≥0.4632 IPLV.IP | 44[f] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | ≥8.330 | ≥6.410 | ≥4.862 | ≥4.420 | |
| | | | | 65[m] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | NA | NA | NA | NA | |
| | ≥ 150 and < 300 | ≥0.0.6190 FL ≥0.5474 IPLV.IP | ≥0.6684 FL ≥0.4211 IPLV.IP | 44[m] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | ≥8.330 | ≥6.410 | ≥4.862 | ≥4.420 | |
| | | | | 65[m] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | NA | NA | NA | NA | |
| | ≥ 300 and < 400 | ≥0.5895 FL ≥0.5526 IPLV.IP | ≥0.6263 FL ≥0.4105 IPLV.IP | 44[m] | ≥4.640 | ≥3.680 | ≥2.680 | NA | ≥8.330 | ≥6.410 | ≥4.420 | NA | ≥8.330 | ≥6.410 | ≥4.862 | ≥4.420 | |
| | | | | 65[m] | NA | NA | NA | ≥3.550 | NA | NA | NA | ≥6.150 | NA | NA | NA | NA | |
| | ≥ 400 and < 600 | ≥0.5895 FL ≥0.5263 IPLV.IP | ≥0.6158 FL ≥0.4000 IPLV.IP | 44[m] | ≥4.930 | ≥3.960 | ≥2.970 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | ≥8.900 | ≥6.980 | ≥5.500 | ≥5.000 | |
| | | | | 65[m] | NA | NA | NA | ≥3.900 | NA | NA | NA | ≥6.850 | NA | NA | NA | NA | |
| | ≥ 600 | ≥0.5895 FL ≥0.5263 IPLV.IP | ≥0.6158 FL ≥0.400 IPLV.IP | 44[m] | ≥4.930 | ≥3.960 | ≥2.970 | NA | ≥8.900 | ≥6.980 | ≥5.000 | NA | ≥8.900 | ≥6.980 | ≥5.500 | ≥5.000 | |
| | | | | 65[m] | NA | NA | NA | ≥3.900 | NA | NA | NA | ≥6.850 | NA | NA | NA | NA | |

**Footnotes for Table C403.3.2(15):**

For SI: °C = [(°F) - 32]/1.8.

NA = Not Applicable

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b.a. Cooling only rating conditions are standard rating conditions defined in AHRI 550/590 (I-P), Table 14, except for liquid-cooled centrifugal chilling packages which can adjust cooling efficiency for nonstandard rating conditions using $K_{adj}$ procedure in accordance with ASHRAE 90.1 Section 6.4.1.2.1.

c.b. Heating full-load rating conditions are at rating conditions defined in AHRI 550/590 (I-P), Table 14; includes the impact of defrost for air source heating ratings.

d.c. For water-cooled liquid-source heat recovery chillers chilling packages that have capabilities for heat rejection to a heat recovery condenser and a tower condenser, the $COP_{HR}$ applies to operation at full load with 100 percent heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table C403.3.2(3)ASHRAE 90.1 Table 6.8.1-3.

d. For cooling operation, compliance with both the FL and IPLV is required, but only compliance with Path A or Path B cooling efficiency is required.

e. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.

f. For applications where the chilling package is installed to operate only in heating, compliance only with the heating performance COPh is required at only one of the heating AHRI 550/590 (I-P) standard rating conditions of Low, Medium, High or Boost. Compliance with cooling performance is not required.

g. For air-source heat pumps, compliance with both the 47°F and 17°F heating source outdoor air temperature (OAT) rating efficiency is required for heating.

h. For heat-pump chilling package applications where the cooling capacity is not being used for conditioning, compliance with the heating performance COPH is only required at one of the four heating AHRI 550/590 standard ratings conditions of Low, Medium, High, or Boost. Compliance with the cooling performance is required as defined in notes a and d, except as noted in note f.

i. For simultaneous cooling and heating chillers applications where there is simultaneous cooling and heating, compliance with the simultaneous cooling performance heat recovery COPSHC is only required at one of the four simultaneous cooling and heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, High, or Boost. Compliance with the cooling only performance is required as defined in notes a and d.

j. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recovery COPHR is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1, or Hot-Water 2. Compliance with the cooling only performance is required as defined in notes a and d.

k. Chilling packages employing a freeze-protection liquid in accordance with ASHRAE 90.1 Section 6.4.1.2.2 shall be tested or rated with water for the purpose of compliance with the requirements of this table.

e.l. Outdoor air entering dry-bulb (db) temperature and wet-bulb (wb) temperature.

m. Source-water entering and leaving water temperature.

- The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air-to-water heat pump shall be the flow rate determined during the full-load cooling rating.
- The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
- For heating-only fluid-to-fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54°F and a leaving liquid temperature of 44°F shall be used.

f. This table is a replica of ASHRAE 90.1 Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages—Minimum Efficiency Requirements.

g. AHRI ratings are not required for equipment sizes larger than those covered by the test standard.

h. Air-to-water heat pumps that are configured to operate only in heating and not in cooling only need to comply with the minimum heating efficiencies.

i. Units that are both an air-to-water heat pump and a heat recovery chiller are required to comply with either the applicable air source efficiency requirements or the heat recovery chiller requirements but not both.

j. Heat pumps and heat recovery chillers are only required to comply with one of the four leaving heating water temperature criteria. The leaving heater water temperature criteria that are closest to the design leaving water temperature shall be utilized.

n. The size category is the full-load net refrigerating cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

o. A heat recovery condenser at its maximum load point must remove enough heat from the refrigerant to cool the refrigerant to remove all superheat energy and begin condensation of the refrigerant. A heat recovery system where

only the superheat is reduced is not covered by ASHRAE 90.1 Table 6.8.1-16 and is considered a desuperheater, and the chiller package must comply with ASHRAE 90.1 Table 6.8.1-3.

p. Water-to-water heat pumps with a capacity less than 135,000 Btu/h are covered by ASHRAE 90.1 Table 6.8.1-15.

**TABLE C403.3.2(16)**
**CEILING-MOUNTED COMPUTER-ROOM AIR CONDITIONERS—**
**MINIMUM EFFICIENCY REQUIREMENTS[b]**

| Equipment Type | Standard Model | Net Sensible Cooling Capacity | Minimum Net Sensible COP | Rating Conditions Return Air (dry-bulb/dew point) | Test Procedure[a] |
|---|---|---|---|---|---|
| Air cooled with free air discharge condenser | Ducted | < 29,000 Btu/h | 2.05 | 75°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 2.02 | | |
| | | ≥ 65,000 Btu/h | 1.92 | | |
| | Nonducted | < 29,000 Btu/h | 2.08 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 2.05 | | |
| | | ≥ 65,000 Btu/h | 1.94 | | |
| Air cooled with free air discharge condenser with fluid economizer | Ducted | < 29,000 Btu/h | 2.01 | 75°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.97 | | |
| | | ≥ 65,000 Btu/h | 1.87 | | |
| | Nonducted | < 29,000 Btu/h | 2.04 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 2.00 | | |
| | | ≥ 65,000 Btu/h | 1.89 | | |
| Air cooled with ducted condenser | Ducted | < 29,000 Btu/h | 1.86 | 75°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.83 | | |
| | | ≥ 65,000 Btu/h | 1.73 | | |
| | Nonducted | < 29,000 Btu/h | 1.89 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.86 | | |
| | | ≥ 65,000 Btu/h | 1.75 | | |
| Air cooled with fluid economizer and ducted condenser | Ducted | < 29,000 Btu/h | 1.82 | 75°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.78 | | |
| | | ≥ 65,000 Btu/h | 1.68 | | |
| | Nonducted | < 29,000 Btu/h | 1.85 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.81 | | |
| | | ≥ 65,000 Btu/h | 1.70 | | |
| Water cooled | Ducted | < 29,000 Btu/h | 2.38 | 75°F/52°F (Class 1) | AHRI 1360 |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 2.28 | | |
| | | ≥ 65,000 Btu/h | 2.18 | | |
| | Nonducted | < 29,000 Btu/h | 2.41 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 2.31 | | |
| | | ≥ 65,000 Btu/h | 2.20 | | |
| Water cooled | Ducted | < 29,000 Btu/h | 2.33 | 75°F/52°F (Class 1) | AHRI 1360 |

| Equipment Type | Standard Model | Net Sensible Cooling Capacity | Minimum Net Sensible COP | Rating Conditions Return Air (dry-bulb/dew point) | Test Procedure[a] |
|---|---|---|---|---|---|
| with fluid economizer | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 2.23 | | |
| | | ≥ 65,000 Btu/h | 2.13 | | |
| | Nonducted | < 29,000 Btu/h | 2.36 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 2.26 | | |
| | | ≥ 65,000 Btu/h | 2.16 | | |
| Glycol cooled | Ducted | < 29,000 Btu/h | 1.97 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.93 | | |
| | | ≥ 65,000 Btu/h | 1.78 | 75°F/52°F (Class 1) | AHRI 1360 |
| | Nonducted | < 29,000 Btu/h | 2.00 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.98 | | |
| | | ≥ 65,000 Btu/h | 1.81 | | |
| Glycol cooled with fluid economizer | Ducted | < 29,000 Btu/h | 1.92 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.88 | | |
| | | ≥ 65,000 Btu/h | 1.73 | 75°F/52°F (Class 1) | AHRI 1360 |
| | Nonducted | < 29,000 Btu/h | 1.95 | | |
| | | ≥ 29,000 Btu/h and < 65,000 Btu/h | 1.93 | | |
| | | ≥ 65,000 Btu/h | 1.76 | | |

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) – 32]/1.8, COP = (Btu/h × hp)(2,550.7).

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

~~b. This table is a replica of ASHRAE 90.1 Table 6.8.1-17 Ceiling-Mounted Computer-Room Air Conditioners—Minimum Efficiency Requirements.~~

**C403.3.2.1 Gas-fired and oil-fired forced air furnaces.** Forced air furnaces with input ratings of 225,000 Btu/h (65 kW) or greater and all unit heaters shall also have an intermittent ignition or interrupted device (IID), and have either mechanical draft (including power venting) or a flue damper. A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings of 225,000 Btu/h (65 kW) or greater, including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating.

**C403.3.2.2 Hydronic and multiple-zone HVAC system controls and equipment.** Hydronic and multiple-zone HVAC system controls and equipment shall comply with this section.

For buildings with a total equipment cooling capacity of 300 tons and above, the equipment shall comply with one of the following:

1. No one unit shall have a cooling capacity of more than 2/3 of the total installed cooling equipment capacity;
2. The equipment shall have a variable speed drive; or
3. The equipment shall have multiple compressors.

**C403.3.2.3 Chillers.** Chilled water plants and buildings with more than 500 tons total capacity shall not have more than 100 tons provided by air-cooled chillers.

**Exceptions:**

1. Where the designer demonstrates that the water quality at the building site fails to meet

manufacturer's specifications for the use of water-cooled equipment.

2. Air-cooled chillers with minimum efficiencies at least 10 percent higher than those listed in Table C403.3.2(7).
3. Replacement of existing air-cooled chiller equipment.
4. Air-to-water heat pump units that are configured to provide both heating and cooling and that are rated in accordance with AHRI 550/590.

**C403.3.2.4 Water-cooled centrifugal chilling package.** Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44.00°F (6.67°C) leaving and 54.00°F (12.22°C) entering chilled-water temperatures and with 85.00°F (29.44°C) entering and 94.30°F (34.61°C) leaving condenser-fluid temperatures, shall have maximum full-load kW/ton (*FL*) and part-load ratings adjusted using the following equations.

$$FL_{adj} = FL/K_{adj}$$

**(Equation 4-74-6)**

$$PLV_{adj} = IPLV.IP/K_{adj}$$

**(Equation 4-84-7)**

Where:

$K_{adj} = A \times B$

FL = Full-load kW/ton values as specified in Table C403.3.2(7)

$FL_{adj}$ = Maximum full-load kW/ton rating, adjusted for nonstandard conditions

IPLV.IP = Values as specified in Table C403.3.2(7)

$PLV_{adj}$ = Maximum NPLV rating, adjusted for nonstandard conditions.

A = $0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times LIFT + 3.93073$

B = $0.0015 \times L_{vg}{}^{Evap}$ (°F) + 0.934

LIFT = $L_{vg}Cond - L_{vg}Evap$

$L_{vg}{}^{Cond}$ = Full-load condenser leaving fluid temperature (°F)

$L_{vg}{}^{Evap}$ = Full-load evaporator leaving temperature (°F)

The *FLadj* and *PLVadj* values are applicable only for centrifugal chillers meeting all of the following full-load design ranges:

- 3.006°F ≤ $L_{vg}{}^{Evap}$ ≤ 60.00°F.
- $L_{vg}{}^{Cond}$ ≤115.00°F.
- 20.00°F ≤ LIFT ≤ 80.00°F.

Manufacturers shall calculate the *FLadj* and *PLVadj* before determining whether to label the chiller. Centrifugal chillers designed to operate outside of these ranges are not covered by this code.

**C403.3.2.5 Positive displacement (air- and water-cooled) chilling package.** 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 the tables in Section C403.3.2 when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

**C403.3.2.6 Packaged and split system electric heating and cooling equipment.** Packaged and split system equipment providing both electric heating and cooling, and cooling-only equipment with electric heat in the main supply duct before VAV boxes, in each case with a total cooling capacity greater than 6,000 Btu/h shall be a heat pump configured to operate in heat pump mode whenever the outdoor air temperature is above 25°F (-3.9°C) and the unit is not in defrost. The unit shall have reverse-cycle demand defrost.

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

**C403.3.2.7 Humidification.** If an air economizer is required on a cooling system for which humidification equipment is to be provided to maintain minimum indoor humidity levels, then the humidifier shall be of the

**Commented [BK(48]:** See also new section C403.4.13

adiabatic type (direct evaporative media or fog atomization type).

**Exceptions:**

1. Health care facilities licensed by the state where Chapter 246-320 or 246-330 WAC requires steam injection humidifiers in duct work downstream of final filters.
2. Systems with water economizer.
3. 100% outside air systems with no provisions for air recirculation to the central supply fan.
4. Nonadiabatic humidifiers cumulatively serving no more than 10% of a building's air economizer capacity as measured in cfm. This refers to the system cfm serving rooms with stand-alone or duct mounted humidifiers.

**C403.3.3 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 C403.3.3, as limited by Section C403.5.1

**TABLE C403.3.3**
**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 British thermal unit per hour = 0.2931 W.

**C403.3.4 Boiler requirements.** *Boiler systems* shall comply with Sections C403.3.4.1 through C403.3.4.5.2.

**C403.3.4.1 Combustion air positive shut-off.** Combustion air positive shut-off shall be provided on all newly installed *boiler systems* ~~as follows~~that meet one or more of the following conditions:

1. All *boiler systems* with an input capacity of 2,500,000 Btu/h and above, in which the boiler is designed to operate with a nonpositive vent static pressure.
2. All *boiler systems* where one stack serves two or more boilers with a total combined input capacity per stack of 2,500,000 Btu/h.

**C403.3.4.2 Boiler system oxygen concentration controls.** Newly installed boilers or boiler systems with a combustion air fan~~s with motors~~ motor *nameplate horsepower* rating of 10 horsepower (7.46 kW) or ~~larger~~ more shall ~~meet~~ comply with one of the following ~~for newly installed boilers~~:

1. The fan motor shall be variable speed~~; or~~.
2. The fan motor shall include controls that limit the fan motor demand to no more than 30 percent of the total design wattage at 50 percent of design air volume. ((The fan motor shall include controls that modulate fan airflow as a function of the load to a speed 50 percent or less of design aire volume.))

**Commented [BK(49]:** New IECC language. It seems a bit less stringent than existing WSEC language.

**C403.3.4.3 Boiler oxygen concentration controls.** Newly installed boilers with an input capacity of 5,000,000 Btu/h and greater and a steady state full-load combustion efficiency less than 90 percent shall maintain stack-gas oxygen concentrations not greater than the values specified in Table C403.3.4.3. Combustion air volume shall be controlled with respect to measured flue gas oxygen concentration. The use of a common gas and combustion air control linkage or jack shaft is prohibited.

**Exception**: These concentration limits do not apply where 50 percent or more of the boiler system capacity serves Group R-2 occupancies.

**TABLE C403.3.4.3**
**BOILER STACK-GAS OXYGEN CONCENTRATIONS**

| Boiler System Type | Maximum Stack-Gas Oxygen Concentration[a] |
|---|---|
| ~~Less than 10% of the boiler system capacity is used for process applications at design~~ | 5% |

| Boiler System Type | Maximum Stack-Gas Oxygen Concentration[a] |
|---|---|
| ~~conditions~~Commercial boilers or where ≤ 10% of the boiler system capacity is used for process applications at design conditions | |
| ~~All others~~Process boilers | 3% |

a. Concentration levels measured by volume on a dry basis over firing rates of 20 to 100 percent.

**C403.3.4.4 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 C403.3.4.4.

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 C403.3.4.4**
**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 |

**C403.3.4.5 Buildings with high-capacity space-heating gas boiler systems.** ~~New buildings with~~ Gas hot water boiler systems for space heating with a total system input of ~~at least~~ not less than 1,000,000 Btu/h (293 kW) ~~but not more~~ and not greater than 10,000,000 Btu/h (2931 kW) in new buildings shall comply with ~~this section~~Sections C403.3.4.5.1 and C403.3.4.5.2.

**Exceptions**:

1. Where 25 percent of the annual space heating requirement is provided by site-recovered energy, or heat recovery chillers.
2. Space heating boilers installed in individual dwelling units.
3. Where 50 percent or more of the design heat load is served using perimeter convective heating, radiant ceiling panels, or both.
4. Individual gas boilers with input capacity less than 300,000 Btu/h shall not be included in the calculations of the total system input or total system efficiency.

**C403.3.4.5.1 Boiler efficiency.** Gas hot water boilers shall have a minimum thermal efficiency ($E_t$) of 90 percent when rated in accordance with the test procedures in Table C403.3.2(6). Systems with multiple boilers are allowed to meet this requirement if the space-heating input provided by equipment with thermal efficiency ($E_t$) above and below 90 percent provides an input capacity-weighted average thermal efficiency of at least 90 percent. For boilers rated only for combustion efficiency, the calculation for the input capacity-weighted average thermal efficiency shall use the combustion efficiency value.

**C403.3.4.5.2 Hot water distribution system design.** The hot water distribution system shall be designed to meet ~~all of~~ the following:

1. Coils and other heat exchangers shall be selected so that at design conditions the hot water return temperature entering the boilers is 120°F (48.9°C) or less.
2. Under all operating conditions, the water temperature entering the boiler is 120°F (48.9°C) or less, or the flow rate of supply hot water that recirculates directly into the return system, such as three-way valves or minimum flow bypass controls, shall be no greater than 20 percent of the design flow of the operating boilers.

**C403.3.5 Dedicated outdoor air systems (DOAS).** For buildings with occupancies as shown in Table C403.3.5, outdoor air shall be provided to each occupied space by a dedicated outdoor air system (DOAS) which delivers 100 percent outdoor air without requiring operation of the heating and cooling system fans for ventilation air delivery.

**Exceptions:**

1. Occupied spaces that are not ventilated by a mechanical ventilation system and are only ventilated by a natural ventilation system in accordance with Section 402 of the *International Mechanical Code*.
2. High efficiency variable air volume (VAV) systems complying with Section C403.6.10 for occupancy classifications other than Groups A-1, A-2 and A-3 as specified in Table C403.3.5, and high efficiency VAV systems complying with Section C403.12 for occupancy classifications Groups A-1, A-2 and A-3 as specified in Table C403.3.5. This exception shall not be used as a substitution for a DOAS per Section C406.6.

**TABLE C403.3.5**
**OCCUPANCY CLASSIFICATIONS REQUIRING DOAS**

| Occupancy Classification[a] | Inclusions | Exempted |
|---|---|---|
| A-1 | All occupancies not specifically exempted | Television and radio studios |
| A-2 | Casinos (gaming area) | All other A-2 occupancies |
| A-3 | Lecture halls, community halls, exhibition halls, gymnasiums, courtrooms, libraries, places of religious worship | All other A-3 occupancies |
| A-4, A-5 | | All occupancies excluded |
| B | All occupancies not specifically exempted | Food processing establishments including commercial kitchens, restaurants, cafeterias; laboratories for testing and research; data processing facilities and telephone exchanges; air traffic control towers; animal hospitals, kennels, pounds; ambulatory care facilities. |
| F, H, I, R, S, U | | All occupancies excluded |
| E, M | All occupancies included | |

a. Occupancy classification from the *International Building Code* Chapter 3.

**C403.3.5.1 DOAS with energy recovery ventilation.** The DOAS shall include energy recovery. The energy recovery device shall have a 68 percent minimum sensible recovery effectiveness calculated in accordance with Equation ~~4-9~~4-8 or provide an enthalpy recovery ratio of not less than 60 percent at design conditions in accordance with Section C403.7.6. The airflow rate thresholds in Section C403.7.6 that define when the energy recovery requirements in that section do not apply, are not applicable to this section. The return/exhaust air stream temperature for heat recovery device selection shall be 70°F (21°C) at 30 percent relative humidity, or as calculated by the registered design professional.

**(Equation ~~4-9~~4-8)**

$$\text{Sensible Recovery Effectiveness} = \frac{T_{OA}-T_{SA}}{T_{OA}-T_{RA}}$$

Where:

$T_{OA}$ = Design outdoor air dry bulb temperature entering the energy recovery device

$T_{SA}$ = Supply air dry bulb temperature leaving the energy recovery device at design temperatures and airflow conditions, as selected for the proposed DOAS unit(s)

$T_{RA}$ = Design return air dry bulb temperature

**Exceptions:**

1. Systems installed for the sole purpose of providing makeup air for systems exhausting toxic,

flammable, paint, or corrosive fumes or dust, dryer exhaust, or commercial kitchen hoods used for collecting and removing grease vapors and smoke.

2. Heat recovery and energy recovery ventilators (H/ERV) that are rated and *listed* in accordance with HVI 920 can demonstrate compliance with the sensible recovery effectiveness requirements using the adjusted sensible recovery effectiveness (ASRE) rating of the equipment at 32°F test conditions. Applied flow rate for ASRE rating shall be no less than the design flow rate or the closest value interpolated between two listed flow rates.

**C403.3.5.2 DOAS fan power.** For a DOAS that does not have at least one fan or fan array with fan electrical input power ≥1 kW, the total combined fan power shall not exceed 1 watt per cfm of outdoor air as calculated in accordance with Equation ~~4-10~~4-9 using design maximum airflows and external static pressures. For a DOAS with at least one fan or fan array with fan electrical input power ≥1 kW, the DOAS shall comply with the fan power limitations of Section C403.8.1. DOAS total combined fan power shall include all supply,

exhaust and other fans utilized for the purpose of ventilation. This fan power restriction applies to each DOAS in the permitted project, but does not include the fan power associated with the zonal heating and cooling equipment.

**(Equation ~~4-10~~4-9)**

$$\text{DOAS Total Combined Fan Power } \left(\frac{Watts}{CFM}\right) = \sum \left(\frac{Fan\ bhp}{\eta_m}\right) \times \frac{746}{CFM_{supply}}$$

Where:

| | | |
|---|---|---|
| Fan bhp | = | Brake horsepower for each supply, exhaust and other fan in the system at design maximum airflow rate |
| $\eta_m$ | = | Fan motor efficiency including all motor, drive and other losses for each fan in the system |
| $CFM_{supply}$ | = | Design maximum airflow rate of outdoor (supply) air |

**C403.3.5.3 Heating and cooling system fan controls.** Heating and cooling equipment fans, heating and cooling circulation pumps, and terminal unit fans shall cycle off and terminal unit primary cooling air shall be shut off when there is no call for heating or cooling in the *zone*.

**Exception:** Fans used for heating and cooling using less than 0.12 watts per cfm may operate when space temperatures are within the setpoint dead band (Section C403.4.1.2) to provide destratification and air mixing in the space.

**C403.3.5.4 Decoupled DOAS supply air.** The DOAS supply air shall be delivered directly to the occupied space or downstream of the terminal heating and/or cooling coils.

**Exceptions:**

1. Active chilled beam systems.
2. Sensible only cooling terminal units with pressure independent variable airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.
3. Terminal heating and/or cooling units that comply with the low fan power allowance requirements in the exception of Section C403.3.5.3.

**C403.3.5.5 Supplemental heating and cooling.** Supply air stream heating in the DOAS system shall comply with Section C403.7.3. Cooling is permitted for dehumidification only. Cooling coil shall be sized to meet peak dehumidification requirement at design outdoor temperatures, and no larger. Cooling coil shall be controlled to maintain supply air RH or *zone* RH.

**Exception:** Heating permitted for defrost control shall be locked out when outside air temperatures are above 35°F (2°C). Supplemental heating for defrost shall modulate to 10 percent of the peak capacity, and shall be sized to prevent frost damage to the unit at design temperatures and provide supply air less than or equal to 55°F (13°C).

**C403.3.5.6 Impracticality.** Where the *code official* determines that full compliance with one or more of the requirements in Sections C403.3.5.1 through C403.3.5.5 is impractical, it is permissible to provide an approved alternate means of compliance that achieves a comparable level of energy efficiency as the requirement(s) deemed impractical. For the purposes of this section, impractical means that an HVAC

system complying with all requirements in Section C403.3.5 cannot effectively be utilized due to an unusual use or configuration of the building.

**C403.3.6 Ventilation for Group R-2 occupancy.** For all Group R-2 dwelling and sleeping units, a balanced ventilation system with a heat recovery system shall provide outdoor air directly to all habitable space. The heat recovery system shall have a 60 percent minimum *sensible recovery effectiveness* as calculated in accordance with Section C403.3.5.1. The ventilation system shall allow for the design flow rates to be tested and verified at each habitable space as part of the commissioning process in accordance with Section C408.2.2.

**Exception:** Heat recovery and energy recovery ventilators (H/ERV) that are rated and *listed* in accordance with HVI 920 can demonstrate compliance with the sensible recovery effectiveness requirements using the adjusted sensible recovery effectiveness (ASRE) rating of the equipment at 32°F test conditions. Applied flow rate for ASRE rating shall be no less than the design flow rate or the closest value interpolated between two listed flow rates

**C403.3.7 Hydronic system flow rate.** Chilled water and condenser water piping shall be designed such that the design flow rate in each pipe segment shall not exceed the values listed in Table C403.3.7 for the appropriate total annual hours of operation. Pipe sizes for systems that operate under variable flow conditions (e.g. modulating 2-way control valves at coils) and that contain variable speed pump motors are permitted to be selected from the "Variable Flow/Variable Speed" columns. All others shall be selected from the "Other" columns.

**Exception**: Design flow rates exceeding the values in Table C403.3.7 are permitted in specific sections of pipe if the pipe is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during more than 30 percent of operating hours.

**TABLE C403.3.7**
**PIPING SYSTEM DESIGN MAXIMUM FLOW RATE IN GPM[a]**

| Pipe Size (in) | ≤ 2000 hours/yr | | >2000 and ≤ 4400 hours/year | | > 4400 hours/year | |
|---|---|---|---|---|---|---|
| | Other | Variable Flow/ Variable Speed | Other | Variable Flow/ Variable Speed | Other | Variable Flow/ Variable Speed |
| 2 1/2 | 120 | 180 | 85 | 130 | 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 to 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 |

a. There are no requirements for pipe sizes smaller than the minimum size or larger than the maximum size shown in the table.

**C403.3.8 Hydronic coil selection.** Hydronic coils shall comply with Sections C403.3.8.1 and C403.3.8.2.

**Exception**: Replacement coils within existing equipment.

**C403.3.8.1 Chilled-water coil selection.** Chilled-water cooling coils shall be selected to provide a 15°F or higher temperature difference between leaving and entering water temperatures and a minimum of 57°F (13.9°C) leaving water temperature at design conditions.

**Exceptions**:

1. Chilled-water cooling coils that have an airside pressure drop exceeding 0.70 in. of water when rated at 500 fpm face velocity and dry conditions (no condensation).
2. Individual fan-cooling units with a design supply airflow rate ≤ 5000 cfm.
3. Constant-air-volume systems.
4. Coils selected at the maximum temperature difference allowed by the chiller.

5. Passive coils (no mechanically supplied airflow).
6. Coils with design entering chilled-water temperature ≥ 50°F (10°C).
7. Coils with design entering air dry-bulb temperature ≤ 65°F (18°C).

**C403.3.8.2 Hot-water coil selection.** Hot-water heating coils shall be selected to provide a maximum 20°F temperature difference between leaving and entering water temperatures and a maximum of 118°F (48°C) entering water temperature at design conditions.

**Exceptions**:

1. Hot-water heating systems which utilize heat pumps as the primary source.
2. Individual terminal fan units with a design supply airflow rate ≤1500 cfm are exempt from the 20°F maximum temperature difference between leaving and entering water temperature requirement.
3. Passive coils (no mechanically supplied airflow).
4. Coils with design leaving air temperature ≥95°F (35°C).

**C403.4 ~~HVAC~~ Heating and cooling system controls.** ~~HVAC~~ Heating and cooling systems shall be provided with controls in accordance with Sections C403.4.1 through C403.4.12 and shall be capable of and configured to implement all required control functions in this code.

**C403.4.1 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*. Controls in the same *zone* or in neighboring *zones* connected by openings larger than 10 percent of the floor area of either *zone* shall not allow for simultaneous heating and cooling. At a minimum, each floor of a building shall be considered as a separate *zone*. Controls on systems required to have economizers and serving single *zones* shall have multiple cooling stage capability and activate the economizer when appropriate as the first stage of cooling. See Section C403.5 for further economizer requirements. Where humidification or dehumidification or both is provided, at least one humidity control device shall be provided for each humidity control system.

**Exceptions:**

1. Independent perimeter systems that are designed to offset only *building thermal envelope* heat losses or gains or both serving one or more perimeter *zones* also served by an interior system provided:
   1.1. 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 (15,240 mm);
   1.2. The perimeter system heating and cooling supply is controlled by a thermostat located within the *zones* served by the system; and
   1.3. Controls are configured to prevent the perimeter system from operating in a different heating or cooling mode from the other equipment within the *zones* or from neighboring *zones* connected by openings larger than 10 percent of the floor area of either *zone*.
2. Where an interior zone and a perimeter zone are open to each other with permanent openings larger than 10 percent of the floor area of either zone, cooling in the interior zone is permitted to operate at times when the perimeter zone is in heating and the interior zone temperature is at least 5°F (2.8°C) higher than the perimeter zone temperature. For the purposes of this exception, a permanent opening is an opening without doors or other operable closures.
3. Dedicated outdoor air units that provide *ventilation air*, make-up air or *replacement air* for exhaust systems are permitted to be controlled based on supply air temperature. The supply air temperature shall be controlled to a maximum of 65°F (18.3°C) in heating and a minimum of 72°F (22°C) in cooling unless the supply air temperature is being reset based on the status of cooling or heating in the *zones* served or it being reset based on outdoor air temperature.

**C403.4.1.1 Heat pump supplementary heat control.** Heat pumps equipped with internal electric resistance heaters shall have controls that prevent supplemental heater operation when the heating load can be met by the heat pump alone during both steady-state operation and setback recovery. Supplemental heat operation is permitted during outdoor coil defrost cycles. Heat pumps equipped with supplemental heaters shall comply with all conditions of Section C403.1.4.

**Exceptions:**

1. Packaged terminal heat pumps (PTHPs) of less than 2 tons (24,000 Btu/hr) cooling capacity and whose ratings meet the requirements shown in Table C403.3.2(4) that have reverse-cycle demand defrost and are configured to operate in heat pump mode whenever the outdoor air temperatures

are above 25°F
(-3.9°C) and the unit is not in defrost.

2. Heat pumps whose minimum efficiency is regulated by NAECA and whose ratings meet the requirements shown in Table C403.3.2(2) and include all usage of internal electric resistance heating.

**C403.4.1.2 Deadband.** Where used to control both heating and cooling, *zone* thermostatic controls shall be: ~~configured to provide a temperature range or dead band of at least 5°F (2.8°C) within which the supply of heating and cooling energy to the *zone* is shut off or reduced to a minimum~~.

1. Have separate setpoints for heating and cooling, each individually adjustable.
2. Be capable of and initially configured to provide a temperature range or deadband between the two setpoints of not less than 5°F (2.8°C) within which the supply of heating and cooling energy to the *zone* is shut off or reduced to a minimum.

~~1.~~3. Have a minimum deadband of not less than 1°F (0.56°C) when setpoints are adjusted.

**Exceptions:**

1. Thermostats requiring *manual* changeover between heating and cooling modes.
2. Occupancies or applications where applicable codes or accreditation standards requiring precision in indoor temperature control ~~as *approved* by the *code official*~~shall be permitted to be initially configured to not less than 1°F (0.56°C) deadband.

**C403.4.1.3 Setpoint adjustment and display.** Where thermostatic control setpoints are capable of being adjusted by occupants or HVAC system operators, the adjustment shall be independent for the heating setpoint and the cooling setpoint; when one setpoint is changed, the other shall not change except as needed to maintain the minimum deadband required by Section C403.4.1.2. For thermostatic controls that display setpoints, both the heating and cooling setpoints shall be displayed simultaneously, or the setpoint of the currently active mode (heating or cooling) shall be displayed along with an indication of that mode.

~~C403.4.1.3~~**C403.4.1.4 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 system with software programming shall be configured to prevent the heating set point from exceeding the cooling set point and to maintain a dead band in accordance with Section C403.4.1.2~~ Where heating and cooling to a *zone* are controlled by separate *zone* thermostatic controls located within the *zone*, mechanical or software means shall be provided to prevent the heating setpoint from exceeding the cooling setpoint, minus the deadband required by Section C403.4.1.2.

~~C403.4.1.4~~**C403.4.1.5 Heated or cooled vestibules and air curtains**. The heating system for heated vestibules and air curtains with integral heating shall be provided with controls configured to shut off the source of heating when the outdoor air temperature is greater than 45°F (7°C). Vestibule heating and cooling systems shall be controlled by a thermostat located in the vestibule configured to limit heating to a temperature not greater than 60°F (16°C) and cooling to a temperature not less than 85°F (29°C).

**Exceptions:**

1. Control of heating or cooling provided by transfer air that would otherwise be exhausted.
2. Vestibule heating only systems are permitted to be controlled without an outdoor air temperature lockout when controlled by a thermostat located in the vestibule configured to limit heating to a temperature not greater than 45°F (7°C) where required for freeze protection of piping and sprinkler heads located in the vestibule.

~~C403.4.1.5~~**C403.4.1.6 Hot water boiler outdoor temperature setback 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.

~~C403.4.1.6~~**C403.4.1.7 Operable opening switches for HVAC system thermostatic control.** All doors and other operable openings meeting the minimum size criteria of Section C402.5.11 when fully open and that open to the outdoors from a conditioned space shall have automatic controls interlocked with the heating and cooling system. The controls shall be configured ~~must have controls configured~~ to do the following ~~once doors have been open for~~ within 5 minutes of opening:

1. Disable the mechanical heating to the *zone* or reset the space heating temperature setpoint to 55°F or less ~~within 5 minutes of the door open enable signal.~~

2. Disable the mechanical cooling to the *zone* or reset the space cooling temperature setpoint to 85°F or more ~~within 5 minutes of the door open enable signal~~. Disable mechanical cooling to the zone or reset the space cooling temperature setpoint to 90°F or more. Mechanical cooling can remain enabled if the outdoor air temperature is below the space temperature.

**Exception~~s~~**:

1. Operable openings into spaces served by hydronic radiant heating and cooling systems.
2. Emergency exits with an *automatic* alarm that sounds when open.
3. Operable openings and doors serving *enclosed spaces* without a *thermostat* or heating or cooling temperature sensor.
4. Separately zoned areas associated with thepreparation of foot that contain appliances that contribute to the heating or cooling loads of a restaurant or similar type of occupancy.
5. *Alterations* where walls would have to be opened solely for the purpose of meeting this requirement and where *approved*.
6. ~~1.~~ Doors served by air curtains meeting the requirements of Section C402.5.6.

**~~C403.4.1.7~~C403.4.1.8 Demand responsive controls.** Thermostatic controls for heating or cooling systems shall be provided with *demand responsive controls* capable of increasing the cooling setpoint and decreasing the heating setpoint by no less than 4°F (2.2°C). The thermostatic controls shall be capable of performing all other functions provided by the control with the *demand responsive controls* are not available. Systems with *direct digital control* of individual *zones* reporting to a central control panel shall be capable of remotely increasing the cooling setpoint and decreasing the heating setpoint for each *zone* by no less than 4°F (2.2°C).

**Exception**: Health care and assisted living facilities.

**C403.4.2 Off-hour controls.** For all occupancies other than Group R, 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 manual shutoff switch located with *ready access*.

**C403.4.2.1 Thermostatic setback.** Thermostatic setback controls shall be configured 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).

**C403.4.2.2 Automatic setback and shutdown.** *Automatic* time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours. Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer configured to operate the system for up to 2 hours; or an occupancy sensor.

**C403.4.2.3 ~~Automatic~~ Optimum start and stop.** ~~*Automatic*~~ Optimum start and stop controls shall be provided for each ~~HVAC~~ heating and cooling system with direct control of individual *zones*. The ~~*automatic*~~ optimum start controls shall be configured to automatically adjust the daily start time of the ~~HVAC~~ heating and cooling system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy. ~~Automated stop controls shall be provided for each HVAC system with *direct digital control* of individual *zones*.~~ The ~~*automatic*~~ optimum stop controls shall be configured to reduce the ~~HVAC~~ heating and cooling system's heating temperature setpoint and increase the cooling temperature setpoint by at least 2°F (1.1°C) before scheduled unoccupied periods based upon the thermal lag and acceptable drift in space temperature that is within comfort limits.

**Exception**: Dwelling units and sleeping units are not required to have optimum start controls.

**C403.4.2.4 Exhaust system off-hour controls.** For all occupancies other than Group R, exhaust systems serving spaces within the conditioned envelope shall be controlled by either an *automatic* time clock, thermostatic controls or programmable control system to operate on the same schedule as the HVAC systems providing their make-up air.

**Exceptions:**

1. Exhaust systems requiring continuous operation.
2. Exhaust systems that are controlled by occupancy sensor control configured with *automatic* on and

*automatic* shutoff within 15 minutes after occupants have left the space.

**C403.4.2.5 Transfer and destratification fan system off-hour controls.** For all occupancies other than Group R, transfer fan or mixing fan systems serving spaces within the conditioned envelope shall be controlled by either an *automatic* time clock, thermostatic controls or programmable control system to operate on the same schedule as the associated HVAC systems.

**Exception:** Transfer fan and destratification fan systems that are controlled by occupancy sensor control configured with manual on and *automatic* shutoff within 15 minutes after occupants have left the space.

**C403.4.3 Hydronic systems controls.** The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections C403.4.3.1 through C403.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include *automatic* controls configured to sequence operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h (146,550 W) input design capacity shall include either a multi-staged or modulating burner.

**C403.4.3.1 Three-pipe system.** Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

**C403.4.3.2 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.

**C403.4.3.3 Hydronic (water loop) heat pump systems.** Hydronic heat pump systems shall comply with Sections C403.4.3.3.1 through C403.4.3.3.3.

**C403.4.3.3.1 Temperature dead band.** Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are configured to provide a heat pump water supply temperature dead band of at least 20°F (11.1°C) between initiation of heat rejection and heat addition by the central devices.

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

**C403.4.3.3.2 Heat rejection.** The following shall apply to hydronic water loop heat pump systems:

1. Where a closed-circuit cooling tower is used directly in the heat pump loop, either an *automatic* valve shall be installed to bypass the flow of water around the closed-circuit cooling tower, except for the minimum flow necessary for freeze protection. Flow controls for freeze protection shall not allow water through the closed-circuit cooling tower when outdoor temperatures are above the freezing point of the glycol/water solution, i.e. 32°F (0°C) for 100 percent water applications, and 18°F (-7.8°C) for 20 percent by mass propylene glycol solution.
2. Where an open-circuit cooling tower is used directly in the heat pump loop, an *automatic* valve shall be installed to bypass all heat pump water flow around the open-circuit cooling tower.
3. Where an open-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the open-circuit cooling tower from the heat pump loop, heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

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

**C403.4.3.3.3 Isolation 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-way (but not three-way) valve. For the purposes of this section, pump system power is the sum of the nominal power demand (i.e., nameplate horsepower at nominal motor efficiency) of motors of all pumps that are required to operate at design conditions to supply fluid from the heating or cooling source to all heat transfer devices (e.g., coils, heat exchanger) and return it to the source. This converts the system into a variable flow system and, as such, the primary circulation pumps shall comply with the variable flow requirements in Section C403.4.6.

**C403.4.4 Part load controls.** Hydronic systems greater than or equal to 300,000 Btu/h (88 kW) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that are configured to:

1. Automatically reset the supply-water temperatures in response to varying building heating and cooling demand using coil valve position, zone-return water temperature or outdoor air temperature. The temperature shall be reset by not less than 25 percent of the design supply-to-return water temperature difference.

   **Exceptions**:

   1. Hydronic systems serving hydronic heat pumps.
   2. Hydronic systems with thermal energy storage where resetting the supply-water temperature would reduce the capacity of the storage.

2. Automatically vary fluid flow for hydronic systems with a combined pump motor capacity of 2 hp or larger with three or more control valves or other devices by reducing the system design flow rate by not less than 50 percent or the maximum reduction allowed by the equipment manufacturer for proper operation of equipment by 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 heating water systems, chilled-water systems and heat rejection loops serving water-cooled unitary air conditioners as follows:

   3.1. Where pumps operate continuously or operate based on a time schedule, pumps with nominal output motor power of 2 hp or more shall have a variable speed drive.

   3.2. Where pumps have *automatic* direct digital control configured to operate pumps only when *zone* heating or cooling is required, a variable speed drive shall be provided for pumps with motors having the same or greater nominal output power indicated in Table C403.4.4 based on the climate zone and system served.

4. Where a variable speed drive is required by Item 3 of this Section, pump motor power input shall be not more than 30 percent of design wattage at 50 percent of the design water flow. 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 is not required for chilled-water systems supplied by off-site district chilled water or chilled water from ice storage systems.
2. Variable pump flow is not required on dedicated coil circulation pumps where needed for freeze protection.
3. Variable pump flow is not required on dedicated equipment circulation pumps where configured in primary/secondary design to provide the minimum flow requirements of the equipment manufacturer for proper operation of equipment.
4. Variable speed drives are not required on heating water pumps where more than 50 percent of annual heat is generated by an electric boiler.

**TABLE C403.4.4**
**VARIABLE SPEED DRIVE (VSD) REQUIREMENTS FOR DEMAND-CONTROLLED PUMPS**

| Climate Zones 4c, 5b | VSD Required for Motors with Rated Output of at Least |
|---|---|
| Heating Water Pumps | ≥7.5 HP |
| Chilled water and Heat Rejection Loop Pumps | ≥7.5 HP |

**C403.4.5 Pump isolation.** Chilled water plants including more than one chiller shall be capable of and configured to reduce flow automatically through the chiller plant when a chiller is shut down and automatically shut off flow to chillers that are shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

Boiler systems including more than one boiler shall be capable of and configured to reduce flow automatically through the boiler system when a boiler is shut down.

**C403.4.6 Variable flow controls.** Individual pumps required by this code to have variable speed control shall

be controlled in one of the following manners:

1. For systems having a combined pump motor horsepower less than or equal to 20 hp (15 kW) and without direct digital control of individual coils, pump speed shall be a function of either:
    1.1. Required differential pressure; or
    1.2. Reset directly based on zone hydronic demand, or other zone load indicators; or
    1.3. Reset directly based on pump power and pump differential pressure; or
    1.4. Reset directly by an integral controller based on the relationship between variable speed controller frequency and power.
2. For systems having a combined pump motor horsepower that exceeds 20 hp (15 kW) or smaller systems with direct digital control, pump speed shall be a function of either:
    2.1. The static pressure setpoint as reset based on the valve requiring the most pressure; or
    2.2. Directly controlled based on zone hydronic demand; or
    2.3. Reset directly by an integral controller based on the relationship between variable speed controller frequency and power.

**C403.4.7 Combustion heating equipment controls.** Combustion heating equipment with a capacity over 225,000 Btu/h shall have modulating or staged combustion control.

**Exceptions:**

1. Boilers.
2. Radiant heaters.

**C403.4.7.1 Combustion decorative vented appliance, combustion fireplace and fire pit controls.** Combustion decorative vented appliances, combustion fireplaces and fire pits shall be equipped with local controls to limit operation to a maximum duration of one hour without override hold capability or shall be controlled by occupancy sensor control configured with manual on and *automatic* shutoff within 15 minutes after occupants have left the space.

**C403.4.8 Group R-1 hotel/motel guestrooms.** See Section C403.7.4.

**C403.4.9 Group R-2 and R-3 dwelling units.** The primary space conditioning system within each dwelling unit shall be provided with at least one programmable thermostat for the regulation of space temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback periods per day.

Each additional system provided within the dwelling unit shall be provided with at least one adjustable thermostat for the regulation of temperature.

**Exceptions:**

1. Systems controlled by an occupant sensor that is configured to shut the system off when no occupant is sensed for a period of up to 30 minutes.
2. Systems controlled solely by a manually operated timer configured to operate the system for no more than two hours.
3. Ductless heat pumps.

Each thermostat shall be capable of being set by adjustment or selection of sensors and configured as follows:

1. When used to control heating only: 55°F to 75°F.
2. When used to control cooling only: 70°F to 85°F.
3. All other: 55°F to 85°F with an adjustable dead band configured to at least 5°F in accordance with Section C403.4.1.2.

**C403.4.10 Group R-2 sleeping units.** The primary space conditioning system within each sleeping unit shall be provided with at least one programmable thermostat for the regulation of space temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback periods per day.

Each additional system provided within the sleeping unit shall be provided with at least one adjustable thermostat for the regulation of temperature.

**Exceptions:**

1. Systems controlled by an occupant sensor that is configured to shut the system off when no occupant

is sensed for a period of up to 30 minutes.
2. Systems controlled solely by a manually operated timer configured to operate the system for no more than two hours.
3. *Zones* with a full HVAC load demand not exceeding 3,400 Btu/h (1 kW) and having a manual shutoff switch located with ready access.
4. Ductless heat pumps.

Each thermostat shall be capable of being set by adjustment or selection of sensors and configured as follows:

1. When used to control heating only: 55°F to 75°F;
2. When used to control cooling only: 70°F to 85°F;
3. All other: 55°F to 85°F with an adjustable dead band configured to at least 5°F in accordance with Section C403.4.1.2.

**C403.4.11 Direct digital control systems.** Direct digital control (DDC) shall be required as specified in Sections C403.4.11.1 through C403.4.11.4.

**C403.4.11.1 DDC applications**. DDC shall be provided in the applications and qualifications listed in Table C403.4.11.1 and for load management measures where installed to meet the requirements of Section C406.3.

**TABLE C403.4.11.1**
**DDC APPLICATIONS AND QUALIFICATIONS**

| Building Status | Application | Qualifications |
|---|---|---|
| New Building | Air-handling system and all zones served by the system | All air-handling systems in buildings with building cooling capacity greater than 780,000 Btu/h |
| | Air-handling system and all zones served by the system | Individual systems supplying more than three zones and with fan system bhp of 10 hp and larger |
| | Chilled-water plant and all coils and terminal units served by the system | Individual plants supplying more than three zones and with design cooling capacity of 300,000 Btu/h and larger |
| | Hot-water plant and all coils and terminal units served by the system | Individual plants supplying more than three zones and with design heating capacity of 300,000 Btu/h and larger |
| Alteration or addition | Zone terminal units such as VAV box | Where existing zones served by the same air-handling, chilled-water, or hot-water system have DDC |
| | Air-handling system or fan coil | Where existing air-handling system(s) and fan coil(s) served by the same chilled- or hot-water plant have DDC |
| | New air-handling system and all new zones served by the system | Individual systems with fan system bhp 10 hp and larger and supplying more than three zones and more than 75% of zones are new |
| | New or upgraded chilled-water plant | Where all chillers are new and plant design cooling capacity is 300,000 Btu/h and larger |
| | New or upgraded hot-water plant | Where all boilers are new and plant design heating capacity is 300,000 Btu/h and larger |

**C403.4.11.2 DDC controls**. Where DDC is required by Section C403.4.11.1, the DDC system shall be to perform all of the following functions, as required to provide the system and zone control logic required in Sections C403.2, C403.4.3, C403.5, and C403.6.8:

1. Monitor zone and system demand for fan pressure, pump pressure, heating and cooling.
2. Transfer zone and system demand information from zones to air distribution system controllers and from air distribution systems to heating and cooling plant controllers.

**C403.4.11.3 DDC display**. Where DDC is required by Section C403.4.11.1 for new buildings, the DDC system shall be configured to gather and provide trending data and graphically displaying input and output points.

**C403.4.11.4 DDC demand response setpoint adjustment.** Where DDC is required by Section C403.4.11.1 for new buildings and serve mechanical systems with a cooling capacity exceeding 780,000 Btu/h (2,662 kW), the *DDC system* shall be capable of demand response setpoint adjustment. The *DDC system* shall be configured with control logic to increase the cooling zone setpoints by at least 2°F (1°C) and

reduce the heating zone setpoints by at least 2°F (1°C) when activated by a *demand response signal*. The *demand response signal* shall be a binary input to the control system or other interface approved by the serving electric utility.

**C403.4.12 Pressure independent control valves.** Where design flow rate of heating water and chilled water coils is 5 gpm or higher, modulating pressure independent control valves shall be provided.

**C403.4.13 Humidification and dehumidification controls.** Humidification and dehumidification controls shall be in accordance with this section.

**C403.4.13.1 Dehumidification.** *Humidistatic controls* shall not use mechanical cooling to reduce the humidity below the lower of a dew point of 55°F (13°C) or relative humidity of 60 percent in the coldest *zone* served by the system. Lower humidity shall be permitted where mechanical cooling is being used for temperature control.

**Exceptions:**

1. Where approved, systems serving zones where specific humidity levels are required, such as museums and hospitals, and where *humidistatic controls* are capable of and configured to maintain a dead band of at least 10 percent relative humidity where no active humidification or dehumidification takes place.
2. Systems serving *zones* where humidity levels are required to be maintained with precision of not more than ±5 percent relative humidity to comply with applicable codes or accreditation standards or as *approved* by the authority having jurisdiction.

**C403.4.13.2 Humidification.** *Humidistatic controls* shall not use fossil fuels or electricity to produce relative humidity above 30 percent in the warmest *zone* served by the system.

**Exceptions:**

1. Where *approved*, systems serving *zones* where specific humidity levels are required, such as museums and hospitals, and where *humidistatic controls* are capable of and configured to maintain a deadband of at least 10 percent relative humidity where no active humidification or dehumidification takes place.
2. Systems serving *zones* where humidity levels are required to be maintained with precision of not more than ±5 percent relative humidity to comply with applicable codes or accreditation standards or as *approved* by the authority having jurisdiction.

**C403.4.13.3 Control interlock.** Where a *zone* is served by a system or systems with both humidification and dehumidification capability, means such as limit switches, mechanical stops, or for DDC systems, software programming, shall be provided capable of and configured to prevent simultaneous operation of humidification and dehumidification equipment.

**Exception:** Systems serving *zones* where humidity levels are required to be maintained with precision of not more than ±5 percent relative humidity to comply with applicable codes or accreditation standards or as *approved* by the authority having jurisdiction.

~~C403.13~~**C403.4.13.4 Dehumidification in spaces for plant growth and maintenance.** Equipment that dehumidifies building spaces used for plant growth and maintenance shall be one of the following:

1. *Stand-alone dehumidifiers* that meet the following minimum integrated energy factors as measured by the test conditions in Appendix X1 to Subpart B of 10 C.F.R. Part 430:
   1.1. Minimum integrated energy factor of 1.77 L/kWh for product case volumes of 8.0 cubic feet or less;
   1.2. Minimum integrated energy factor of 2.41 L/kWh for product case volumes greater than 8.0 cubic feet;
2. *Integrated HVAC system* including, but not limited to, heat pump technology, with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat;
3. Chilled water system including, but not limited to, heat pump technology, with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat; or
4. Solid or liquid *desiccant dehumidification system* for system designs that require dewpoint of 50°F (10°C) or less.

**C403.5 Economizers.** Air economizers shall be provided on all new cooling systems including those serving

**Commented [BK(50]:** This is a new IECC section. We currently have a WSEC section with the same title in C403.3.2.7 requiring that if a humidifier is added to an economizer system it must be adiabatic.

**Commented [DJ51R50]:** Need working group

computer server rooms, electronic equipment, radio equipment, and telephone switchgear. Economizers shall comply with Sections C403.5.1 through C403.5.5.

**Exceptions**:

1a. For other than Group R-2 occupancies, cooling system where the supply fan is not installed outside the *building thermal envelope* nor in a *mechanical room* adjacent to outdoors and is installed in conjunction with DOAS complying with Section C403.3.5 and serving only spaces with year-round cooling loads from lights and equipment of less than 5 watts per square foot.

1b. For Group R-2 occupancies, cooling system where the supply fan is not installed outside the *building thermal envelope* nor in a *mechanical room* adjacent to outdoors, and is installed in conjunction with DOAS complying with Section C403.3.5, where the ERV/HRV has a minimum 68 percent sensible recovery or 60 percent enthalpy recovery heating effectiveness, and serving only spaces with year-round cooling loads from lights and equipment of less than 5 watts per square foot.

2. Unitary or packaged systems serving one zone with dehumidification that affect other systems so as to increase the overall building energy consumption. New humidification equipment shall comply with Section C403.3.2.5.

3. Unitary or packaged systems serving one zone where the cooling efficiency meets or exceeds the efficiency requirements in Table C403.5.

4. Equipment serving chilled beams and chilled ceiling space cooling systems only which are provided with a water economizer meeting the requirements of Section C403.5.4.

5. For Group R occupancies, cooling unit where the supply fan is not installed outside the building thermal envelope or in a mechanical room adjacent to outdoors with a total cooling capacity less than 20,000 Btu/h and other cooling units with a total cooling capacity less than 54,000 Btu/h provided that these are high-efficiency cooling equipment with IEER, CEER, SEER, and EER values more than 15 percent higher than minimum efficiencies listed in Tables C403.3.2(1), C403.3.2(2), C403.3.2(4), C403.3.2(8) and C403.3.2(9) or an IPLV kW/ton that is at least 15 percent lower than the minimum efficiencies listed in Table C403.3.2(3) or C403.3.2(15), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. For split systems, compliance is based on the cooling capacity of individual fan coil units.

6. Equipment used to cool *Controlled Plant Growth Environments* provided these are high-efficiency cooling equipment with SEER, EER and IEER values a minimum of 20 percent greater than the values listed in Tables C403.3.2(1), (3), (4) and (15).

7. Equipment serving a space with year-round cooling loads from lights and equipment of 5 watts per square foot or greater complying with the following criteria:

   7.1. Equipment serving the space utilizes chilled water as the cooling source; and

   7.2. The chilled water plant includes a condenser heat recovery system that meets the requirements of Section C403.9.5 or the building and water-cooled system meets the following requirements:

      7.2.1. A minimum of 90 percent (capacity-weighted) of the building space heat is provided by hydronic heating water.

      7.2.2. Chilled water plant includes a heat recovery chiller or water-to-water heat pump capable of rejecting heat from the chilled water system to the hydronic heating equipment capacity.

   7.2.3. Heat recovery chillers shall have a minimum COP of 7.0 when providing heating and cooling water simultaneously.

8. Water-cooled equipment served by systems meeting the requirements of Section C403.9.2.4, Condenser heat recovery.

9. Dedicated outdoor air systems that include energy recovery as required by Section C403.7.6 but that do not include mechanical cooling.

10. Dedicated outdoor air systems not required by Section C403.7.6 to include energy recovery that modulate the supply airflow to provide only the minimum outdoor air required by Section C403.2.2.1 for ventilation, exhaust air make-up, or other process air delivery.

~~10.~~11. Direct-expansion fan coils or unitary equipment with a capacity less than 54,000 Btu/h and multiple stages of compressor capacity installed with a dedicated outdoor air system.

~~11.~~12. Equipment used to cool any dedicated server room, electronic equipment room or telecom

**Commented [BK(52]:** New IECC exception. Don't know how appropriate the inclusion is for the WSEC.

switch room provided the system complies with Option a, b or c in the table below. The total cooling capacity of all fan systems without economizers shall not exceed 240,000 Btu/h per building or 10 percent of its air economizer capacity, whichever is greater. This exception shall not be used for Total Building Performance.

| | Equipment Type | Higher Equipment Efficiency | Part-Load Control | Economizer |
|---|---|---|---|---|
| Option a | Tables C403.3.2(1), C403.3.2(2), and C403.3.2(14)[a] | +15%[b] | Required over 85,000 Btu/h[c] | None Required |
| Option b | Tables C403.3.2(1), C403.3.2(2), and C403.3.2(14)[a] | +5%[d] | Required over 85,000 Btu/h[c] | Water-side Economizer[e] |
| Option c | ASHRAE Standard 127[f] | +0%[g] | Required over 85,000 Btu/h[c] | Water-side Economizer[e] |

Notes for Exception 11:

a. For a system where all of the cooling equipment is subject to the AHRI standards listed in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(14), the system shall comply with all of the following (note that if the system contains any cooling equipment that exceeds the capacity limits in Table C403.3.2(1), C403.3.2(2), or C403.3.2(14) or if the system contains any cooling equipment that is not included in Table C403.3.2(1), C403.3.2(2) or C403.3.2(14), then the system is not allowed to use this option).

b. The cooling equipment shall have an EER value and an IPLV value that is a minimum of 15 percent greater than the value listed in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(14).

c. For units with a total cooling capacity over 85,000 Btu/h, the system shall utilize part-load capacity control schemes that are able to modulate to a part-load capacity of 50 percent of the load or less that results in the compressor operating at the same or higher EER at part loads than at full load (e.g., minimum of two-stages of compressor unloading such as cylinder unloading, two-stage scrolls, dual tandem scrolls, but hot gas bypass is not credited as a compressor unloading system).

d. The cooling equipment shall have an EER value and an IPLV value that is a minimum of 5 percent greater than the value listed in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(14).

e. The system shall include a water economizer in lieu of air economizer. Water economizers shall meet the requirements of Sections C403.5.1 and C403.5.2 and be capable of providing the total concurrent cooling load served by the connected terminal equipment lacking airside economizer, at outside air temperatures of 50°F dry-bulb/45°F wet-bulb and below. For this calculation, all factors including solar and internal load shall be the same as those used for peak load calculations, except for the outside temperatures. The equipment shall be served by a dedicated condenser water system unless a non-dedicated condenser water system exists that can provide appropriate water temperatures during hours when water-side economizer cooling is available.

f. For a system where all cooling equipment is subject to ASHRAE Standard 127.

g. The cooling equipment subject to ASHRAE Standard 127 shall have an EER value and an IPLV value that is equal or greater than the value listed in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(14) when determined in accordance with the rating conditions in ASHRAE Standard 127 (i.e., not the rating conditions in AHRI Standard 210/240 or 340/360). This information shall be provided by an independent third party.

**TABLE C403.5**
**EQUIPMENT EFFICIENCY PERFORMANCE EXCEPTION FOR ECONOMIZERS**

| Climate Zone | Efficiency Improvement[a] |
|---|---|
| 4C | 64% |
| 5B | 59% |

a. If a unit is rated with an IPLV, IEER or SEER then to eliminate the required air or water economizer, the minimum cooling efficiency of the HVAC unit must be increased by the percentage shown. If the HVAC unit is only rated with a full load metric like EER or COP cooling, then these must be increased by the percentage shown.

**C403.5.1 Integrated economizer control.** Economizer systems shall be integrated with the mechanical cooling system and be configured to provide 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 system by limiting or disabling the economizer or any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

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 the outdoor air damper is at the 100 percent open position when mechanical cooling is on and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C).
2. Direct expansion (DX) units with cooling capacity 65,000 Btu/H (19 kW) or greater of rated capacity shall comply with the following:
   2.1. DX units that control the capacity of the mechanical cooling directly based on occupied space temperature shall have not fewer than two stages of mechanical cooling capacity.
   2.2. Other DX units, including those that control space temperature by modulating the airflow to the space, shall be in accordance with Table C403.5.1.

**TABLE C403.5.1**
**DX COOLING STAGE 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% of full load |

For SI: 1 Btu/h = 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.

**C403.5.2 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 VAV systems that cause *zone* level heating to increase due to a reduction in supply air temperature.

**C403.5.3. Air economizers.** Air economizers shall comply with Sections C403.5.3.1 through C403.5.3.5.

**C403.5.3.1 Design capacity.** Air economizer systems shall be configured to modulate *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.

**C403.5.3.2 Control signal.** Economizer controls and dampers shall be configured to sequence the dampers with mechanical cooling equipment and shall not be controlled by only mixed air temperature. Air economizers on systems with cooling capacity greater than 65,000 Btu/h shall be configured to provide partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

**Exception:** The use of mixed air temperature limit control shall be permitted for systems that are both controlled from space temperature (such as single *zone* systems) and having cooling capacity less than 65,000 Btu/h.

**C403.5.3.3 High-limit shutoff.** Air economizers shall be configured to automatically reduce *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 C403.5.3.3. High-limit shutoff control settings for these control types shall be those specified in Table C403.5.3.3.

**TABLE C403.5.3.3**
**HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS[b]**

| DEVICE TYPE | REQUIRED HIGH LIMIT (Economizer Off When): | | REQUIRED HIGH LIMIT FOR CYCLING FANS[c] (Economizer Off When): | |
|---|---|---|---|---|
| | EQUATION | DESCRIPTION | EQUATION | DESCRIPTION |
| Fixed dry bulb | $TOA > 75°F$ | Outdoor air temperature exceeds 75°F | $TOA > 70°F$ | Outdoor air temperature exceeds 70°F |
| Differential dry bulb | $T_{OA} > T_{RA}$ | Outdoor air temperature exceeds return air | $T_{OA} > (T_{RA} - 5)$ | Outdoor air temperature exceeds return air |

| | | | | |
|---|---|---|---|---|
| | | temperature | | temperature - 5°F |
| Fixed enthalpy with fixed dry-bulb temperatures | $h_{OA}$ > 28 Btu/lb[a] or $T_{OA}$ > 75°F | Outdoor air enthalpy exceeds 28 Btu/lb of dry air[a] or outdoor temperature exceeds 75°F | $h_{OA}$ > 26 Btu/lb[a] or $T_{OA}$ > 70°F | Outdoor air enthalpy exceeds 26 Btu/lb of dry air[d] or outdoor temperature exceeds 70°F |
| Differential enthalpy with fixed dry-bulb temperatures | $h_{OA}$ > $h_{RA}$ or $T_{OA}$ > 75°F | Outdoor air enthalpy exceeds return air enthalpy oroutdoor temperature exceeds 75°F | $h_{OA}$ > ($h_{RA}$ – 2) or $T_{OA}$ > 70°F | Outdoor air enthalpy exceeds return air enthalpy or outdoor temperature exceeds 70°F |

For SI: °C = (°F - 32) × 5/9, 1 Btu/lb = 2.33 kJ/kg.

a. At altitudes substantially different than sea level, the Fixed Enthalpy limit shall be set to the enthalpy value at 75°F and 50-percent relative humidity. As an example, at approximately 6,000 feet elevation the fixed enthalpy limit is approximately 30.7 Btu/lb.

b. Devices with selectable setpoint shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

c. Where fans cycle on only to provide heating and cooling, limits are adjusted lower to compensate for fan energy use in economizer mode.

d. For cycling fans, at altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 70°F and 50% relative humidity.

**C403.5.3.4 Relief of excess outdoor air.** Systems shall ~~be capable of relieving~~ provide one of the following means to relieve 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.~~

1. Return or relief fan(s) meeting the requirements of Section C403.11.1.
2. A barometric or motorized damper relief path with a total pressure drop at a design relief airflow rate less than 0.10 inches water column (25 Pa) from the occupied space to the outdoors. Design relief airflow rate shall be the design supply airflow rate minus any continuous exhaust flows, such as toilet exhaust fans, whose makeup is provided by the economizer system.

The relief air outlet shall be located to avoid recirculation into the building.

**C403.5.3.5 Economizer dampers**. Return, exhaust/relief and outdoor air dampers used in economizers shall comply with Section C403.7.8.

**C403.5.4 Water-side economizers.** Water-side economizers shall comply with Sections C403.5.4.1 and C403.5.4.2.

**C403.5.4.1 Design capacity.** Water economizer systems shall be configured to cool supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at *outdoor air* temperatures of not greater than 50°F dry-bulb (10°C dry-bulb)/45°F wet-bulb (7.2°C wet-bulb.

**Exception:** Systems where dehumidification requirements cannot be met using outdoor air temperatures of 50°F dry-bulb (10°C dry-bulb)/45°F wet-bulb (7.2°C wet-bulb) and where 100 percent of the expected system cooling load at 45°F dry-bulb (7.2°C dry-bulb)/40°F wet-bulb (4.5°C wet-bulb) is met with evaporative water economizers.

**C403.5.4.2 Maximum pressure drop.** Precooling 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 (4572 mm) 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 (noneconomizer) mode.

**C403.5.5 Economizer fault detection and diagnostics (FDD)**. Air-cooled unitary direct-expansion units with a cooling capacity of 54,000 Btu/h or greater listed in the tables in Section C403.3.2 that are equipped with an economizer in accordance with Section C403.5 shall include a fault detection and diagnostics (FDD) system complying with the following:

1. The following temperature sensors shall be permanently 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 configured to provide 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 operation of compressors, economizers, fans and the heating system can be independently tested and verified.
6. The unit shall be configured to report faults to a fault management application available for access by day-to-day operating or service personnel or annunciated locally on zone thermostats.
7. The FDD system shall be configured to detect 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.

**C403.6 Requirements for mechanical systems serving multiple zones.** Sections C403.6.1 through C403.6.10 shall apply to mechanical systems serving multiple zones.

**C403.6.1 Variable air volume (VAV) and multiple zone systems.** Supply air systems serving multiple zones shall be VAV systems that have zone controls configured to reduce the volume of air that is reheated, recooled or mixed in each *zone* to one of the following:

1. ~~Twenty~~ Thirty percent of the zone design peak supply for systems with *direct digital* control (DDC) ~~and thirty percent of the maximum supply air for other systems~~.
2. Systems with DDC where items 2.1 through 2.3 apply.
   2.1 The airflow rate in the dead band between heating and cooling does not exceed ~~20 percent of the zone design peak supply rate or higher~~ the highest of the allowed rates under items 3, 4, ~~or~~ 5 or 6 of this section.
   2.2 The first stage of heating modulates the zone supply air temperature setpoint up to a maximum setpoint while the airflow is maintained at the dead band flow rate.
   2.3 The second stage of heating modulates the airflow rate from the dead band flow rate up to the heating maximum flow rate that is less than 50 percent of the zone design peak supply rate.
3. The outdoor airflow rate required to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.
4. The minimum primary airflow rate required to meet the Simplified Procedure ventilation requirements of ASHRAE 62.1 for the zone and is permitted to be the average airflow rate as allowed by ASHRAE 62.1.
5. 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*.
6. 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* or supply air systems where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered source, including condenser heat.
   2. Systems that prevent reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has

**Commented [DJ53]:** Have we adopted the latest 62.1 with a "simplified procedure"?

**Commented [KB54R53]:** The standard is referenced in Chapter 6 (as the 2019 edition). It is also adopted through the Mechanical Code (but as the 2022 edition) and allowed as an alternate ventilation system.

been previously mechanically heated.

3. .Ventilation systems complying with Section C403.3.5, DOAS, with ventilation rates complying with Section C403.2.2.

**C403.6.2 Single duct variable air volume (VAV) systems, terminal devices.** Single duct VAV systems shall use terminal devices capable of and configured to reduce the supply of primary supply air before reheating or recooling takes place.

**C403.6.3 Dual duct and mixing VAV systems, terminal devices.** Systems that have one warm air duct and one cool air duct shall use terminal devices which are capable of and configured to reduce the flow from one duct to a minimum before mixing of air from the other duct takes place.

**C403.6.4 Supply-air temperature reset controls.** Multiple *zone* HVAC systems shall include controls that are capable of and configured to automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be configured to reset the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity are allowed. HVAC zones that are expected to experience relatively constant loads shall have maximum airflow designed to accommodate the fully reset supply air temperature.

**Exceptions:**

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. Seventy-five percent (75%) of the energy for reheating is from a site-recovered source.

**C403.6.5 Multiple-zone VAV system ventilation optimization control.** Multiple-zone VAV systems with direct digital control of individual zone boxes reporting to a central control panel shall have *automatic* controls configured to reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency ($E_V$) as defined by the *International Mechanical Code*.

**Exceptions:**

1. VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units.
2. Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements.

**C403.6.6 Parallel-flow fan-powered VAV air terminal control.** Parallel-flow fan-powered VAV air terminals shall have *automatic* controls configured to:

1. Turn off the terminal fan except when space heating is required or where required for ventilation.
2. Turn on the terminal fan as the first stage of heating before the heating coil is activated.
3. During heating for warmup or setback temperature control, either:
   3.1. Operate the terminal fan and heating coil without primary air.
   3.2. Reverse the terminal damper logic and provide heating from the central air handler by primary air.

**C403.6.7 Reserved.**

**C403.6.8 Setpoints for direct digital control.** For systems with direct digital control of individual *zones* reporting to the central control panel, the static pressure setpoint shall be reset based on the *zone* requiring the most pressure. In such cases, the setpoint 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 configured to provide 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.

**C403.6.9 Static pressure sensor location.** Static pressure sensors used to control VAV fans shall be located such that the controller setpoint is no 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.

**Exception:** Systems complying with Section C403.6.8.

**C403.6.10 High efficiency variable air volume (VAV) systems.** For HVAC systems subject to the

requirements of Section C403.3.5 but utilizing Exception 2 of that section, a high efficiency multiple-zone VAV system may be provided without a separate parallel DOAS when the system is designed, installed, and configured to comply with all of the following criteria (this exception shall not be used as a substitution for a DOAS per Section C406.6:

1. Each VAV system must serve a minimum of 3,000 square feet (278.7 $m^2$) and have a minimum of five VAV zones.
2. The VAV systems are provided with airside economizer per Section C403.5 without exceptions.
3. A direct-digital control (DDC) system is provided to control the VAV air handling units and associated terminal units per Section C403.4.11 regardless of sizing thresholds of Table C403.4.11.1.
4. Multiple-zone VAV systems with a minimum outdoor air requirement of 2,500 cfm (1180 L/s) or greater shall be equipped with a device capable of measuring outdoor airflow intake under all load conditions. The system shall be capable of increasing or reducing the outdoor airflow intake based on feedback from the VAV terminal units as required by Section C403.6.5, without exceptions, and Section C403.7.1, Demand controlled ventilation.
5. Multiple-zone VAV systems with a minimum outdoor air requirement of 2,500 cfm (1180 L/s) or greater shall be equipped with a device capable of measuring supply airflow to the VAV terminal units under all load conditions.
6. In addition to meeting the zone isolation requirements of C403.2.1 a single VAV air handling unit shall not serve more than 50,000 square feet (4645 $m^2$) unless a single floor is greater than 50,000 square feet (4645 $m^2$) in which case the air handler is permitted to serve the entire floor.
7. The primary maximum cooling air for the VAV terminal units serving interior cooling load driven zones shall be sized for a supply air temperature that is a minimum of 5°F greater than the supply air temperature for the exterior zones in cooling.
8. Air terminal units with a minimum primary airflow setpoint of 50 percent or greater of the maximum primary airflow setpoint shall be sized with an inlet velocity of no greater than 900 feet per minute. Allowable fan motor horsepower shall not exceed 90 percent of the allowable HVAC *fan system bhp* (Option 2) as defined by Section C403.8.1.1.
9. *Fan system electrical input* power (Fan $kW_{design\ system}$) shall not exceed 90 percent of the fan power budget (Fan $kW_{budget}$) as defined by Section C403.8.1.1.
10. All fan powered VAV terminal units (series or parallel) shall be provided with electronically commutated motors. The DDC system shall be configured to vary the speed of the motor as a function of the heating and cooling load in the space. Minimum speed shall not be greater than 66 percent of design airflow required for the greater of heating or cooling operation. Minimum speed shall be used during periods of low heating and cooling operation and ventilation-only operation.

    **Exception:** For series fan powered terminal units where the volume of primary air required to deliver the ventilation requirements at minimum speed exceeds the air that would be delivered at the speed defined above, the minimum speed setpoint shall be configured to exceed the value required to provide the required ventilation air**.**
11. Fan-powered VAV terminal units shall only be permitted at perimeter zones with an envelope heating load requirement. All other VAV terminal units shall be single duct terminal units.

    **Exception:** Fan powered VAV terminal units are allowed at interior spaces with an occupant load greater than or equal to 25 people per 1000 square feet of floor area (as established in Table 403.3.1.1 of the *International Mechanical Code*) with demand control ventilation in accordance with Section C403.7.1.
12. When in occupied heating or in occupied dead band between heating and cooling all fan powered VAV terminal units shall be configured to reset the primary air supply setpoint, based on the VAV air handling unit outdoor air vent fraction, to the minimum ventilation airflow required per *International Mechanical Code*.
13. Spaces that are larger than 150 square feet (14 $m^2$) and with an occupant load greater than or equal to 25 people per 1000 square feet (93 $m^2$) of floor area (as established in Table 403.3.1.1 of the *International Mechanical Code*) shall be provided with all of the following features:
    13.1. A dedicated VAV terminal unit capable of controlling the space temperature and minimum ventilation shall be provided.

13.2. Demand control ventilation (DCV) shall be provided that utilizes a carbon dioxide sensor to reset the ventilation setpoint of the VAV terminal unit from the design minimum to design maximum ventilation rate as required by Chapter 4 of the *International Mechanical Code*.

13.3. Occupancy sensors shall be provided that are configured to reduce the minimum ventilation rate to zero and setback room temperature setpoints by a minimum of 5°F, for both cooling and heating, when the space is unoccupied.

14. Dedicated data centers, computer rooms, electronic equipment rooms, telecom rooms, or other similar spaces with cooling loads greater than 5 watts/ft$^2$ shall be provided with separate, cooling systems to allow the VAV air handlers to turn off during unoccupied hours in the office space and to allow the supply air temperature reset to occur.

**Exception:** The VAV air handling unit and VAV terminal units may be used for secondary backup cooling when there is a failure of the primary HVAC system.

Additionally, computer rooms, electronic equipment rooms, telecom rooms, or other similar spaces shall be provided with airside economizer in accordance with Section C403.5 without using the exceptions to Section C403.5.

**Exception**: Heat recovery per exception 9 of Section C403.5 may be in lieu of airside economizer for the separate, independent HVAC system.

15. HVAC system central heating or cooling plant will include a minimum of one of the following options:

15.1. VAV terminal units with hydronic heating coils connected to systems with hot water generation equipment limited to the following types of equipment: gas-fired hydronic boilers with a thermal efficiency, $E_t$, of not less than 92 percent, air-to-water heat pumps or heat recovery chillers. Hydronic heating coils shall be sized for a maximum entering hot water temperature of 120°F (48.9°C) for peak anticipated heating load conditions.

15.2. Chilled water VAV air handing units connected to systems with chilled water generation equipment with IPLV values more than 25 percent higher than the minimum part load efficiencies listed in Table C403.3.2(3), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify. The smallest chiller or compressor in the central plant shall not exceed 20 percent of the total central plant cooling capacity or the chilled water system shall include thermal storage sized for a minimum of 20 percent of the total central cooling plant capacity.

16. The DDC system shall include a fault detection and diagnostics (FDD) system complying with the following:

16.1. The following temperature sensors shall be permanently installed to monitor system operation:

16.1.1. Outside air.

16.1.2. Supply air.

16.1.3. Return air.

16.2. 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).

16.3. The VAV air handling unit controller shall be configured to provide system status by indicating the following:

16.3.1. Free cooling available.

16.3.2. Economizer enabled.

16.3.3. Compressor enabled.

16.3.4. Heating enabled.

16.3.5. Mixed air low limit cycle active.

16.3.6. The current value of each sensor.

16.4. The VAV air handling unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.

16.5. The VAV air handling unit shall be configured to report faults to a fault management application able to be accessed by day-to-day operating or service personnel or annunciated locally on zone thermostats.

16.6. The VAV terminal unit shall be configured to report if the VAV inlet valve has failed by performing the following diagnostic check at a maximum interval of once a month:

16.6.1. Command VAV terminal unit primary air inlet valve closed and verify that primary airflow goes to zero.

16.6.2. Command VAV thermal unit primary air inlet valve to design airflow and verify that unit is controlling to with 10% of design airflow.

16.7. The VAV terminal unit shall be configured to report and trend when the zone is driving the following VAV air handling unit reset sequences. The building operator shall have the capability to exclude zones used in the reset sequences from the DDC control system graphical user interface:

16.7.1. Supply air temperature setpoint reset to lowest supply air temperature setpoint for cooling operation.

16.7.2. Supply air duct static pressure setpoint reset for the highest duct static pressure setpoint allowable.

16.8. The FDD system shall be configured to detect the following faults:

16.8.1. Air temperature sensor failure/fault.

16.8.2. Not economizing when the unit should be economizing.

16.8.3. Economizing when the unit should not be economizing.

16.8.4. Outdoor air or return air damper not modulating.

16.8.5. Excess outdoor air.

16.8.6. VAV terminal unit primary air valve failure.

**C403.7 Ventilation and exhaust systems.** In addition to other requirements of Section C403 applicable to the provisions of ventilation air or the exhaust of air, ventilation and exhaust systems shall be in accordance with Sections C403.7.1 through C403.7.8.

**C403.7.1 Demand control ventilation.**

**C403.7.1.1 Spaces requiring demand control ventilation.** Demand control ventilation (DCV) shall be provided for the following:

1. Spaces with ventilation provided by single-zone systems where an air economizer is provided to comply with Section C403.5.
2. Spaces with an occupant load greater than or equal to 15 people per 1000 square feet (93 $m^2$) of floor area (as established in Table 403.3.1.1 of the *International Mechanical Code*) or with an occupant outdoor airflow rate greater than or equal to 15 cfm/person, as established in Table 403.3.1.1 of the *International Mechanical Code*.

**Exceptions:**

1. Spaces including, but not limited to, dining areas, where more than 75 percent of the space design outdoor airflow is transfer air required for makeup air supplying an adjacent commercial kitchen.
2. Spaces with one of the following occupancy classifications as defined in Table 403.3.1.1 of the *International Mechanical Code*: Correctional cells, educational laboratories, barbers, beauty and nail salons, and bowling alley seating.
3. Dormitory sleeping areas with fewer than five occupants per space.
4. Spaces with ventilation not provided by a single-zone system where the design occupant component outdoor airflow is less than 100 cfm (23.6 L/s), or 200 cfm (47.2 L/s) with system having energy recovery with minimum 60 percent sensible effectiveness. Design occupant component outdoor airflow shall be calculated as the product of the design number of occupants in the space and the people outdoor airflow rate per occupant ($R_p$) as established in Table 403.3.1.1 of the *International Mechanical Code*.
5. Spaces with ventilation not provided by a single-zone system where the total system design outdoor airflow is less than 750 cfm (354 L/s), or 1500 cfm (708 L/s) with system having energy recovery with minimum 60 percent sensible effectiveness.
6. Spaces where the *registered design professional* demonstrates an engineered ventilation system design that:

6.1. Prevents the maximum concentration of contaminants from being more than that obtainable by the required rate of outdoor air *ventilation*.

~~4.1.~~6.2. Allows the required minimum design rate of outdoor air to be reduced by not less than 15 percent.

**C403.7.1.2 Demand control ventilation design.** Each space required to have demand control ventilation shall have equipment and controls capable of and configured to automatically change the quantity of outdoor air supplied to the space based upon the output of a $CO_2$ sensor. System outdoor air intake shall be

adjusted from peak design levels in response to changes in outdoor air required in the spaces served by the system. This adjustment shall be accomplished by variable speed fan control.

**Exception:** These system types may use other means of adjusting outdoor air:

~~2.~~4. Single zone systems designed to recirculate return air.
~~3.~~5. Systems with total supply air less than 1500 cfm (708 L/s).

**C403.7.2 Occupancy sensors.** Classrooms, gyms, auditoriums, conference rooms, and other spaces with an occupant load greater than or equal to 25 people per 1000 square feet (93 $m^2$) of floor area (as established in Table 403.3.1.1 of the *International Mechanical Code*) that are larger than 500 square feet (46 $m^2$) of floor area shall have occupancy sensor control that will either close outside air dampers, close ventilation supply dampers or turn off ventilation equipment when the space is unoccupied except where equipped with another means to automatically reduce outside air intake below design rates when spaces are partially occupied.

**Exceptions:**

1. Spaces with one of the following occupancy categories (as defined by the *International Mechanical Code*):
   1.1. Correctional cells.
   1.2. Daycare sickrooms.
   1.3. Science labs.
   1.4. Barbers.
   1.5. Beauty and nail salons.
   1.6. Bowling alley seating.
2. When the space is unoccupied during occupied building hours, a ventilation rate equal to or less than the zone outdoor airflow as defined in Section 403.3.1.1.1 of the *International Mechanical Code* with a zone population of zero.

**C403.7.3. Ventilation air heating control.** For ventilation air units with supplemental heating capacity that operate in conjunction with zone heating and cooling systems, supplemental heating shall not warm ventilation supply air to a temperature greater than 55°F (13°C).

**C403.7.4 Automatic control of HVAC systems serving guestrooms.** In Group R-1 buildings containing more than 50 guestrooms, each guestroom shall be provided with controls complying with the provisions of Sections C403.7.4.1 and C403.7.4.2. ~~Card key controls comply with these requirements.~~

**C403.7.4.1 Temperature setpoint controls.** Controls shall be provided on each HVAC system that are capable of and configured with three modes of temperature control.

1. When the guestroom is rented but unoccupied, the controls shall automatically raise the cooling setpoint and lower the heating setpoint by not less than 4°F (2°C) from the occupant setpoint within 30 minutes after the occupants have left the guestroom.
2. When the guestroom is unrented and unoccupied, the controls shall automatically raise the cooling setpoint to not lower than 80°F (27°C) and lower the heating setpoint to not higher than 60°F (16°C) Unrented and unoccupied guestroom mode shall be initiated within 16 hours of the guestroom being continuously occupied or where a *networked guestroom control system* indicates that the guestroom is unrented and the guestroom is unoccupied for more than 20 minutes. A *networked guestroom control system* that is capable of returning the thermostat setpoints to default occupied setpoints 60 minutes prior to the time a guestroom is scheduled to be occupied is not precluded by this section. Cooling that is capable of limiting relative humidity with a setpoint not lower than 65 percent relative humidity during unoccupied periods is not precluded by this section.
3. When the guestroom is occupied, HVAC setpoints shall return to their occupied setpoint once occupancy is sensed.

**C403.7.4.2 Ventilation controls.** Controls shall be provided on each HVAC system that are capable of and configured to automatically turn off the ventilation and exhaust fans within 20 minutes of the occupants leaving the guestroom, or isolation devices shall be provided to each guestroom that are capable of automatically shutting off the supply of outdoor air to and exhaust air from the guestroom.

**Exception:** Guestroom ventilation systems are not precluded from having an *automatic* daily pre-occupancy purge cycle that provides daily outdoor air ventilation during unrented periods at the design ventilation rate for 60 minutes, or at a rate and duration equivalent to one air change.

**C403.7.5 Loading dock, motor vehicle repair garage, and parking garage ventilation system controls.** Mechanical ventilation systems for loading docks, motor vehicle repair garages, and parking garages shall be designed to exhaust the airflow rates (maximum and minimum) determined in accordance with the *International Mechanical Code*.

Ventilation systems shall be equipped with a control device that operates the system automatically by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors. Controllers shall be configured to shut off fans or modulate fan speed to 20 percent or less of design capacity, or intermittently operate fans less than 20 percent of the occupied time or as required to maintain acceptable contaminant levels in accordance with the *International Mechanical Code* provisions.

Ventilation systems with total ventilation system motor nameplate horsepower exceeding 5 hp (3.7 kW) at fan system design conditions and those with heating and/or cooling shall have controls and devices that modulate fan speed and result in fan motor demand of the design airflow.

Gas sensor controllers used to activate the exhaust ventilation system shall stage or modulate fan speed upon detection of specified gas levels. All equipment used in sensor controlled systems shall be designed for the specific use and installed in accordance with the manufacturer's recommendations. The system shall be arranged to operate automatically by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors. Parking garages, repair garages, and loading docks shall be equipped with a controller and a full array of carbon monoxide (CO) sensors set to maintain levels of carbon monoxide below 35 parts per million (ppm). Additionally, a full array of nitrogen dioxide detectors shall be connected to the controller set to maintain the nitrogen dioxide level below the OSHA standard for eight hour exposure.

Spacing and location of the sensors shall be installed in accordance with manufacturer recommendations.

**C403.7.2 Parking garage ventilation controls.** Ventilation systems employed in enclosed parking garages shall comply with **Section 404.1** of the *International Mechanical Code* and the following:

1. Separate ventilation systems and control systems shall be provided for each *parking garage section*.
2. Control systems for each *parking garage section* shall be capable of and configured to reduce fan airflow to not less than 0.05 cfm per square foot [0.00025 m3 /(s × m2)] of the floor area served and not more than 20 percent of the design capacity.
3. The ventilation system for each *parking garage section* shall have controls and devices that result in fan motor demand of not more than 30 percent of design wattage at 50 percent of the design airflow.

**Exception:** Garage ventilation systems serving a single *parking garage section* having a total ventilation system motor *nameplate horsepower* (ventilation system motor nameplate kilowatt) not exceeding 5 hp (3.7 kW) at *fan system design conditions* and where the *parking garage section* has no mechanical cooling or mechanical heating.

Nothing in this section shall be construed to require more than one *parking garage section* in any parking structure.

**Commented [BK(55]:** This is how the IECC modified this section for the 2024. I am providing the text here in case any of the new language should be incorporated into our state amended version.

**Commented [DJ56R55]:** Requires new definition for "parking garage section," which I'm not wild about.

**C403.7.5.1 System activation devices for loading docks.** Ventilation systems for enclosed loading docks shall operate continuously during unoccupied hours at 50 percent or less of design capacity and shall be activated to the full required ventilation rate by one of the following:

1. Gas sensors installed in accordance with the *International Mechanical Code*; or
2. Occupant detection sensors used to activate the system that detects entry into the loading area along both the vehicle and pedestrian pathways.

**C403.7.5.2 System activation devices for parking garages.** Ventilation systems for enclosed parking garages shall operate continuously be activated by gas sensors.

**C403.7.6 Energy recovery ventilation systems.** Energy recovery ventilation systems shall be provided as specified in Sections C403.7.6.1 and C403.7.6.2.

**C403.7.6.1 Ventilation for Group R-2 occupancy.** For all Group R-2 dwelling and sleeping units, a balanced ventilation system with heat recovery system with minimum 60 percent sensible recovery effectiveness shall provide outdoor air directly to each habitable space in accordance with the *International Mechanical Code*. The ventilation system shall allow for the design flow rates to be tested and verified at

each habitable space as part of the commissioning process in accordance with Section C408.2.2. The return/exhaust air stream temperature for heat recovery device selection shall be 70°F (21°C), or as calculated by the *registered design professional*.

**Exception:** Heat recovery and energy recovery ventilators (H/ERV) that are rated and *listed* with HVI 920 can demonstrate compliance with the sensible recovery effectiveness requirement using the adjusted sensible recovery effectiveness (ASRE) rating of the equipment at 32°F (0°C) test conditions. Applied flow rate for ASRE rating shall be no less than the design flow rate or the closest value interpolated between two listed flow rates.

**TABLE C403.7.6(1)**
**ENERGY RECOVERY REQUIREMENT**
**(VENTILATION SYSTEMS OPERATING LESS THAN 8,000 HOURS PER YEAR)**

| CLIMATE ZONE | PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ≥ 10% and < 20% | ≥ 20% and < 30% | ≥ 30% and < 40% | ≥ 40% and < 50% | ≥ 50% and < 60% | ≥ 60% and < 70% | ≥70% and < 80% | ≥ 80% |
| | DESIGN SUPPLY FAN AIRFLOW RATE (cfm) | | | | | | | |
| 4C, 5B | NR | NR | NR | NR | NR | NR | ≥5000 | ≥5000 |

NR = not required

**TABLE C403.7.6.1(2)**
**ENERGY RECOVERY REQUIREMENT**
**(VENTILATION SYSTEMS OPERATING NOT LESS 8,000 HOURS PER YEAR)**

| CLIMATE ZONE | PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ≥ 10% and < 20% | ≥ 20% and < 30% | ≥ 30% and < 40% | ≥ 40% and < 50% | ≥ 50% and < 60% | ≥ 60% and < 70% | ≥70% and < 80% | ≥ 80% |
| | DESIGN SUPPLY FAN AIRFLOW RATE (cfm) | | | | | | | |
| 4C | NR | ≥ 19500 | ≥ 9000 | ≥ 5000 | ≥ 4000 | ≥ 3000 | ≥ 1500 | ≥120 |
| 5B | ≥ 2500 | ≥ 2000 | ≥ 1000 | ≥ 500 | ≥ 140 | ≥ 120 | ≥ 100 | ≥ 80 |

NR = not required

**C403.7.6.2 Spaces other than Group R-2 dwelling units.** Any system serving a space other than a Group R-2 dwelling or sleeping unit with minimum outside air requirements at design conditions greater than 5,000 cfm or any system where the system's supply airflow rate exceeds the value listed in Tables C403.7.6(1) and C403.7.6(2), based on the climate zone and percentage of outdoor airflow rate at design conditions, shall include an energy recovery system. Table C403.7.6(1) shall be used for all ventilation systems that operate less than 8,000 hours per year, and Table C403.7.6(2) shall be used for all ventilation systems that operate 8,000 hours or more per year. The energy recovery system shall provide a 68 percent minimum sensible recovery effectiveness or have an *enthalpy recovery ratio* of not less than 60 percent at design conditions. Where an air economizer is required, the energy recovery system shall include a bypass of the energy recovery media for both the outdoor air and exhaust air or return air dampers and controls which permit operation of the air economizer as required by Section C403.5. Where a single room or space is supplied by multiple units, the aggregate ventilation (cfm) of those units shall be used in applying this requirement. The return/exhaust air stream temperature for heat recovery device selection shall be 70°F (21°C) at 30 percent relative humidity, or as calculated by the registered design professional.

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

1. Where energy recovery systems are restricted per Section 514 of the *International Mechanical Code* to sensible energy, recovery shall comply with one of the following:
   1.1. Kitchen exhaust systems where they comply with Section C403.7.7.1.
   1.2. Laboratory fume hood systems where they comply with Exception 2 of Section C403.7.6.
   1.3. Other sensible energy recovery systems with the capability to provide a change in dry bulb temperature of the outdoor air supply of not less than 50 percent of the difference between the outdoor air and the return air dry bulb temperatures, at design conditions.

2. Laboratory fume hood systems that include at least one of the following features and also comply with Section C403.7.7.2:
   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) above room setpoint, cooled to no cooler than 3°F (1.7°C) below room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
3. Systems serving spaces that are heated to less than 60°F (15.5°C) and are not cooled.
4. ~~Where~~ Heating energy recovery where more than 60 percent of the outdoor air heating energy is provided from site-recovered energy in Climate Zone 5.
5. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.
6. Cooling energy recovery in Climate Zones 3C, 4C, 5B, 5C, 6B, 7 and 8.
7. Systems in Climate Zone 4 requiring dehumidification that employ series energy recovery ~~in series with the cooling coil~~ and have a minimum SERR of 0.40.
8. Multi-zone systems where the supply airflow rate is less than the values specified in Tables C403.7.6(1) and C403.7.6(2) for the corresponding percent of outdoor air. Where a value of NR is listed, energy recovery shall not be required.
9. Equipment which meets the requirements of Section C403.9.2.4.
10. Systems serving Group R-1 dwelling or sleeping units where the largest source of air exhausted at a single location at the building exterior is less than 25 percent of the design outdoor air flow rate.

**C403.7.7 Exhaust systems.**

**C403.7.7.1 Kitchen exhaust systems.**

**C403.7.7.1.1 Replacement air.** Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate.

**C403.7.7.1.2 Kitchen exhaust hood certification and maximum airflow.** Where a kitchen or kitchen/dining facility has a total kitchen hood exhaust airflow rate that is greater than 2,000 cfm, each hood shall be a factory built commercial exhaust hood listed by a nationally recognized testing laboratory in compliance with UL 710 and each hood shall have a maximum exhaust rate as specified in Table C403.7.7.1.2.

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

**Exception:** Type II dishwasher exhaust hoods that have an exhaust airflow of 1000 cfm or less.

**TABLE C403.7.7.1.2**
**MAXIMUM NET EXHAUST FLOW RATE,**
**CFM PER LINEAR FOOT OF HOOD LENGTH**

| TYPE OF HOOD | LIGHT-DUTY EQUIPMENT | MEDIUM-DUTY EQUIPMENT | HEAVY-DUTY EQUIPMENT | EXTRA-HEAVY-DUTY EQUIPMENT |
|---|---|---|---|---|
| Wall-mounted canopy | 140 | 210 | 280 | 385 |
| Single island | 280 | 350 | 420 | 490 |
| Double island (per side) | 175 | 210 | 280 | 385 |
| Eyebrow | 175 | 175 | NA | NA |
| Backshelf/Pass-over | 210 | 210 | 280 | NA |

For SI: 1 cfm = 0.4719 L/s; 1 foot = 305 mm.
NA = Not Allowed

**C403.7.7.1.3 Kitchen exhaust hood system**. Kitchen exhaust hood systems serving Type I exhaust hoods shall be provided with *demand control kitchen ventilation* (*DCKV*) controls where a kitchen or

kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 2000 cfm. DCKV systems shall be configured to provide a minimum of 50 percent reduction in exhaust and replacement air system ~~airflows in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle operation~~airflow rates. Systems shall include controls necessary to modulate exhaust and replacement air system airflows in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle operation Each hood shall be a factory-built commercial exhaust hood *listed* by a nationally recognized testing laboratory and shall have a maximum exhaust rate as specified by Table C403.7.7.1.2.

**Commented [DJ57]:** Note that this duplicates the stricken language above. We say "modulate" instead of "50% reduction."

**Exceptions:**

1. UL 710 listed exhaust hoods that have a design maximum exhaust flow rate no greater than 250 cfm per linear foot of hood that serve kitchen or kitchen/dining facilities with a total kitchen hood exhaust airflow rate less than 5000 cfm.
2. Where allowed by the *International Mechanical* Code, ~~An~~ an energy recovery ~~device~~ ventilation system is installed on the kitchen exhaust with a sensible heat recovery effectiveness of not less than 40 percent or not less than 50 percent of the total exhaust hood airflow.

**C403.7.7.2 Laboratory exhaust systems.** Buildings with laboratory exhaust systems having a total exhaust rate greater than 5,000 cfm (2,360 L/s) shall include heat recovery systems to preconditioned replacement air from laboratory exhaust. The heat recovery system shall be capable of increasing the outside air supply temperature at design heating conditions by 25°F (13.9°C). A provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by Section C403.5.

**Exceptions:**

1. Variable air volume laboratory exhaust and room supply systems configured to reduce exhaust and make-up air volume to 50% or less of design values; or
2. Direct make-up (auxiliary) air supply equal to at least 75% 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; or
3. Combined energy reduction method: VAV exhaust and room supply system configured to reduce exhaust and makeup air volumes and a heat recovery system to precondition makeup air from laboratory exhaust that when combined will produce the same energy reduction as achieved by a heat recovery system with a 50% sensible recovery effectiveness as required above. For calculation purposes, the heat recovery component can be assumed to include the maximum design supply airflow rate at design conditions. The combined energy reduction ($Q_{ER}$) shall meet the following:

   $Q_{ER} \geq Q_{MIN}$

   $Q_{MIN} = CFM_S \times (T_R - T_O) \times 1.1 \times 0.6$

   $Q_{ER} = CFM_S \times (T_R - T_O) \times 1.1(A+B)/100$

   Where:

   $Q_{MIN}$ = Energy recovery at 60% sensible effectiveness (Btu/h)

   $Q_{ER}$ = Combined energy reduction (Btu/h)

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

   $T_R$ = Space return air dry bulb at winter design conditions

   $T_O$ = Outdoor air dry bulb at winter design conditions

   A = Percentage that the exhaust and makeup air volumes can be reduced from design conditions

   B = Percentage sensible heat recovery effectiveness

**C403.7.7.3 Transfer air.** Conditioned supply air delivered to any space with mechanical exhaust shall not exceed the greater of:

1. The supply flow required to meet the space heating or cooling load;

2. The ventilation rate required by the authority having jurisdiction, the facility Environmental Health and Safety department, or Section C403.2.2; or
3. The mechanical exhaust flow minus the available transfer air from conditioned spaces or return air plenums that at their closest point are within 15 feet of each other on the same floor that are not in different smoke or fire compartments. Available transfer air is that portion of outdoor ventilation air that:
    3.1. Is not required to satisfy other exhaust needs,
    3.2. Is not required to maintain pressurization of other spaces, and
    3.3. Is transferable according to applicable codes and standards and per the *International Mechanical Code*.

**Exceptions:**

1. Laboratories classified as biosafety level 3 or higher.
2. Vivarium spaces.
3. Spaces that are required by applicable codes and standards to be maintained at positive pressure relative to adjacent spaces. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.
4. Spaces where the demand for transfer air may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.

**C403.7.8 Shutoff dampers.** Mechanical openings shall be provided with shutoff dampers in accordance with Sections C403.7.8.1 through C403.7.8.4.

**C403.7.8.1 Shutoff dampers for building isolation.** Outdoor air supply, exhaust openings and relief outlets and stairway and elevator hoistway shaft vents shall be provided with Class I motorized dampers. See Sections C403.10.1 and C403.10.2 for ductwork insulation requirements upstream and downstream of the shutoff damper.

**Exceptions:**

1. Gravity (nonmotorized) dampers shall be permitted in lieu of motorized dampers as follows:
    1.1. Relief dampers serving systems less than 5,000 cfm total supply shall be permitted in buildings less than three stories in height.
    1.2. Gravity (nonmotorized) dampers where the design outdoor air intake or exhaust capacity does not exceed 300 cfm (142 L/s).
    1.3. Systems serving areas which require continuous operation for 24/7 occupancy schedules.
2. Shutoff dampers are not required in:
    2.1. Combustion air intakes.
    2.2. Systems serving areas which require continuous operation in animal hospitals, kennels and pounds, laboratories, and Group H, I and R occupancies.
    2.3. Subduct exhaust systems or other systems that are required to operate continuously by the *International Mechanical Code.*
    2.4. Type I grease exhaust systems or other systems where dampers are prohibited by the *International Mechanical Code* to be in the airstream.
    2.5. Unconditioned stairwells or unconditioned elevator hoistway shafts that are only connected to unconditioned spaces.

**C403.7.8.2 Shutoff dampers for return air.** Return air openings used for airside economizer operation shall be equipped with Class I motorized dampers.

**C403.7.8.3 Damper leakage rating.** Class I dampers shall have a maximum leakage rate of 4 cfm/ft$^2$ (20.3 L/s x m$^2$) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with AMCA 500D and shall be labeled by an approved agency for such purpose. Gravity (nonmotorized) dampers shall have an air leakage rate not greater than 20 cfm/ft$^2$ where not less than 24 inches (610 mm) in either dimension and 40 cfm/ft$^2$ where less than 24 inches in either dimension. The rate of air leakage shall be determined at 1.0 inch w.g. (249 Pa) when tested in accordance with AMCA 500D for such purpose. The dampers shall be labeled by an approve agency. Gravity dampers for ventilation air intakes shall be protected from direct exposure to

wind.

**Exceptions:**

1. Gravity (nonmotorized) dampers are not required to be tested to verify the air leakage rating when installed in exhaust systems where the exhaust capacity does not exceed 400 cfm (189 L/s) and the gravity damper is provided with a gasketed seal.
2. Motorized dampers on return air openings in unitary packaged equipment that have the minimum leakage rate available from the manufacturer.

**C403.7.8.4 Damper actuation.** Outdoor air intake, relief and exhaust shutoff dampers shall be installed with *automatic* controls configured to close when the systems or spaces served are not in use or during 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 economizer cooling. Stairway and elevator hoistway 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, or by thermostatic control systems.

**C403.7.9 Occupied standby controls.** The following spaces shall be equipped with occupied standby controls in accordance with Section C403.7.9.1 for each ventilation zone:

1. Postsecondary classrooms, lecture rooms and training rooms.
2. Conference/meeting/multipurpose rooms.
3. Lounges/breakrooms.
4. Enclosed offices.
5. Open-plan office areas.
6. Corridors.

**Exception:** *Zones* that are part of a multiple-zone system without *automatic* zone flow control dampers.

**C403.7.9.1 Occupied-standby zone controls.** Within 5 minutes of all spaces in that *zone* entering *occupied-standby mode*, the *zone* control shall operate as follows:

1. The active heating setpoint shall be set back by not less than 1°F (0.55°C).
2. The active cooling setpoint shall be set up by not less than 1°F (0.55°C).
3. All airflow supplied to the *zone* shall be shut off whenever the space temperature is between the active heating and cooling setpoints.
4. Multiple-zone systems shall comply with Section C403.7.9.1.1.

**C403.7.9.1.1 Multiple-zone system controls.** Multiple-zone systems required to automatically reset the effective minimum outdoor air setpoint, per Section C403.6.6, shall reset the effective minimum outdoor air setpoint based on a *zone* outdoor air requirement of zero for all *zones* in *occupied-standby mode*. Sequences of operation for system outside air reset shall comply with an *approved* method.

**C403.7.10 Dwelling unit ventilation system.** A fan that is the air mover for a heating or cooling system that serves an individual *dwelling unit* shall not be used to provide outdoor air.

**Exception:** Where the fan efficacy is not less than 1.2 cubic feet per minute (0.56 L/s) of outdoor airflow per watt when there is no demand for heating or cooling.

**C403.8 Fan and fan controls.** Fans in HVAC systems shall comply with Sections C403.8.1 through C403.8.5.1.

The airflow requirements of Section C403.8.5.1 shall apply to all fan motors. Low capacity ventilation fans shall also comply with Section C403.8.4.

**C403.8.1 Fan systems.** Each fan system that includes at least one fan or fan array with fan electrical input power ≥ 1 kW, moving air into, out of, or between conditioned spaces or circulating air for the purpose of conditioning air within a space shall comply with Sections C403.8.1.1.

**C403.8.1.1 Determining fan power budget.** For each *fan system*, the *fan system electrical input power* (Fan $kW_{design,system}$) determined in accordance with Section C403.8.1.2 at the *fan system airflow* shall ~~not exceed~~ be greater than Fan $kW_{budget}$. Calculate fan power budget (Fan $kW_{budget}$) for each *fan system* as follows:

1. Determine the *fan system airflow* and choose the appropriate table(s) for fan power allowance.

**Commented [BK(58]:** I think this would require a change to the mechanical code. Need to research.

**Commented [DJ59R58]:** This is basically the definition of DOAS: ventilation air supply is separate from heat/cool air movement. I'm wonder if those new combo heat pump/ERV units for apartments might be disqualified?

1.1. For *single-cabinet fan systems*, use the *fan system airflow* and the power allowances in both Table C403.8.1.1(1) and Table C403.8.1.1(2).
1.2. For *supply-only fan systems*, use the *fan system airflow* and power allowances in Table C403.8.1.1(1).
1.3. For *relief fan systems*, use the design relief airflow and the power allowances in Table C403.8.1.1(2).
1.4. For exhaust, return and transfer *fan systems*, use the *fan system airflow* and the power allowances in Table C403.8.1.1(2).
1.5. For complex and DOAS with energy recovery *fan systems*, separately calculate the *fan power* allowance for the supply and return/exhaust systems and sum them. For the supply airflow, use supply airflow at the *fan system* design conditions, and the power allowances in Table C403.8.1.1(1). For the return/exhaust airflow, use return/exhaust airflow at the *fan system* design conditions, and the power allowances in Table C403.8.1.1(2).

2. For each *fan system*, determine the components included in the fan system and sum the fan power allowances of those components. All fan systems shall include the system base allowance. If, for a given component, only a portion of the fan system airflow passes through the component, calculate the fan power allowance for that component in accordance with Equation ~~4-11~~4-10:

**(Equation ~~4-11~~4-10)**

$$FPA_{adj} = (Q_{comp}/Q_{sys}) \times FPA_{comp}$$

Where:

$FPA_{adj}$ = The corrected fan power allowance for the component in W/cfm.

$Q_{comp}$ = The airflow through component in cfm.

$Q_{sys}$ = The *fan system airflow* in cfm.

$FPA_{comp}$ = The fan power allowance of the component from Table C403.8.1.1(1) or Table C403.8.1.1(2).

3. Multiply the *fan system airflow* by the sum of the fan power allowances for the *fan system*.
4. Divide by 1,000 to convert to Fan $kW_{budget}$.
5. For building sites at elevations greater than 3,000 feet, multiply Fan $kW_{budget}$ by 0.896.

**TABLE C403.8.1.1(1)**
**SUPPLY FAN POWER ALLOWANCES (W/CFM)**

| Airflow | Multi-Zone VAV Systems[a] ≤ 5,000 cfm | Multi-Zone VAV Systems[a] > 5,000 and ≤ 10,000 cfm | Multi-Zone VAV Systems[a] > 10,000 cfm | All Other *Fan Systems* ≤ 5,000 cfm | All Other *Fan Systems* > 5,000 and ≤ 10,000 cfm | All Other *Fan Systems* > 10,000 cfm |
|---|---|---|---|---|---|---|
| Supply system base allowance for AHU serving spaces ≤ 6 floors away | 0.395 | 0.453 | 0.413 | 0.232 | 0.256 | 0.236 |
| Supply system base allowance for AHU serving spaces > 6 floors away | 0.508 | 0.548 | 0.501 | 0.349 | 0.356 | 0.325 |
| MERV 13 to MERV 16 Filter upstream of thermal conditioning equipment (two-times the clean filter pressure drop)[b] | 0.136 | 0.114 | 0.105 | 0.139 | 0.120 | 0.107 |
| MERV 13 to MERV 16 Final filter downstream of thermal conditioning equipment (two-times the clean filter pressure drop)[b] | 0.225 | 0.188 | 0.176 | 0.231 | 0.197 | 0.177 |
| Filtration allowance for > MERV 16 or HEPA Filter (two-times the clean filter pressure drop)[b] | 0.335 | 0.280 | 0.265 | 0.342 | 0.292 | 0.264 |
| Central hydronic heating coil allowance | 0.046 | 0.048 | 0.052 | 0.046 | 0.050 | 0.054 |
| Electric heat allowance | 0.046 | 0.038 | 0.035 | 0.046 | 0.040 | 0.036 |
| Gas heat allowance | 0.069 | 0.057 | 0.070 | 0.058 | 0.060 | 0.072 |
| Hydronic/DX cooling coil or heat pump | 0.135 | 0.114 | 0.105 | 0.139 | 0.120 | 0.107 |

| Airflow | Multi-Zone VAV Systems[a] ≤ 5,000 cfm | Multi-Zone VAV Systems[a] > 5,000 and ≤ 10,000 cfm | Multi-Zone VAV Systems[a] > 10,000 cfm | All Other *Fan Systems* ≤ 5,000 cfm | All Other *Fan Systems* > 5,000 and ≤ 10,000 cfm | All Other *Fan Systems* > 10,000 cfm |
|---|---|---|---|---|---|---|
| coil (wet) allowance[c] | | | | | | |
| Solid or liquid desiccant system allowance | 0.157 | 0.132 | 0.123 | 0.163 | 0.139 | 0.124 |
| Reheat coil for dehumidification allowance | 0.045 | 0.038 | 0.035 | 0.046 | 0.040 | 0.036 |
| Allowance for evaporative humidifier/cooler in series with a cooling coil. Value shown is allowed W/cfm per 1.0 inches of water gauge (in. w.g.). Determine pressure loss (in. w.g.) at 400 fpm or maximum velocity allowed by the manufacturer, whichever is less[d] | 0.224 | 0.188 | 0.176 | 0.231 | 0.197 | 0.177 |
| Allowance for 100% Outdoor air system[e] | 0.000 | 0.000 | 0.000 | 0.070 | 0.100 | 0.107 |
| Energy recovery allowance for 0.50 ≤ ERR <0.55[f] | 0.135 | 0.114 | 0.105 | 0.139 | 0.120 | 0.107 |
| Energy recovery allowance for 0.55 ≤ ERR <0.60f | 0.160 | 0.134 | 0.124 | 0.165 | 0.141 | 0.126 |
| Energy recovery allowance for 0.60 ≤ ERR <0.65f | 0.184 | 0.155 | 0.144 | 0.190 | 0.163 | 0.146 |
| Energy recovery allowance for 0.65 ≤ ERR <0.70f | 0.208 | 0.175 | 0.163 | 0.215 | 0.184 | 0.165 |
| Energy recovery allowance for 0.70 ≤ ERR <0.75f | 0.232 | 0.196 | 0.183 | 0.240 | 0.205 | 0.184 |
| Energy recovery allowance for 0.75 ≤ ERR <0.80f | 0.257 | 0.216 | 0.202 | 0.264 | 0.226 | 0.203 |
| Energy recovery allowance for ERR ≥ 0.80f | 0.281 | 0.236 | 0.222 | 0.289 | 0.247 | 0.222 |
| Coil runaround loop | 0.135 | 0.114 | 0.105 | 0.139 | 0.120 | 0.107 |
| Allowance for Gas phase filtration required by code or accredited standard. Value shown is allowed W/cfm per 1.0 in. wg air pressure drop[d] | 0.224 | 0.188 | 0.176 | 0.231 | 0.197 | 0.177 |
| Economizer damper return | 0.045 | 0.038 | 0.035 | 0.046 | 0.040 | 0.036 |
| Air blender allowance | 0.045 | 0.038 | 0.035 | 0.046 | 0.040 | 0.036 |
| Sound attenuation section [fans serving spaces with design background noise goals below NC35] | 0.034 | 0.029 | 0.026 | 0.035 | 0.030 | 0.027 |
| Deduction for systems that feed a terminal unit with a fan with electrical input power < 1kW | -0.100 | -0.100 | -0.100 | -0.100 | -0.100 | -0.100 |
| Low-turndown single-zone VAV fan systems[g] | 0.000 | 0.000 | 0.000 | 0.070 | 0.100 | 0.089 |

a. See definition of *FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME* (VAV).
b. Filter fan power allowance can only be counted once per fan system, except fan systems in health care facilities, which can claim one of the MERV 13 to 16 filter allowances and the HEPA filter allowance if both are included in the *fan system*.
c. Health care facilities can claim this fan power allowance twice per *fan system* where coil design leaving air temperature is less than 44ºF.
d. Power allowance requires further calculation by multiplying the actual inches of water gauge (in.w.g.) of the device/component by the w/cfm in Table C403.8.1(1).
e. The 100% outdoor air system must serve 3 or more HVAC zones and airflow during noneconomizer operating periods must comply with Section C403.2.2.1.
f. Enthalpy Recovery Ratio (ERR) calculated per ANSI/ASHRAE 84-2020.
g. A low-turndown single-zone VAV fan system must be capable of and configured to reduce airflow to 50 percent of design airflow and use no more than 30 percent of the design wattage at that airflow. No more than 10 percent of the design load served by the equipment shall have fixed loads.

**TABLE C403.8.1.1(2)**

**EXHAUST, RETURN, RELIEF, TRANSFER FAN POWER ALLOWANCES (W/CFM)**

| Airflow | Multi-Zone VAV Systems[a] ≤ 5,000 cfm | Multi-Zone VAV Systems[a] > 5,000 and ≤ 10,000 cfm | Multi-Zone VAV Systems[a] > 10,000 cfm | All Other *Fan Systems* ≤ 5,000 cfm | All Other *Fan Systems* > 5,000 and ≤ 10,000 cfm | All Other *Fan Systems* > 10,000 cfm |
|---|---|---|---|---|---|---|
| Exhaust system base allowance | 0.221 | 0.246 | 0.236 | 0.186 | 0.184 | 0.190 |
| Filter (any MERV value)[b] | 0.046 | 0.041 | 0.036 | 0.046 | 0.041 | 0.035 |
| Energy recovery allowance for 0.50 ≤ ERR <0.55[c] | 0.139 | 0.120 | 0.107 | 0.139 | 0.123 | 0.109 |
| Energy recovery allowance for 0.55 ≤ ERR <0.60[c] | 0.165 | 0.142 | 0.126 | 0.165 | 0.144 | 0.128 |
| Energy recovery allowance for 0.60 ≤ ERR <0.65[c] | 0.190 | 0.163 | 0.146 | 0.191 | 0.166 | 0.148 |
| Energy recovery allowance for 0.65 ≤ ERR <0.70[c] | 0.215 | 0.184 | 0.165 | 0.216 | 0.188 | 0.167 |
| Energy recovery allowance for 0.70 ≤ ERR <0.75[c] | 0.240 | 0.206 | 0.184 | 0.241 | 0.209 | 0.186 |
| Energy recovery allowance for 0.75 ≤ ERR <0.80[c] | 0.265 | 0.227 | 0.203 | 0.266 | 0.231 | 0.205 |
| Energy recovery allowance for ERR ≥ 0.80[c] | 0.289 | 0.248 | 0.222 | 0.291 | 0.252 | 0.225 |
| Coil runaround loop | 0.139 | 0.120 | 0.107 | 0.139 | 0.123 | 0.109 |
| Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms | 0.116 | 0.100 | 0.089 | 0.116 | 0.102 | 0.091 |
| Return and/or exhaust airflow control devices | 0.116 | 0.100 | 0.089 | 0.116 | 0.102 | 0.091 |
| Laboratory and vivarium exhaust systems in high-rise buildings for vertical duct exceeding 75 ft. Value shown is allowed W/cfm per 0.25 in. wg for each 100 feet exceeding 75 feet[d] | 0.058 | 0.051 | 0.045 | 0.058 | 0.052 | 0.046 |
| Biosafety cabinet. Value shown is allowed W/cfm per 1.0 in. wg air pressure drop[d] | 0.231 | 0.198 | 0.177 | 0.232 | 0.202 | 0.179 |
| Exhaust filters, scrubbers, or other exhaust treatment required by code or standard. Value shown is allowed W/cfm per 1.0 in. wg air pressure drop[d] | 0.231 | 0.198 | 0.177 | 0.232 | 0.202 | 0.179 |
| Health care facility allowancee | 0.231 | 0.198 | 0.177 | 0.232 | 0.202 | 0.179 |
| Sound attenuation section [Fans serving spaces with design background noise goals below NC35.] | 0.035 | 0.030 | 0.027 | 0.035 | 0.031 | 0.028 |

a. See definition of *FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME* (VAV) to be classified as a Multi-Zone VAV System.
b. Filter pressure loss can only be counted once per fan system.
c. Enthalpy Recovery Ratio (ERR) calculated per ANSI/ASHRAE 84-2020.

d. Power allowance requires further calculation, multiplying the actual pressure drop (in. wg) of the device/component by the W/cfm in the Table C403.8.1(2).
e. This allowance can only be taken for health care facilities.

**C403.8.1.2 Determining *Fan System Electrical Input Power* (Fan $kW_{design,system}$).** *Fan* $kW_{design,system}$ is the sum of *Fan* $kW_{design}$ for each fan or fan array included in the *fan system*. If variable speed drives are used, their efficiency losses shall be included. Fan input power shall be calculated with two-times the clean filter pressure drop. The *Fan* $kW_{design}$ for each fan or fan array shall be determined using one of the following methods. There is no requirement to use the same method for all fans in a *fan system*:

1. Use the default *Fan* $kW_{design}$ in Table C403.8.1.2 for one or more of the fans. This method cannot be used for *complex fan systems*.
2. Use the *Fan* $kW_{design}$ at *fan system design conditions* provided by the manufacturer of the fan, fan array, or equipment that includes the fan or fan array calculated per a test procedure included in 10 C.F.R. Part 430, 10 C.F.R. Part 431, ANSI/AMCA 208, ANSI/AMCA S210, AHRI 430, AHRI 440, or ISO 5801.
3. Use the *Fan* $kW_{design}$ provided by the manufacturer, calculated at *fan system design conditions* per one of the methods listed in Section 5.3 of ANSI/AMCA 208.
4. Determine the *Fan* $kW_{design}$ by using the maximum electrical input power provided on the motor nameplate.

**TABLE C403.8.1.2**
**DEFAULT VALUES FOR FAN $KW_{DESIGN}$ BASED ON MOTOR NAMEPLATE HP[a,b]**

| Motor Nameplate HP | Default *Fan* $kW_{design}$ with variable speed drive (Fan $kW_{design}$) | Default *Fan* $kW_{design}$ without variable speed drive (Fan $kW_{design}$) |
|---|---|---|
| <1 | 0.96 | 0.89 |
| ≥1 and <1.5 | 1.38 | 1.29 |
| ≥1.5 and <2 | 1.84 | 1.72 |
| ≥2 and <3 | 2.73 | 2.57 |
| ≥3 and <5 | 4.38 | 4.17 |
| ≥5 and <7.5 | 6.43 | 6.15 |
| ≥7.5 and <10 | 8.46 | 8.13 |
| ≥10 and <15 | 12.4 | 12.0 |
| ≥15 and <20 | 16.5 | 16.0 |
| ≥20 and <25 | 20.5 | 19.9 |
| ≥25 and <30 | 24.5 | 23.7 |
| ≥30 and <40 | 32.7 | 31.7 |
| ≥40 and <50 | 40.7 | 39.4 |
| ≥50 and <60 | 48.5 | 47.1 |
| ≥60 and <75 | 60.4 | 58.8 |
| ≥75 and ≤100 | 80.4 | 78.1 |

a. This table cannot be used for motor nameplate horsepower values greater than 100.
b. This table is to be used only with motors with a service factor ≤1.15. If the service factor is not provided, this table may not be used.

**C403.8.2 Motor nameplate horsepower.** For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp). The fan bhp shall be indicated on the design documents to allow for compliance verification by the *code official*.

**Exceptions:**

1. For fans less than 6 bhp (4476 W), where the first available motor larger than the brake horsepower has a nameplate rating within 50 percent of the bhp, selection of the next larger nameplate motor size is allowed.
2. For fans 6 bhp (4476 W) and larger, where the first available motor larger than the bhp has a nameplate rating within 30 percent of the bhp, selection of the next larger nameplate motor size is allowed.

3. For fans used only in *approved* life safety applications such as smoke evacuation.
4. Fans with motor nameplate horsepower less than 1 hp or fans with a fan motor nameplate electrical input power of less than 0.89 kW.
5. Fans equipped with electronic speed control devices to vary the fan airflow as a function of load.

**C403.8.3 Fan efficiency.** Each fan and fan array shall have a fan energy index (FEI) of not less than 1.00 at the design point of operation, as determined in accordance with AMCA 208 by an approved, independent testing laboratory and labeled by the manufacturer. Each fan and fan array used for a variable-air volume system shall have an FEI of not less than 0.95 at the design point of operation as determined in accordance with AMCA 208 by an approved, independent testing laboratory and labeled by the manufacturer. The FEI for fan arrays shall be calculated in accordance with AMCA 208 Annex C.

**Exception:** The following fans are not required to have a fan energy index:

1. Fans that are not *embedded fans* with motor nameplate horsepower of less than 1.0 hp (0.75 kW) or with a nameplate electrical input power of less than 0.89 kW.
2. *Embedded fans* that have a motor nameplate horsepower of 5 hp (3.7 kW) or less or with a fan system electrical input power of 4.1 kW or less.
3. Multiple fans operated in series or parallel as the functional equivalent of a single fan that have a combined motor nameplate horsepower of 5 hp (3.7 kW) or less or with a fan system electrical input power of 4.1 kW or less.
4. Fans that are part of equipment covered under Section C403.3.2.
5. Fans included in an equipment package certified by an *approved agency* for air or energy performance.
6. *Ceiling fans*.
7. Fans used for moving gases at temperatures above 482°F (250°C).
8. Fans used for operation in explosive atmospheres.
9. Reversible fans used for tunnel ventilation.
10. Fans that are intended to operate only during emergency conditions.
11. Fans outside the scope of AMCA 208.

**C403.8.4 Low-capacity ventilation fans.** Mechanical ventilation system fans with motors less than 1/12 hp (0.062 kW) in capacity shall meet the efficacy requirements of Table C403.8.4 at one or more rating points. Airflow shall be tested in accordance with the test procedure referenced in Table C403.8.4 and *listed*. The airflow shall be reported in the product listing or on the label. Fan efficacy shall be reported in the product listing or shall be derived from the input power and airflow values reported in the product listing or on the label. Fan efficacy for fully ducted HRV, ERV, balanced and in-line fans shall be determined at a static pressure not less than 0.2 inch w.c. (49.8 Pa). Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure not less than 0.1 inch w.c. (24.9 Pa).

**Exceptions:**

1. Where ventilation fans are a component of a listed heating or cooling appliance.
2. Dryer exhaust duct power ventilators and domestic range booster fans that operate intermittently.
3. Fans in radon mitigation systems.
4. Fans not covered within the scope of the test methods referenced in Table C403.8.4.
2.5. Ceiling fans regulated under 10 CFR 430, Appendix U.

**TABLE C403.8.4**
**LOW-CAPACITY VENTILATION FAN EFFICACY[a]**

| ~~Fan location~~System Type | Air Flow Rate ~~Minimum~~ (cfm) | Minimum Efficacy (cfm/watt) | ~~Air Flow Rate Minimum (cfm)~~Test Procedure |
|---|---|---|---|
| Balanced ventilation system without heat or energy recovery | Any | 1.2[a] | ASHRAE Standard 51 (ANSI/AMCA Standard 210) |
| HRV or ERV | Any | 1.2 | ~~Any~~CAN/CSA 439 |
| Range hood | Any | 2.8 | ~~Any~~ ~~< 90~~ |
| In-line supply or exhaust fan | Any | 3.8 | |

| | | | |
|---|---|---|---|
| ~~Bathroom, utility room~~ | ~~10~~ <90 | 2.8 | ~~Any~~ ASHRAE Standard 51 (ANSI/AMCA Standard 210) |
| ~~Bathroom, utility room~~ | ≥ 90 and < 200 | 3.5 | |
| Other exhaust fan | ~~90~~ ≥ 200 | ~~3.5~~ 4.0 | |

For SI: 1 cfm/ft = ~~47.82 W~~0.47 L/s.

a. ~~Airflow shall be tested in accordance with HVI 916 and listed. Efficacy shall be listed or shall be derived from listed power and airflow. Fan efficacy for fully ducted HRV, ERV, balanced and in-line fans shall be determined at a static pressure not less than 0.2 inch w.c. Fan efficacy for ducted range hoods, bathroom, and utility room fans shall be determined at a static pressure not less than 0.1 inch w.c~~For balanced systems, HRVs and ERVs, determine the efficacy as the outdoor airflow divided by the total fan power.

**C403.8.5 Fan controls.** Controls shall be provided for fans in accordance with Section C403.8.5.1 and as required for specific systems provided in Section C403.

**C403.8.5.1 Fan airflow control.** Each cooling system listed in Table C403.8.5.1 shall be designed to vary the indoor fan airflow as a function of load and shall comply 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 temperature 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 no more than 30 percent of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.
3. Units that include an airside economizer in accordance with Section C403.5 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 the *International Mechanical Code* at low speed exceeds the air that would be delivered at the minimum speed defined in Section C403.8.5, the minimum speed shall be selected to provide the required *ventilation air*.

**TABLE C403.8.5.1**
**FAN CONTROL**

| Cooling System Type | Fan Motor Size | Mechanical Cooling Capacity |
|---|---|---|
| DX cooling | Any | ≥ 42,000 Btu/h |
| Chilled water and evaporative cooling | ≥ ¼ hp | Any |

**C403.8.5.2 Intermittent exhaust control for bathrooms and toilet rooms.** Where an exhaust system serving a bathroom or toilet room is designed for intermittent operation, the exhaust system shall be provided with *manual* on capability and one or more of the following controls:

1. A timer control that has a minimum setpoint not greater than 30 minutes.
2. An *occupant sensor control* that automatically turns off exhaust fans within 30 minutes after all occupants have left the space.
3. A humidity control capable of *manual* or *automatic* adjustment from a minimum setpoint not greater than 50 percent to a maximum setpoint not greater than 80 percent relative humidity.
4. A contaminant control that responds to a particle or gaseous concentration.

**Exception:** Bathroom and toilet room exhaust systems serving as an integral component of an outdoor air

ventilation system in Group R-2, R-3 and R-4 occupancies shall ~~not be required to~~ provide controls ~~other than *manual* on capability~~ complying with Section 403.4.5 of the *International Mechanical Code*.

An off setpoint shall not be used to comply with a minimum setpoint requirement.

**Commented [BK(60]:** The new language in the IECC conflicts with requirements of the whole house ventilation requirements in the IMC. Suggested modification is shown.

**C403.8.6 Large-diameter ceiling fans.** Where provided, *large-diameter ceiling fans* shall be tested and labeled in accordance with AMCA 230 and shall meet the efficiency requirements of Table C403.8.6 and Section C403.8.6.1.

**TABLE C403.8.6.1**
**CEILING FAN EFFICIENCY REQUIREMENTS[a]**

| Equipment Type | Minimum Efficiency[b,c] | Test Procedure |
|---|---|---|
| Large diameter ceiling fan | CFEI ≥ 1.00 at high (maximum) speed; and<br>CFEI ≥ 1.31 at 40% of high speed or the nearest speed that is not less than 40% of high speed | 10 CFR 430, Appendix U |

a. The minimum efficiency requirements at both high speed and 40% of maximum speed shall be met or exceeded to comply with this code.

b. Ceiling fans are regulated as consumer products by 10 CFR 430.

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

**C403.8.6.1 Ceiling Fan Energy Index (CFEI).** The Ceiling Fan Energy Index shall be calculated as the ratio of the electric input power of a reference *large-diameter ceiling fan* to the electric input power of the actual *large-diameter ceiling fan* as calculated in accordance with AMCA 208 with the following modifications to the calculations for the reference fan: using an airflow constant (Q) of 26,500 cfm (12.5 $m^3/s$), a pressure constant (P) of 0.0027 inch of water (0.6719 Pa), and fan efficiency constant (η) of 42 percent.

**C403.9 Heat rejection and heat recovery equipment.**

**C403.9.1 Heat rejection equipment.** Heat rejection equipment, including air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers and evaporative condensers, shall comply with this section.

**Exception**: Heat rejection devices where energy use is included in the equipment efficiency ratings listed in Tables C403.3.2(1), C403.3.2(2), C403.3.2(3), C403.3.2(4), C403.3.2(8), C403.3.2(9), C403.3.2(10), and C403.3.2(16).

Heat rejection equipment shall have a minimum efficiency performance not less than values specified in Table C403.3.2(7).

**C403.9.1.1 Fan speed control.** Each fan powered by an individual motor or array of motors with a connected power, including the motor service factor, totaling 5 hp (3.7 kW) or more shall have controls and devices configured to automatically modulate the fan speed to control the leaving fluid temperature or condensing temperature and pressure of the heat rejection device. Fan motor power input shall be not more than 30 percent of design wattage at 50 percent of the design airflow.

**Exceptions**:

1. Fans serving multiple refrigerant or fluid cooling circuits.
2. Condenser fans serving flooded condensers.

**C403.9.1.2 Multiple-cell heat rejection equipment.** Multiple-cell heat rejection equipment with variable speed fan drives shall be controlled to operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components and so that all fans can operate at the same fan speed required for the instantaneous cooling duty, as opposed to staged (on/off) operation. The minimum fan speed shall be the minimum allowable speed of the fan drive system in accordance with the manufacturer's recommendations.

**C403.9.1.3 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 C403.3.2(8).

**C403.9.1.4 Tower flow turndown.** Open-circuit cooling towers used on water-cooled chiller systems that are configured with multiple- or variable-speed condenser 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 percent of the design flow for the cell.

**C403.9.2 Heat recovery.**

**C403.9.2.1 Condenser 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 1,500,000 Btu/hr of heat rejection, and the design service water heating load exceeds 250,000 Btu/hr.

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 recovered energy.

**C403.9.2.2 Steam condensate systems.** On-site steam heating systems shall have condensate water heat recovery. On-site includes a system that is located within or adjacent to one or more buildings within the boundary of a contiguous area or campus under one ownership and which serves one or more of those buildings.

Buildings using off-site generated steam where the condensate is not returned to the source, shall have an on-site condensate water heat recovery shall have condensate water recovery system.

**C403.9.2.3 Refrigeration condenser heat recovery.** Facilities having food service, meat or deli departments and having 500,000 Btu/h or greater of remote refrigeration condensers shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, space heating or for dehumidification reheat. Facilities having a gross *conditioned floor area* of 40,000 $ft^2$ or greater and 1,000,000 Btu/h or greater of remote refrigeration shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, and either for space heating or for dehumidification reheat for maintaining low space humidity.

**C403.9.2.4 Condenser heat recovery for space heating.** A water-source condenser heat recovery system meeting the requirements of Sections C403.9.2.4.1 through C403.9.2.4.4 shall be installed to serve space and ventilation heating systems in new buildings and additions meeting the following criteria:

1. The facility operates greater than 70 hours per week.
2. The sum of all heat rejection equipment capacity serving the new building or addition exceeds 1,500,000 BTU/hr.
3. The sum of zone minimum airflows in all zones with zone reheat coils divided by the *conditioned floor area* served by those systems is at least 0.45 cfm per square foot.

**Exception:** Systems complying with Section C403.3.5, Dedicated outdoor air systems (DOAS).

**C403.9.2.4.1 Water to water heat recovery.** Ninety percent (90%) of the total building space and ventilation heating system design load shall be served by systems that include heat recovery chiller or water to water heat pump equipment capable of rejecting heat from the cooling loop to the space and ventilation heating loop as the first stage of heating.

**C403.9.2.4.2 Exhaust heat recovery.** Heat shall be recovered by the heat recovery system from 90 percent of the total building exhaust airflow. The maximum leaving air temperature of exhaust air after heat recovery shall be 55°F dry-bulb when operating at full capacity in heat recovery mode.

**Exceptions:**

1. Where energy recovery systems are restricted by Section 514 of the *International Mechanical Code* to sensible energy, those systems shall not be included in the calculation of total building exhaust airflow.
2. Exhaust air systems handling contaminated airstreams that are regulated by applicable codes or accreditation standards and pose a health risk to maintenance personnel to maintain heat recovery devices, those systems shall not be included in the calculation of total building exhaust airflow.

**C403.9.2.4.3 Process heat recovery.** Spaces with year-round cooling loads from lights and equipment of 5 watts and greater per square foot shall be served by water-cooled equipment. Cooling loops serving the water-cooled equipment shall be served by water source heat recovery systems meeting the requirements of Section C403.9.2.4.1. If such spaces are provided with an air or water economizer, the economizer controls shall be configured with an override signal from the building automation system to disable economizer operation during heat recovery mode.

**C403.9.2.4.4 Water to water heat recovery sizing.** The minimum total combined capacity of heat recovery chillers or water to water heat pumps shall match the total combined capacity of installed equipment sized to meet the requirements of Sections C403.9.2.4.2 and C403.9.2.4.3.

**C403.10 Construction of HVAC system elements.** Ducts, plenums, piping and other elements that are part of an HVAC system shall be constructed and insulated in accordance with Sections C403.10.1 through C403.10.3.1

**C403.10.1 Duct and plenum insulation and sealing.**

**C403.10.1.1 Ducts, shafts, and plenums conveying outdoor air**. Shafts and plenums conveying outdoor air from the exterior of the building to the mechanical system shall meet all air leakage and ~~building envelope~~*building thermal envelope* insulation requirements of Section C402, plus *building thermal envelope* vapor control requirements from the *International Building Code*.

Ducts conveying outdoor air shall be insulated continuously from the building exterior to an *automatic* shutoff damper or heating or cooling equipment. Duct surfaces shall be insulated with the minimum insulation values in Table C403.10.1.1. Duct surfaces included as part of the *building thermal envelope* shall not be used in the calculation of maximum glazing area as described in Section C402.4.1.

**Exception:** Outdoor air ducts serving individual supply air units with less than 2,800 cfm of total supply air capacity, provided these are insulated to the minimum insulation values in Table C403.10.1.1.

**C403.10.1.2 Other supply and return ducts**. All other supply and return air ducts and plenums shall be insulated with a minimum of R-6 insulation where located in unconditioned spaces, and where located outside the building with a minimum of R-8 insulation in Climate Zone 4 and R-12 insulation in Climate Zone 5. Ducts located underground beneath buildings shall be insulated as required in this section or have an equivalent *thermal distribution* efficiency. Underground ducts utilizing the *thermal distribution* efficiency method shall be listed and labeled to indicate the R-value equivalency. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by minimum insulation value as required for exterior walls by Section C402.1.3.

**Exceptions:**

1. Where located within equipment.
2. Supply and return ductwork located in unconditioned spaces where the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C) and insulated in accordance with Table C403.10.1.2.

Where located within conditioned space, supply ducts which convey supply air at temperatures less than 55°F or greater than 105°F shall be insulated with a minimum insulation *R*-value in accordance with Table C403.10.1.2.

**Exception:** Ductwork exposed to view within a *zone* that serves that zone is not required to be insulated.

Where located within conditioned space, return or exhaust air ducts that convey return or exhaust air downstream of an energy recovery media shall be insulated with a minimum *R*-value in accordance with Table C403.10.1.2.

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

**TABLE C403.10.1.1**
**OUTDOOR AIR DUCTWORK INSULATION**

| Duct system | Duct Location and Use | Climate Zone | Airflow | Minimum Installed Duct Insulation *R*-value [a,b] | Notes |
|---|---|---|---|---|---|
| Outdoor Air | Inside conditioned space and upstream of *automatic* shutoff damper | 4C and 5B | ≥ 2800 CFM | R-16 | See Section C403.10.1.1 for additional requirements |
| Outdoor Air | Inside conditioned space and downstream | 4C | ≥ 2800 CFM | R-8 | |

| | | | | | |
|---|---|---|---|---|---|
| | of *automatic* shutoff damper to HVAC unit or room | | | | |
| Outdoor Air | Inside conditioned space and downstream of *automatic* shutoff damper to HVAC unit or room | 5B | ≥ 2800 CFM | R-12 | |
| Outdoor Air | Inside conditioned space | 4C and 5B | < 2800 CFM | R-7 | See Exception 1 to Section C403.10.1.1 for additional details |

a. Insulation R-values, measured in h·ft$^2$·°F/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.

b. See International Mechanical Code Sections 603.12 and 604 for further details on duct insulation requirements.

**TABLE C403.10.1.2**
**SUPPLY, RETURN, EXHAUST, and RELIEF AIR DUCTWORK INSULATION**

| Duct system | Duct Location and Use | Climate Zone | Minimum Installed Duct Insulation *R*-value [a,b] | Notes |
|---|---|---|---|---|
| Supply Air or Return Air | Outside the building (outdoors and exposed to weather)[c] | 4C | R-8 | See Section C403.10.1.2 for details |
| Supply Air or Return Air | Outside the building (outdoors and exposed to weather)[c] | 5B | R-12 | See Section C403.10.1.2 for details |
| Supply Air or Return Air | Unconditioned space (enclosed but not in the building conditioned envelope) | 4C and 5B | R-6 | See Section C403.10.1.2 for details |
| Supply Air or Return Air | Unconditioned space where the duct conveys air that is within 15°F of the air temperature of the surrounding unconditioned space | 4C and 5B | R-3.3 | See IMC Section 603.12 for additional requirements for condensation control at ductwork |
| Supply Air or Return Air | Where located in a *building thermal envelope* assembly | 4C and 5B | R-16 | Duct or plenum is separated from *building thermal envelope* assembly with the minimum insulation value |
| Supply Air | Within conditioned space where the supply duct conveys air that is less than 55°F or greater than 105°F | 4C and 5B | R-3.3 | See Section C403.10.1.2 for details |
| Supply Air | Within conditioned space that the duct directly serves where the supply duct conveys air that is less than 55°F or greater than 105°F | 4C and 5B | None | See Section C403.10.1.2 for details |
| Supply Air | Within conditioned space where the supply duct conveys air that is 55 °F or greater and 105 °F or less | 4C and 5B | None | |
| Return or Exhaust Air | Within conditioned space, downstream of an energy recovery media, upstream of an *automatic* shutoff damper | 4C | R-8 | |
| Return or Exhaust Air | Within conditioned space, downstream of an energy recovery media, upstream of an *automatic* shutoff damper | 5B | R-12 | |
| Relief or Exhaust Air | Conditioned space and downstream of an *automatic* shutoff damper | 4C and 5B | R-16 | |

a. Insulation R-values, measured in $h \cdot ft^2 \cdot °F/Btu$, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.
b. See International Mechanical Code Sections 603.12 and 604 for further details on duct insulation requirements.
c. Includes attics above insulated ceilings, parking garages and crawl spaces.

**C403.10.2 Duct construction.** Ductwork shall be constructed and erected in accordance with the *International Mechanical Code*. For the purposes of this section, longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw, fastener, pipe, rod, or wire. All other connections are considered transverse joints including, but not limited to, spin-ins, taps and other branch connections, access door frames and jambs, and duct connections to equipment.

**C403.10.2.1 Low-pressure duct systems.** Longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (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 water gauge (w.g.) (500 Pa) pressure classification.

**C403.10.2.2 Medium-pressure duct systems.** Ducts and plenums designed to operate at a static pressure greater than 2 inches water gauge (w.g.) (500 Pa) but less than 3 inches w.g. (750 Pa) shall be insulated and sealed in accordance with Section C403.10.1. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

**C403.10.2.3 High-pressure duct systems.** Ducts designed to operate at static pressures equal to or greater than 3 inches water gauge (w.g.) (750 Pa) shall be insulated and sealed in accordance with Section C403.10.1. In addition, ducts and plenums shall be leak-tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* and shown to have a rate of air leakage (*CL*) less than or equal to 4.0 as determined in accordance with Equation ~~4-12~~4-11.

$$CL = F/P^{0.65} \qquad \textbf{(Equation ~~4-12~~4-11)}$$

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 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.

**C403.10.3 Piping insulation.** All piping, other than field installed HVAC system refrigerant piping, serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.10.3(1) or C403.10.3(2).

**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 (15°C) and 105°F (41°C).
4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
5. 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).
7. In radiant heating systems, section of piping intended by design to radiate heat.

**TABLE C403.10.3**
**MINIMUM PIPE INSULATION THICKNESS (~~thickness in inches~~in inches or *R*-value)[a,c]**

| FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F) | INSULATION CONDUCTIVITY | | INCHES OR *R*-VALUE | NOMINAL PIPE OR TUBE SIZE (inches) | | | | |
|---|---|---|---|---|---|---|---|---|
| | Conductivity Btu · in./(h · ft² · °F)[b] | Mean Rating Temperature, °F | | < 1 | 1 to < 1-1/2 | 1-1/2 to < 4 | 4 to < 8 | ≥ 8 |
| > 350 | 0.32 – 0.34 | 250 | Inches | 4.5 | 5.0 | 5.0 | 5.0 | 5.0 |
| | | | *R*-value | *R*-32 | *R*-36 | *R*-34 | *R*-26 | *R*-21 |
| 251 – 350 | 0.29 – 0.32 | 200 | Inches | 3.0 | 4.0 | 4.5 | 4.5 | 4.5 |
| | | | *R*-value | *R*-20 | *R*-29 | *R*-32 | *R*-24 | *R*-20 |
| 201 – 250 | 0.27 – 0.30 | 150 | Inches | 2.5 | 2.5 | 2.5 | 3.0 | 3.0 |
| | | | *R*-value | *R*-17 | *R*-17 | *R*-17 | *R*-15 | *R*-13 |
| 141 – 200 | 0.25 – 0.29 | 125 | Inches | 1.5 | 1.5 | 2.0 | 2.0 | 2.0 |
| | | | *R*-value | *R*-9 | *R*-9 | *R*-11 | *R*-10 | *R*-9 |
| 105 – 140 | 0.21 – 0.28 | 100 | Inches | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| | | | *R*-value | *R*-5 | *R*-9 | *R*-8 | *R*-8 | *R*-7 |
| 40 – 60 | 0.21 – 0.27 | 75 | Inches | 0.5 | 0.5 | 1.0 | 1.0 | 1.0 |
| | | | *R*-value | *R*-2 | *R*-2 | *R*-5 | *R*-5 | *R*-4 |
| < 40 | 0.20 – 0.26 | 75 | Inches | 0.5 | 1.0 | 1.0 | 1.0 | 1.5 |
| | | | *R*-value | *R*-6 | *R*-9 | *R*-9 | *R*-8 | *R*-7 |

a. For piping smaller than 1-1/2 inch (38 mm) and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1 inch (25 mm) shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch (25 mm).

b. 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,
$r$ = actual outside radius of pipe,
$t$ = insulation thickness listed in the table for applicable fluid temperature and pipe size,
$K$ = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu × in/h × ft2 × °F) and
$k$ = the upper value of the conductivity range listed in the table for the applicable fluid temperature.

c. For direct-buried heating and hot water system piping, reduction of these thicknesses by 1-1/2 inches (38 mm) shall be permitted (before thickness adjustment required in footnote b but not to thicknesses less than 1 inch (25 mm).

**TABLE C403.10.3(2)**
**MINIMUM PIPE INSULATION *R*-VALUE[a]**

| Fluid Operating Temperature Range and Usage (°F) | Nominal Pipe or Tube Size (inches) | | | | |
|---|---|---|---|---|---|
| | ≤ 1 | 1 to < 1-½ | 1-½ to <4 | 4 to <8 | ≥8 |
| | Minimum Insulation *R*-value | | | | |
| > 350 | R-32 | R-36 | R-34 | R-26 | R-21 |
| 251 - 350 | R-20 | R-29 | R-32 | R-24 | R-20 |
| 201 – 250 | R-17 | R-17 | R-17 | R-15 | R-13 |
| 141 – 200 | R-9 | R-9 | R-11 | R-10 | R-9 |
| 105 - 140 | R-5 | R-9 | R-8 | R-8 | R-7 |
| 40 - 60 | R-2 | R-2 | R-5 | R-5 | R-4 |
| ≤ 40 | R-6 | R-9 | R-9 | R-8 | R-7 |

a. The *R*-value of cylindrical piping insulation shall be determined as follows:

$R = \{ro \ln (ro/ri)\}/k$

where:

$R$ = The interior R-value of the cylindrical piping insulation in Btu × ft² × °F/h.

$ro$ = The outer radius of the piping insulation in inches.

**Commented [DJ61]:** Is something drastically wrong with these R-values, since they mostly run inverse to the thickness requirements? And some have higher values for the middle pipe sizes and lower on each end.

**Commented [DJ62]:** This "ln" appears to be another factor in the equation that's not defined below.

*ri* = The inner radius of the piping insulation in inches.

*k* = The thermal conductivity of the insulation material in Btu × ft² × °F.

**C403.10.3.1 Protection of piping insulation.** Piping insulation exposed to weather shall be protected from damage, including that due to sunlight, moisture, physical damage, and wind.~~,~~ ~~and~~ The protection shall provide shielding from solar radiation that can cause degradation of the material. The protection shall be removeable and reusable for not less than six feet from the connection to the equipment piping for maintenance. Adhesive tape shall not be permitted as a means of insulation protection.

**C403.10.4 Insulation of HVAC system refrigerant piping.** Field installed HVAC refrigerant piping, other than piping factory installed in HVAC equipment, shall have insulation as listed below, at a conductivity rating of 0.21 to 0.26 Btu × in/(h × ft² × °F) with a mean temperature rating of 75°F. Piping insulation exposed to weather shall be protected from damage, including that due to sunlight, moisture, physical damage and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted. Manufacturer's required minimum pipe insulation shall be maintained.

1. For lines that convey hot gas for space heating:
   1.1. Minimum 1-inch insulation on the portions outside the building thermal envelope.
   1.2. Minimum 1/2-inch insulation on the portions within the building thermal envelope.
2. Minimum 1/2-inch insulation on the liquid line for mini-split systems and other systems for which insulation is required by the manufacturer, or where the metering device is located in the outdoor unit.
3. No insulation is required on the liquid line for other heat pump types or for cooling-only units where insulation is not required by the manufacturer.

**C403.11 Mechanical systems located outside of the building thermal envelope.** Mechanical systems providing heat outside of the *building thermal envelope* of a building shall comply with Section C403.11.1 through C403.11.3.

**C403.11.1 Heating outside a building.** Systems installed to provide heat outside a building shall be radiant systems.

Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically deenergized when no occupants are present.

**C403.11.2 Snow- and ice-melt system controls.** Snow- and ice-melting systems, supplied through energy service to the building, shall include *automatic* controls configured to shut off the system when the pavement temperature is above 50°F (10°C) and no precipitation is falling and an *automatic* control that is configured to shut off when the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible.

**C403.11.3 Roof and gutter deicing controls.** Roof and gutter deicing systems, including but not limited to self-regulating cable, shall include *automatic* controls that are configured to shut off the system when the outdoor temperature is above 40°F (4°C) and that include one of the following:

1. A moisture sensor configured to shut off the system in the absence of moisture.
2. A daylight sensor or other means configured to shut off the system between sunset and sunrise.

**Commented [DJ63]:** Weird - why would you shut off a deicing system at night, since that's like 16 hours a day in December?

~~C403.11.3~~**C403.11.4 Freeze protection system controls.** Freeze protection systems, such as heat tracing of outdoor piping 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 protected fluid will prevent freezing.

**C403.12 High efficiency single-zone variable air volume (VAV) systems.** For HVAC systems subject to the requirements of Section C403.3.5 but utilizing Exception 2 of that section, a high efficiency single-zone VAV system may be provided without a separate parallel DOAS when the system is designed, installed, and configured to comply with all of the following criteria (this exception shall not be used as a substitution for a DOAS per Section C406.6 or as a modification to the requirements for the *Standard Reference Design* in accordance with Section C407):

1. The single-zone VAV system is provided with airside economizer in accordance with Section 403.3 without exceptions.
2. A direct-digital control (DDC) system is provided to control the system as a single zone in accordance with Section C403.4.11 regardless of sizing thresholds of Table C403.4.11.1.

3. Single-zone VAV systems with a minimum outdoor air requirement of 1,000 cfm (472 L/s) or greater shall be equipped with a device capable of measuring outdoor airflow intake under all load conditions. The system shall be capable of increasing or reducing the outdoor airflow intake based on Section C403.7.1, Demand controlled ventilation.
4. Allowable fan power shall not exceed 90 percent of the allowable fan power budget as defined by Section C403.8.1.1.
5. Each single-zone VAV system shall be designed to vary the supply fan airflow as a function of heating and cooling load and minimum fan speed shall not be more than the greater of:
   5.1. 30 percent of peak design airflow; or
   5.2. The required ventilation flow assuming no occupants.
6. Spaces that are larger than 150 square feet (14 $m^2$) and with an occupant load greater than or equal to 25 people per 1000 square feet (93 $m^2$) of floor area (as established in Table 403.3.1.1 of the *International Mechanical Code*) shall be provided with all of the following features:
   6.1. Demand control ventilation (DCV) shall be provided that utilizes a carbon dioxide sensor to reset the ventilation setpoint of the single-zone VAV system from the design minimum to design maximum ventilation rate as required by Chapter 4 of the *International Mechanical Code*.
   6.2. Occupancy sensors shall be provided that are configured to reduce the minimum ventilation rate to zero and setback room temperature setpoints by a minimum of 5°F, for both cooling and heating, when the space is unoccupied.
7. Single-zone VAV systems shall comply with one of the following options:
   7.1. Single-zone VAV air handling units with a hydronic heating coil connected to systems with hot water generation equipment limited to the following types of equipment: gas-fired hydronic boilers with a thermal efficiency, $E_t$, of not less than 92 percent, air-to-water heat pumps or heat recovery chillers. Hydronic heating coils shall be sized for a maximum entering hot water temperature of 120°F for peak anticipated heating load conditions.
   7.2. Single-zone VAV air handing units with a chilled water coil connected to systems with chilled water generation equipment with IPLV values more than 25 percent higher than the minimum part load efficiencies listed in Table C403.3.2(3), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify. The smallest chiller or compressor in the central plant shall not exceed 20 percent of the total central plant cooling capacity or the chilled water system shall include thermal storage sized for a minimum of 20 percent of the total central cooling plant capacity.
   7.3. Single-zone VAV air handling units with DX cooling, heat pump heating or gas-fired furnace shall comply with the following requirements as applicable:
      7.3.1. Have a DX cooling coil with cooling part load efficiency that are a minimum of 15 percent higher than the minimum SEER or IEER listed in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(14).
      7.3.2. Have a gas-fired furnace with a thermal efficiency, Et, of not less than 90 percent or heat pump with a minimum heating HSPF or COP efficiency that are a minimum of 10 percent higher than the minimum heating efficiency in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(14).
      7.3.3. Heating coils or burner output shall be modulating or have a minimum of 2 stages with the first stage being less than 50 percent of total heating capacity. Cooling coils shall be modulating or have a minimum of 2 stages with the first stage being less than 50 percent of the total cooling capacity.
8. The DDC system shall include a fault detection and diagnostics (FDD) system complying with the following:
   8.1. The following temperature sensors shall be permanently installed to monitor system operation:
      8.1.1. Outside air.
      8.1.2. Supply air.
      8.1.3. Return air.
   8.2. 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).
   8.3. The single-zone VAV air handling unit controller shall be configured to provide system status by indicating the following:
      8.3.1. Free cooling available.
      8.3.2. Economizer enabled.

8.3.3. Compressor enabled.

8.3.4. Heating enabled.

8.3.5. Mixed air low limit cycle active.

8.3.6. The current value of each sensor.

8.4. The single-zone VAV air handling unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.

8.5. The single-zone VAV air handling unit shall be configured to report faults to a fault management application able to be accessed by day-to-day operating or service personnel or annunciated locally on zone thermostats.

8.6. The FDD system shall be configured to detect the following faults:

8.6.1. Air temperature sensor failure/fault.

8.6.2. Not economizing when the unit should be economizing.

8.6.3. Economizing when the unit should not be economizing.

8.6.4. Outdoor air or return air damper not modulating.

8.6.5. Excess outdoor air.

**C403.13 Clean water pumps.** *Clean water pumps* meeting all the following criteria shall achieve a PEI rating not greater than 1.0:

1. Shaft input power is greater than or equal to 1.0 hp (0.75 kW) and less than or equal to 200 hp (149.1 kW) at its best efficiency point (BEP).
2. Designated as either an end-suction close-coupled, end-suction frame-mounted, in-line, radially split vertical or submersible turbine pump.
3. A flow rate of 25 gallons per minute (1.58 L/s) or greater at its BEP at full impeller diameter.
4. Maximum head of 459 feet (139.9 m) at its BEP at full impeller diameter and the number of stages required for testing.
5. Design temperature range from 14°F (-10°C) to 248°F (120°C).
6. Designed to operate with one of the following. Note that for either Item 6.1 or 6.2, the driver and impeller must rotate at the same speed.
   6.1. A 2- or 4-pole induction motor.
   6.2. A noninduction motor with a speed of rotation operating range that includes speeds of rotation between 2,880 and 4,320 rpm and/or 1,440 and 2,160 rpm.
7. For submersible turbine pumps, a 6-inch (152 mm) or smaller bowl diameter.
8. For end-suction close-coupled pumps and end-suction frame-mounted/own bearings pumps, specific speeds less than or equal to 5,000 rpm when calculated using US customary units.

**Exceptions:** The following pumps are exempt from these requirements:

1. Fire pumps.
2. Self-priming pumps.
3. Prime-assisted pumps.
4. Magnet-driven pumps.
5. Pumps designed to be used in a nuclear facility subject to 10 CFR 50.
6. Pumps meeting the design and construction requirements set forth in US Military Specification MIL-P-17639F (1996), "Pumps, Centrifugal, Miscellaneous Service Naval Shipboard Use" (as amended); MIL-P-17840C (1986), "Pump, Centrifugal, Close Coupled, Navy Standard for Use on Naval Ships" (as amended); MIL-P-17881D (1972), "Pump, Centrifugal, Boiler Feed, (Multi Stage)" (as amended); MIL-P-18472G (1989), "Pumps, Centrifugal, Condensate, Feed Booster, Waste Heat Boiler, and Distilling Plant" (as amended); MIL-P-18682D (1984), "Pump, Centrifugal, Main Condenser Circulating, Naval Shipboard" (as amended).

~~C403.14~~**C403.15 Commissioning.** Mechanical systems shall be commissioned in accordance with Section C408.

**Commented [BK(64]:** The IECC adds service water pressure-booster system here. The language is exactly the same as that found in WSEC C404.13.

**Commented [DJ65R64]:** Service water pressure boosters belong in C404 with the service water, not here in C403

## SECTION C404
## SERVICE WATER HEATING AND PRESSURE-BOOSTER SYSTEMS

**C404.1 General.** This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

**Exception**: Energy using equipment used by a manufacturing, industrial or commercial process other than maintaining comfort and amenities for the occupants are exempt from all Section C404 subsections except Sections C402.2 and C404.13.

**C404.2 Service water-heating equipment performance efficiency.** Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through certification and *listed* under an *approved* certification program, or if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Water-heating equipment intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

**C404.2.1 Service water heating system type.** Service hot water shall be provided by an electric air-source heat pump water heating (HPWH) system meeting the requirements of this section. Supplemental service water heating equipment is permitted to use electric resistance or fossil fuel in compliance with Section C404.2.1.4.

**Exceptions**:

1. 24 kW plus 0.1 watts per square foot of building area of electric resistance service water heating capacity is allowed per building.
2. Solar thermal, wastewater heat recovery, other *approved* waste heat recovery, ground source heat pumps, water-source heat pump systems utilizing waste heat, and combinations thereof, are permitted to offset all or any portion of the required HPWH capacity where such systems comply with this code and the *Uniform Plumbing Code*.
3. Systems that comply with the Northwest Energy Efficiency Alliance (NEEA) Commercial Electric Advanced Water Heating Specification.
4. Service hot water systems served by a district energy system that serves multiple buildings and that was in service before the effective date of this code.
5. Commercial dishwashers, commercial food service equipment, and other *approved* process equipment are permitted to utilize electric booster heaters for supply water temperatures 120°F (49°C) or higher.
6. Systems connected to a *low-carbon district energy exchange system* or a *low-carbon district heating and cooling or heating only system*.
7. Essential facilities. Groups I-2 and I-3 occupancies that by regulation are required to have in place redundant emergency backup systems.

**TABLE C404.2**
**MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT**

| Equipment Type | Size Category (input) | Subcategory or Rating Condition | Draw Pattern | Performance Required[a,j] | Test Procedure[b] |
|---|---|---|---|---|---|
| Electric table-top water ~~heaters~~[k]heaters[c] | ≤ 12 kW[c] | ≥ 20 gal<br>≤ 120 gal[d] | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.6323 - (0.0058 × Vr)<br>UEF ≥ 0.9188 - (0.0031 × Vr)<br>UEF ≥ 0.9577 - (0.0023 × Vr)<br>UEF ≥ 0.9884 - (0.0016 × Vr) | DOE 10 C.F.R. Part 430 App. E |
| Electric storage water heaters[g,e,f] resistance and heat pump | ≤ 12 kW[c] | ≥ 20 gal<br>≤ 55 gal[i] | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.8808 - (0.0008 × Vr)<br>UEF ≥ 0.9254 - (0.0003 × Vr)<br>UEF ≥ 0.9307 - (0.0002 × Vr)<br>UEF ≥ 0.9349 - (0.0001 × Vr) | DOE 10 C.F.R. Part 430 App. E |
| | ≤ 12 kW | > 55 gal<br>≤ 120 gal[i] | Very small<br>Low<br>Medium<br>High | UEF ≥ 1.9236 - (0.0011 × Vr)<br>UEF ≥ 2.0440 - (0.0011 × Vr)<br>UEF ≥ 2.1171 - (0.0011 × Vr)<br>UEF ≥ 2.2418 - (0.0011 × Vr) | DOE 10 C.F.R. Part 430 App. E |
| Electric storage water ~~heaters~~[g]heaters[e,f,m] | > 12 kW | -- | -- | (0.3 + 27/Vm), %/h | DOE 10 C.F.R. 431.106 App B. |

| Equipment Type | Size Category (input) | Subcategory or Rating Condition | Draw Pattern | Performance Required[a,j] | Test Procedure[b] |
|---|---|---|---|---|---|
| Grid-enabled water heaters[g,j] | -- | > 75 gal[d] | Very small<br>Low<br>Medium<br>High | UEF ≥ 1.0136 - (0.0028 × Vr)<br>UEF ≥ 0.9984 - (0.0014 × Vr)<br>UEF ≥ 0.9853 - (0.0010 × Vr)<br>UEF ≥ 0.9720 - (0.0007 × Vr) | DOE 10 C.F.R. 430 Appendix E |
| Electric instantaneous water heater[h] | ≤ 12 kW | < 2 gal[d] | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.91<br>UEF ≥ 0.91<br>UEF ≥ 0.91<br>UEF ≥ 0.92 | DOE 10 C.F.R. Part 430 |
| | > 12 kW & ≤ 58.6 kW[e] kW[i] | ≤ 2 gal & ≤ 180°F | All | UEF ≥ 0.80 | DOE 10 C.F.R. Part 430 |
| Gas storage water heaters[g] heaters[e,m] | ≤ 75,000 Btu/h | ≥ 20 gal & ≤ 55 gal[f] gal[d] | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.3456 - (0.0020 × Vr)<br>UEF ≥ 0.5982 - (0.0019 × Vr)<br>UEF ≥ 0.6483 - (0.0017 × Vr)<br>UEF ≥ 0.6920 - (0.0013 × Vr) | DOE 10 C.F.R. Part 430 App. E |
| | ≤ 75,000 Btu/h | > 55 gal & ≤ 100 gal[f] gal[d] | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.6470 - (0.0006 × Vr)<br>UEF ≥ 0.7689 - (0.0005 × Vr)<br>UEF ≥ 0.7897 - (0.0004 × Vr)<br>UEF ≥ 0.8072 - (0.0003 × Vr) | DOE 10 C.F.R. Part 430 App. E |
| | > 75,000 Btu/h and ≤ 105,000 Btu/h[g] h[j,k] | ≤ 120 gal & ≤ 180°F | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.2674-(0.0009 x Vr)<br>UEF ≥ 0.5362-(0.0012 x Vr)<br>UEF ≥ 0.6002-(0.0011 x Vr)<br>UEF ≥ 0.6597-(0.0009 x Vr) | DOE 10 C.F.R. Part 430 App. E |
| | > 105,000 Btu/h[d,g] | -- | -- | 80% $E_t$<br>SL ≤ (Q/800 +110√V), Btu/h | DOE 10 C.F.R. 431.106 |
| Gas instantaneous water heater[h] heater[i] | > 50,000 Btu/h and < 200,000 Btu/h[k] | < 2 gal[d] | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.80<br>UEF ≥ 0.81<br>UEF ≥ 0.81<br>UEF ≥ 0.81 | DOE 10 C.F.R. Part 430 App. E |
| | ≥ 200,000 Btu/h[d,g] | < 10 gal | -- | 80% $E_t$ | DOE 10 C.F.R. 431.106 |
| | ≥ 200,000 Btu/h[g] h[k] | ≥ 10 gal | -- | 80% $E_t$<br>SL ≤ (Q/800 +110√V), Btu/h | |
| Oil storage water heaters[g] heaters[e,m] | ≤ 105,000 Btu/h | ≤ 50 gal | Very small<br>Low<br>Medium<br>High | UEF = 0.2509 – (0.0012 × Vr)<br>UEF = 0.5330 – (0.0016 × Vr)<br>UEF = 0.6078 – (0.0016 × Vr)<br>UEF = 0.6815 – (0.0014 × Vr) | DOE 10 C.F.R. Part 430 |
| | > 105,000 Btu/h and ≤ 140,000 Btu/h[g] h[j] | ≤ 120 gal & ≤ 180°F | Very small<br>Low<br>Medium<br>High | UEF ≥ 0.2932-(0.0015 x Vr)<br>UEF ≥ 0.5596-(0.0018 x Vr)<br>UEF ≥ 0.6194-(0.0016 x Vr)<br>UEF ≥ 0.6740-(0.0013 x Vr) | DOE 10 C.F.R. Part 430 App. E |
| | > 140,000 Btu/h | All | -- | 80% $E_t$<br>SL ≤ (Q/800 +110√V), Btu/h | DOE 10 C.F.R. 431.106 |
| Oil instantaneous water heater[h] heater[h,m] | ≤ 210,000 Btu/h | < 2 gal | -- | 80% $E_t$<br>EF ≥ 0.59 – (0.0005 x V) | DOE 10 C.F.R. Part 430 App. E |
| | > 210,000 Btu/h | < 10 gal | -- | 80% $E_t$ | DOE 10 C.F.R. 431.106 |
| | > 210,000 Btu/h | ≥ 10 gal | -- | 78% $E_t$<br>SL ≤ (Q/800 +110√V), Btu/h | DOE 10 C.F.R. 431.106 |
| Hot water supply boilers, gas and oil[h] | ≥ 300,000 Btu/h and < 12,500,000 Btu/h | < 10 gal | -- | 80% $E_t$ | DOE 10 C.F.R. 431.106 |
| Hot water supply boilers, gas[h] gas[i,m] | ≥ 300,000 Btu/h and < 12,500,000 Btu/h | ≥ 10 gal | -- | 80% $E_t$<br>SL ≤ (Q/800 +110√V), Btu/h | DOE 10 C.F.R. 431.106 |
| Hot water supply boilers, oil[h,m] | ≥ 300,000 Btu/h and < 12,500,000 | ≥ 10 gal | -- | 78% $E_t$<br>SL ≤ (Q/800 +110√V), Btu/h | DOE 10 C.F.R. 431.106 |

| Equipment Type | Size Category (input) | Subcategory or Rating Condition | Draw Pattern | Performance Required[a,d] | Test Procedure[b] |
|---|---|---|---|---|---|
| | Btu/h | | | | |
| Pool heaters, gas[d] | All | --[f] | -- | 82% $E_t$ | DOE 10 C.F.R. Part 430 App. P |
| Heat pump pool heaters | All | 50°F db & 44.2°F wb outdoor air 80.0°F entering water | -- | 4.0 COP | DOE 10 C.F.R. Part 430 App. P |
| Unfired storage tanks | All | -- | -- | Minimum insulation requirement R-12.5 (h-ft$^2$-°F)/Btu | (none) |

a. Thermal efficiency ($E_t$) is a minimum requirement, while standby loss is a maximum requirement. In the standby loss equation, V is the rated volume in gallons and Q is the nameplate input rate in Btu/h. $V_m$ is the measured volume in the tank in gallons. Standby loss for electric water heaters is in terms of %/h and denoted by the term "S," and standby loss for gas and oil water heaters is in terms of Btu/h and denoted by the term "SL" Draw pattern (DP) refers to the water draw profile in the Uniform Energy Factor (UEF) test. UEF and Energy Factor (EF) are minimum requirements. In the UEF standard equations, $V_r$ refers to the rated volume in gallons.

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

~~b.~~c. A tabletop water heater is a storage water heater that is enclosed in a rectangular cabinet with a flat top surface not more than 3 feet in height and has a ratio of input capacity (Btu/h) to tank volume (gal) < 4,000.

d. Water heaters or gas pool heaters in this category are regulated as consumer products by the USDOE as defined in 10 C.F.R. Part 430.

e. Storage water heaters have a ratio of input capacity (Btu/h) to tank volume (gal) < 4000.

f. Efficiency requirements for electric storage hot water heaters ≤ 12kW apply to both electric-resistance and heat pump water heaters. There are no minimum efficiency requirements for electric heat pump water heaters greater than 12 kW or for gas heat pump water heaters.

g. A grid-enabled water heater is an electric-resistance water heater that meets all of the following:
1. Has a rated storage tank volume of more than 75 gallons.
2. Is manufactured on or after April 16, 2015.
3. Is equipped at the point of manufacture with an activation lock.
4. Bears a permanent label applied by the manufacturer that complies with all of the following:
4.1. Is made of material not adversely affected by water.
4.2. Is attached by means of nonwater soluble adhesive.
4.3. Advises purchasers and end users of the intended and appropriate use of the product with the following notice printed in 16.5 point Arial Narrow Bold font: "IMPORTANT INFORMATION: This water heater is intended only for use as a part of an electric thermal storage or demand response program. It will not provide adequate hot water unless enrolled in such a program and activated by your utility company or another program operator. Confirm the availability of a program in your local area before purchasing or installing this product."

h. Instantaneous water heaters and hot water supply boilers have an input capacity (Btu/h) divided by storage volume (gal) ≥ 4000 Btu/h-gal.

~~c.~~i. i. Electric instantaneous water heaters with input capacity > 12 kW and ≤ 58.6 kW that have either
(1) a storage volume > 2 gal; or
(2) is designed to provide outlet hot water at temperatures greater than 180°F; or
(3) uses three-phase power has no efficiency standard.

~~d.~~j. Gas storage water heaters with input capacity > 75,000 Btu/h and ≤ 105,000 Btu/h must comply with the requirements for the > 105,000 Btu/h if the water heater either (1) has a storage volume > 120 gal; (2) is designed to provide outlet hot water at temperatures greater than 180°F; or (3) uses three-phase power.

~~e.~~k. Oil storage water heaters with input capacity > 105,000 Btu/h and ≤ 140,000 Btu/h must comply with the requirements for the > 140,000 Btu/h if the water heater either (1) has a storage volume > 120 gal; (2) is designed to provide outlet hot water at temperatures greater than 180°F; or (3) uses three-phase power.

~~f.~~a. ~~Water heaters or gas pool heaters in this category are regulated as consumer products by the USDOE as defined in 10 C.F.R. Part 430.~~

~~g.~~a. ~~Storage water heaters have a ratio of input capacity (Btu/h) to tank volume (gal) < 4000.~~

~~h.~~a. ~~Instantaneous water heaters and hot water supply boilers have an input capacity (Btu/h) divided by storage volume (gal) ≥ 4000 Btu/h-gal.~~

~~i.~~l. ~~There are no minimum efficiency requirements for electric heat pump water heaters greater than 12 kW or for gas heat pump water heaters~~.

**C404.2.1.1 Primary heat pump system sizing.** The primary heat pump service water heating system shall be sized to deliver no less than 50 percent of the calculated demand for service hot water production during the peak demand period. Demand shall be calculated using the equipment manufacturer's selection criteria or another *approved* methodology with entering dry bulb or wet bulb outdoor air temperature at 40°F (4°C) for air-source heat pumps, or 44°F (7°C) ground temperature for ground-source heat pumps. Electric air source heat pumps shall also be sized to deliver no less than 25 percent of the calculated demand for

service hot water production during the peak demand period when entering dry bulb or wet bulb outdoor air temperature is 24°F (-4°C). The remaining primary service output may be met by fossil fuel, electric resistance, or heat pump water heating systems.

**Exception:** Twenty-five percent sizing at entering dry bulb or wet bulb air temperature of 24°F (-4°C) is not required for air-source heat pumps located in a below-grade enclosed parking structure or other ventilated and unconditioned space that is not anticipated to fall below 40°F (4°C) at any time.

**C404.2.1.2 Primary hot water storage sizing.** The system shall provide sufficient hot water to satisfy peak demand period requirements.

**C404.2.1.3 System design.** The service water heating system shall be configured to conform to one of the following provisions:

1. For *single-pass heat pump water heaters*, *temperature maintenance* heating provided for reheating return water from the building's heated water circulation system shall be physically decoupled from the primary service water heating system storage tank(s) in a manner that prevents destratification of the primary system storage tanks. *Temperature maintenance* heating is permitted to be provided by electric resistance, fossil fuel, or a separate dedicated heat pump system.
2. For *multi-pass heat pump water heaters*, *recirculated temperature* maintenance water is permitted to be returned to the primary water storage tanks for reheating.
3. For unitary heat pump water heaters, located in conditioned space, are permitted, where they are sized to meet all calculated service water heating demand using the heat pump compressor, and not supplementary heat.

**C404.2.1.3.1 Mixing valve.** A thermostatic mixing valve capable of supplying hot water to the building at the user temperature setpoint shall be provided, in compliance with requirements of the *Uniform Plumbing Code* and the HPWH manufacturer's installation guidelines. The mixing valve shall be sized and rated to deliver tempered water in a range from the minimum flow of the *temperature maintenance* recirculation system up to the maximum demand for the fixtures served.

**C404.2.1.4 Supplemental water heating.** Total supplemental water heating equipment shall not have an output capacity greater than the total summed capacity of all primary water heating equipment. For the purposes of determining this supplemental water heating allowance, the capacity of primary water heating equipment shall be evaluated at 40°F (4°C) entering dry bulb or wet bulb outdoor air temperature for air-source heat pumps, 44°F (7°C) ground temperature for ground-source heat pumps, and at the nameplate input rate for all other water heater system types. Supplemental heating is permitted for the following uses:

1. *Temperature maintenance* of heated-water circulation systems, physically separate from the primary service water heating system.
2. Defrost of compressor coils.
3. Heat tracing of piping for freeze protection or for *temperature maintenance* in lieu of recirculation of hot water.
4. Backup or low ambient temperature conditions, where all of the following are true:
   4.1. During normal operations, the supplemental heating is controlled to operate only when the entering air temperature at the air-source HPWH is below 40°F (4°C), and the primary HPWH compressor continues to operate together with the supplemental heating.
   4.2. The primary water heating equipment cannot satisfy the system load due to equipment failure or entering air temperature below 40°F (4°C).

**C404.2.1.5 System fault detection.** The control system shall be capable of and configured to send automatic error alarms to building or maintenance personnel upon detection of equipment faults, low leaving water temperature from primary storage tanks, or low hot water supply delivery temperature to building distribution system.

**C404.3 ~~Efficient~~ Heated water supply piping.** Heated water supply piping shall be in accordance with Section C404.3.1 or C404.3.2. The flow rate through 1/4-inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through 5/16-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through 3/8-inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m). Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered sources of heated water.

**C404.3.1 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 C404.3.1.

1. For a public lavatory faucet, use the "Public lavatory faucets" column in Table C404.3.1.
2. For all other plumbing fixtures and plumbing appliances, use the "Other fixtures and appliances" column in Table C404.3.1.

**TABLE C404.3.1**
**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 | 8 | 43 |
| 5/8 | 2 | 8 | 32 |
| 3/4 | 3 | 0.5 | 21 |
| 7/8 | 4 | 0.5 | 16 |
| 1 | 5 | 0.5 | 13 |
| 11/4 | 8 | 0.5 | 8 |
| 11/2 | 11 | 0.5 | 6 |
| 2 or larger | 18 | 0.5 | 4 |

**C404.3.2 Maximum allowable pipe volume method.** The water volume in the piping shall be calculated in accordance with Section C404.3.2.1. 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).
2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

**C404.3.2.1 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 C404.3.1 or from Table C404.3.2.1. 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.

**C404.4 Heat traps for hot water storage tanks.** Storage tank-type water heaters and hot water storage tanks that have vertical water pipes connecting to the inlet and outlet of the tank shall be provided with integral heat traps at the vertical inlets and outlets or shall have pipe-configured heat traps in the piping connected to those inlets and outlets. Tank inlets and outlets associated with solar water heating system circulation loops shall not be required to have heat traps.

**TABLE C404.3.2.1**
**INTERNAL VOLUME OF VARIOUS WATER DISTRIBUTION TUBING**

| Ounces of Water per Foot of Tube | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal Size (inches) | Copper Type M | Copper Type L | Copper Type K | CPVC CTS SDR 11 | CPVC SCH 40 | CPVC SCH 80 | PE-RT SDR | Composite ASTM F1281 | PEX CTS SDR 9 |
| 3/8 | 1.06 | 0.97 | 0.84 | N/A | 1.17 | — | 0.64 | 0.63 | 0.64 |
| 1/2 | 1.69 | 1.55 | 1.45 | 1.25 | 1.89 | 1.46 | 1.18 | 1.31 | 1.18 |
| 3/4 | 3.43 | 3.22 | 2.90 | 2.67 | 3.38 | 2.74 | 2.35 | 3.39 | 2.35 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.81 | 5.49 | 5.17 | 4.43 | 5.53 | 4.57 | 3.91 | 5.56 | 3.91 |
| 11/4 | 8.70 | 8.36 | 8.09 | 6.61 | 9.66 | 8.24 | 5.81 | 8.49 | 5.81 |
| 11/2 | 12.18 | 11.83 | 11.45 | 9.22 | 13.20 | 11.38 | 8.09 | 13.88 | 8.09 |
| 2 | 21.08 | 20.58 | 20.04 | 15.79 | 21.88 | 19.11 | 13.86 | 21.48 | 13.86 |

**C404.5 Water heater installation.** Electric water heaters in unconditioned spaces or on concrete floors shall be placed on an incompressible, insulated surface with a minimum thermal resistance of R-10.

**C404.6 ~~Insulation of piping~~Service water heating system piping insulation.** ~~Piping from a water heater to the termination of the heated water fixture supply pipe shall be insulated in accordance with Table C403.10.3. On both the inlet and outlet piping of a storage hot 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 C403.10.3 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, including through hangers and supports, such that thermal bridging is prevented, except where the piping passes through a framing member. The minimum insulation thickness requirements of this section shall not supersede any greater insulation thickness requirements necessary for the protection of piping from freezing temperatures or the protection of personnel against external surface temperatures on the insulation.~~ *Service water heating* system piping shall be surrounded by uncompressed insulation. The wall thickness of the insulation shall be not less than the thickness shown in Table C404.6.1. Where the insulation thermal conductivity is not within the range in the table, **Equation 4-Y** shall be used to calculate the minimum insulation thickness:

$$t_{alt} = r \times \left[\left(1 + {t_{table}}/{r}\right)^{{k_{alt}}/{k_{upper}}} - 1\right] \qquad \textbf{Equation 4-Y}$$

where:

$t_{alt}$ = Minimum insulation thickness of the alternate material (in) (mm).

$r$ = Actual outside radius of the pipe (in) (mm).

$t_{table}$ = Insulation thickness listed in this table for applicable fluid temperature and pipe size.

$k_{alt}$ = Thermal conductivity of the alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu × in/h × ft2 × °F] [W(m × °C)].

$k_{upper}$ = The upper value of the thermal conductivity range listed in this table for the applicable fluid temperature [Btu × in/h × ft2 × °F] [W(m × °C)].

For nonmetallic piping thicker than Schedule 80 and having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot (meter) than a steel pipe of the same size with the insulation thickness shown in the table.

**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~~Factory-installed piping within *water heaters* and hot water storage tanks.
2. Valves, pumps, strainers and threaded unions in piping that is 1 inch (25 mm) or less in nominal diameter.
2.3. Piping that conveys hot water that has not been heated through the use of fossil fuels or electricity.
3.4. Piping from user-controlled shower and bath mixing valves to the water outlets.
4.5. Cold-water piping of a demand recirculation water system.
5.6. ~~Tubing from a hot drinking-water heating unit to the water outlet~~Piping in existing buildings where *alterations* are made to existing *service water heating* systems where there is insufficient space or access to meet the requirements.
6.7. Piping at locations where a vertical support of the piping is installed.
7.8. ~~Piping surrounded by building insulation with a thermal resistance (*R*-value) of not less than R-3~~Where piping passes through a framing member if it requires increasing the size of the framing member.

~~8.~~9. Hot water piping that is part of the final pipe run to the plumbing fixture and is not part of the heated-water circulation system circulation path is not required to meet the minimum insulation requirements of Section C404.6.

**C404.6.1 Installation requirements.** The following piping shall be insulated per the requirements of this section:

1. Recirculating system piping, including the supply and return piping.
2. The first 8 feet (2.4 m) of outlet piping from:
   - 2.1. Storage *water heaters*.
   - 2.2. Hot water storage tanks.
   - 2.3. Any *water heater* and hot water supply boiler containing not less than 10 gallons (37.9 L) of water heated by a direct heat source, an indirect heat source, or both a direct heat source and an indirect heat source.
3. The first 8 feet (2.4 m) of branch piping connecting to recirculated, heat traced or impedance-heated piping.
4. The makeup water inlet piping between *heat traps* and the storage *water heaters* and the storage tanks they are serving, in a nonrecirculating *service water heating* storage system.
5. Hot water piping between multiple *water heaters*, between multiple hot water storage tanks, and between *water heaters* and hot water storage tanks.
6. Piping that is externally heated (such as heat trace or impedance heating).
7. For direct-buried *service water heating* system piping, reduction of these thicknesses by 11/2 inches (38.1 mm) shall be permitted (before thickness adjustment required in Section C404.6) but not to thicknesses less than 1 inch (25.4 mm).

**TABLE C404.6.1**
**MINIMUM PIPING INSULATION THICKNESS FOR SERVICE WATER HEATING SYSTEMSa**

| Service Hot-Water Temperature Range | Insulation Thermal Conductivity | | Nominal Pipe or Tube Size (inches) | | | | |
|---|---|---|---|---|---|---|---|
| | Conductivity (Btu × in/h × ft² × °F) | Mean Rating Temperature (°F) | <1 | 1 to < 1-1/2 | 1-1/2 to < 4 | 4 to < 8 | ≥ 8 |
| | | | Insulation Thickness (inches) | | | | |
| 105°F to 140°F | 0.22 to 0.28 | 100 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| > 140°F to 200°F | 0.25 to 0.29 | 125 | 1.0 | 1.0 | 2.0 | 2.0 | 2.0 |
| > 200°F | 0.27 to 0.30 | 150 | 1.5 | 1.5 | 2.5 | 3.0 | 3.0 |

For SI: 1 inch = 25.4 mm, 1 Btu/h × ft × °F = 1.73 W/mK, °C = [(°F) – 32]/1.8.

a. These thicknesses are based on energy efficiency considerations only. Additional insulation may be necessary for safety.

~~C404.6.1~~**C404.6.2 Storage tank insulation.** Unfired storage tanks used to store service hot water at temperatures above 130°F (54°C) shall be wrapped with an insulating product, installed in accordance with the insulation manufacturer's instructions and providing a minimum of R-2 additional insulation for every 10°F (5°C) increase in stored water temperature above 130°F (54°C). Such additional insulation is also permitted to be integral to the tank. The insulation is permitted to be discontinuous at structural supports.

**C404.7 Heated-water circulating and heat trace temperature maintenance systems.** Heated-water circulation systems for *temperature maintenance* shall be in accordance with Section C404.7.1. Electric resistance heat trace systems for *temperature maintenance* shall be in accordance with Section C404.7.2. Controls for hot water storage shall be in accordance with Section C404.7.3. *Automatic* controls, temperature sensors and pumps shall be in a location with *access*. Manual controls shall be *in* a location with *ready access*.

**C404.7.1 Circulation systems.** Heated-water circulation systems shall be provided with a circulation pump. Gravity and thermo-syphon circulation systems are prohibited. The system return pipe shall be a dedicated return pipe. The pump shall have an electronically commutated motor with a means of adjusting motor speed for system balancing. ~~The system return pipe shall be a dedicated return pipe. Gravity and thermo-syphon~~

**Commented [DJ66]:** We require the whole system to be insulated, not just the first 8 feet. This seems totally wrong.

**Commented [BK(67]:** The highlighted thickness values are less stringent than those currently required in Table C403.10.3

**Commented [DJ68R67]:** I think this is correct, due to an exception in one of the footnotes in the C403 table.

**Commented [DJ69]:** Why strike language in one part of the paragraph and reinsert it in another?

**Commented [KB70R69]:** Just reorganizing it to match the IECC language

~~circulation systems are prohibited.~~ Controls shall start the circulation pump based on the identification of a demand for hot water within the occupancy.

**C404.7.1.1 Single riser systems.** Where the circulation system serves only a single domestic hot water riser or zone, the following controls shall be provided:

1. Controls shall be configured to automatically turn off the pump when the water in the circulation loop is at the design supply temperature and shall not turn the pump back on until the temperature is a minimum of 10°F (5°C) lower than the design supply temperature.
2. Controls shall be equipped with a manual switch or other control method that can be used to turn off the circulating pump during extended periods when hot water is not required.

**C404.7.1.2 Multiple riser systems.** Where the circulation system serves multiple domestic hot water risers or piping zones, the following controls shall be provided:

1. Controls shall be configured to automatically turn off the circulation pump during extended periods when hot water is not required.
2. System shall include means for balancing the flow rate through each individual hot water supply riser or piping zone.
3. For circulation systems that use a variable flow circulation pump, each riser and piping zone shall have a self-actuating thermostatic balancing valve.

**C404.7.1.3 Electronic thermostatic mixing valve (TMV).** Where a heated water circulation system utilizes an electronic TMV to control the temperature of hot water supplied to the building, the TMV shall be configured so that it either reverts closed (fully COLD) or maintains its current valve position upon power failure or cessation of circulation flow.

**C404.7.2 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.

**C404.7.3 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.

**C404.7.3.1 Pipe insulation**. For heated water circulation systems, both supply and return pipe insulation shall be at minimum 1.0 inch thicker than that required by Table ~~C403.10.3~~C404.6.1.

**Exception:** Where piping is centered within a wall, ceiling or floor framing cavity with a depth at least 4 inches greater than the diameter of the pipe and that is completely filled with batt or blown-in insulation, additional pipe insulation is not required.

**C404.8 Demand recirculation controls.** *Demand recirculation water systems* shall have controls that comply with both of the following:

1. The controls 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 controls shall limit the temperature of the water entering the cold water-piping to not greater than 104°F (40°C)

**C404.9 Domestic hot water meters.** Each individual dwelling unit in a Group R-2 occupancy with central service domestic hot water systems shall be provided with a domestic hot water meter to allow for domestic hot water billing based on actual domestic hot water usage.

**Exception:** Dwelling units in other than Group R-2 multi-family and live/work units are not required to provide domestic hot water metering at each dwelling unit where domestic hot water is metered separately for each of the following building end uses:

1. Dwelling units.
2. Sleeping units.
3. Commercial kitchens.
4. Central laundries.

**C404.10 Drain water heat recovery units.** Drain water heat recovery units shall comply with CSA B55.2.

**Commented [BK(71]:** The IECC has more control requirements in this section that are addressed in the two subsections in the WSEC: Controls shall be configured to automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water. Where a circulation pump serves multiple risers or piping zones, controls shall include self-actuating thermostatic balancing valves or another means of flow control to automatically balance the flow rate through each riser or piping zone.

**Commented [DJ72R71]:** Probably better to follow the IECC formatting as long as the content is the same. Part of our charge is to reduce the number of amendments.

**Commented [BK(73]:** This citation would depend on the decision to add the new IECC table or stick to referencing the mechanical table.

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.

**C404.11 Energy consumption of pools and permanent spas.** The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections C404.11.1 through C404.11.4.

**C404.11.1 Heaters.** Pool water heaters using electric resistance heating as the primary source of heat are prohibited for pools over 2,000 gallons. Heat pump pool heaters shall have a minimum COP of 4.0 at 50°F (10°C) db, 44.2 °F (6.8°C) wb outdoor air and 80 °F (27°C) entering water, determined in accordance with AHRI 1160. Other pool heating equipment shall comply with the applicable efficiencies in Section C404.2.

The electric power to all heaters shall be controlled by an 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 of the heater in a location with *ready access*. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. Gas fired heaters shall not be equipped with constant burning pilot lights.

**C404.11.2 Time switches.** Time switches or other control method that can automatically turn off and on heaters and pump motors according to a preset schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built in time switches shall be in compliance with this section.

**Exceptions:**

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

**C404.11.3 Covers.** Heated pools and in-ground permanent spas shall be provided with a vapor-retardant cover on or at the water surface. Pools heated to more than 90°F shall have a pool cover with a minimum insulation value of R-12, and the sides and bottom of the pool shall also have a minimum insulation value of R-12.

**C404.11.4 Heat recovery.** Heated indoor swimming pools, spas or hot tubs with water surface area greater than 200 square feet shall provide for energy conservation by an exhaust air heat recovery system that heats ventilation air, pool water or domestic hot water. The heat recovery system shall be configured to decrease the exhaust air temperature at design heating conditions (80°F indoor) by 36°F (10°C).

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

1. Solar water heating systems not claimed in Section C406.2.5 or Section C407;
2. Dehumidification heat recovery;
3. Waste heat recovery; or
4. A combination of these system sources capable of and configured to provide at least 70 percent of the heating energy required over an operating season.

**C404.12 Portable spas.** The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

**C404.13 Service water pressure-booster systems.** Service water pressure-booster systems shall be designed and configured such that the following apply:

1. One or more pressure sensors shall be used to vary pump speed and/or start and stop pumps. The sensors shall either be located near the critical fixtures that determine the pressure required, or logic shall be employed that adjusts the setpoint to simulate operations of remote sensors.
2. No devices shall be installed for the purpose of reducing the pressure of all of the water supplied by any booster system pump or booster system, except for safety devices.
3. Booster system pumps shall not operate when there is no service water flow except to refill hydro pneumatic tanks.
4. Systems pump motors 7.5 hp and greater shall be provided with variable flow capacity in accordance with Section C403.2.3.

**C404.14 Demand responsive water heating.** Electric storage water heaters with rated water storage volume between 40 and 120 gallons and a nameplate input rating equal to or less than 12kW shall be provided with *demand responsive controls* that comply with ANSI/CTA-2045-B Level 2 or another equivalent *approved demand responsive control*.

**Exceptions**:

1. Water heaters that provide a hot water delivery temperature of 180°F (82°C) or greater.
2. Water heaters that comply with Section IV, Part HLW or Section X of the ASME Boiler and Pressure Vessel Code.
3. Water heaters that use three-phase electric power.
4. Storage water heaters with *demand responsive controls* that comply with ANSI/CTA 2045-A or ANSI/CTA 2045-B Level 1, that are also capable of initiating water heating to meet the temperature setpoint in response to a *demand response signal*.

**C404.15 Commissioning.** Service water heating systems shall be commissioned in accordance with Section C408.

## SECTION C405
## ELECTRICAL POWER AND LIGHTING SYSTEMS

**C405.1 General.** ~~Lighting system controls, the maximum lighting power for interior and exterior applications, electrical energy consumption, vertical and horizontal transportation systems, and minimum efficiencies for motors and transformers shall comply with this section.~~

~~*Sleeping units* shall comply with Section C405.2.6, item 2 and Section C405.1.1 or Section C405.4.~~ Electrical power and lighting systems and generation shall comply with this section.

*General lighting* shall consist of all lighting included when calculating the total connected interior lighting power in accordance with Section C405.4.1 and which does not require specific application controls in accordance with Section C405.2.5

Lighting installed in *walk-in coolers*, *walk-in freezers*, *refrigerated warehouse coolers* and *refrigerated warehouse freezers* shall comply with the lighting requirements of Section C410.2.

~~Transformers, uninterruptable power supplies, motors and electrical power processing equipment in *data center* systems shall comply with Section 8 of ASHRAE Standard 90.4 in addition to this code.~~

**Exceptions:**

1. *Dwelling units* and *Sleeping units* that comply with Sections C405.2.12, C405.4.3 and C405.7.
2. ~~1.~~ Energy using equipment used by a manufacturing, industrial or commercial process other than maintaining comfort and amenities for the occupants are exempt from all Section C405 subsections except Section C405.8. Data center and computer room HVAC equipment is not covered by this exemption.

~~**C405.1.1 Lighting for dwelling and sleeping units.** No less than 90 percent of the permanently installed lighting serving *dwelling units* or *sleeping units*, excluding kitchen appliance lighting, shall be provided by lamps with a minimum efficacy of 65 lumens per watt or luminaires with an efficacy of not less than 45 lumens per watt.~~

**C405.2 Lighting controls.** ~~Lighting systems shall be provided with controls that comply with one of the following:~~ Lighting systems in *interior parking areas* shall be provided with controls that comply with Section C405.2.9. All other lighting systems powered through the energy service for the *building* and building site lighting for which the *building owner* is responsible shall be provided with controls that comply with Sections C405.2.1 through C405.2.8.

~~Lighting controls as specified in Sections C405.2.1 through C405.2.10.~~

~~*Luminaire level lighting controls (LLLC)* and lighting controls as specified in Section C405.2.8.1.~~

**Exception:** Except for specific application controls required by Section C405.2.6, lighting controls are not required for the following:

1. ~~Areas designated as security or emergency areas that are required to be continuously lighted~~Spaces where an *automatic* shutoff could endanger occupant safety or security.
2. Up to 0.01 watts per square foot of means of egress illumination serving ~~the~~ exit access ~~that does not exceed 0.01 watts per square foot of building area is exempt from this requirement~~components that are provided with fire alarm systems.
3. ~~Emergency egress lighting that is normally off~~Emergency lighting that is automatically off during normal operations.

**Commented [DJ74]:** What do they mean by "generation"?

**Commented [BK(75R74]:** The 2024 IECC has our C411 requirements within C405

**Commented [BK(76]:** The 2024 IECC language for this exception is "Up to 0.02 watts per ft2 of lighting in exit access components that are provided with fire alarm systems." I attempted to combine it with our existing exception.

**Commented [DJ77R76]:** I don't think "that are provided with fire alarm systems" has anything to do with this exception. Suggest deleting.

~~3.~~ Emergency lighting required by the *International Building Code* in exit access components that are not provided with fire alarm systems.

4. Industrial or manufacturing process areas, as may be required for production and safety.

**C405.2.1 Occupant sensor controls.** Occupant sensor controls shall be installed to control luminaires in the space types listed in Table C405.2.1, and shall comply with the requirements listed in the table.

**Exceptions:**

1. Corridors in manufacturing facilities.
2. General lighting and task lighting in shop and laboratory classrooms.
3. Luminaires that are required to have specific application controls in accordance with Section C405.2.6 unless specifically required to comply with this section by Section C405.2.6.

**TABLE C405.2.1**
**OCCUPANT SENSOR COMPLIANCE REQUIREMENTS FOR SPACE TYPES**

| Space Type | Comply with Section |
|---|---|
| Classrooms/lecture/training rooms | C405.2.1.1 |
| Computer room, data center | C405.2.1.1 |
| Conference/meeting/multipurpose rooms | C405.2.1.1 |
| Copy/print rooms | C405.2.1.1 |
| Lounge/breakrooms | C405.2.1.1 |
| Medical supply room in a health care facility | C405.2.1.1 |
| Enclosed offices | C405.2.1.1 |
| Laundry/washing area | C405.2.1.1 |
| Open plan office areas | C405.2.1.3 |
| Restrooms | C405.2.1.1 |
| Storage rooms | C405.2.1.1 |
| Telemedicine rooms in a health care facility | C405.2.1.1 |
| Locker rooms | C405.2.1.1 |
| Other spaces 300 square feet (28 $m^2$) or less that are enclosed by floor-to-ceiling height partitions | C405.2.1.1 |
| Warehouse storage areas | C405.2.1.2 |
| Library stacks | C405.2.1.2 |
| Enclosed fire rated stairways | C405.2.1.5 |
| Corridors | C405.2.1.6 |
| Covered parking areas (parking garages) | C405.2.1.4 |

1. **C405.2.1.1 Occupant sensor control function.** Occupant sensor controls for the space types listed in ~~Section~~ Table C405.2.1 indicating the need for compliance with this section shall comply with all of the following:
   2. They shall be configured to automatically turn off lights within 20 minutes of all occupants leaving the space.
   3. They shall be manual on or shall be configured to automatically turn the lighting on to not more than 50 percent power.
   4. They shall incorporate a manual control to allow occupants to turn lights off.

      **Exception:** Full *automatic*-on controls shall be permitted to control lighting in public corridors, *interior parking areas,* 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.

**C405.2.1.2 Occupant sensor control function in warehouse storage areas and library stacks.** Lighting in library stacks and warehouse storage areas shall be controlled as follows:

1. Lighting in each aisleway shall be controlled independently of lighting in all other aisleways and open areas.

**Commented [DJ78]:** This is bizarre

**Commented [BK(79]:** This new language isn't from the 2024 IECC, but this section is lacking some clarity. Not all of the space types in the table are required to comply with this section.

**Commented [DJ80R79]:** "…with this section" is ambiguous. Which section?

2. Occupant sensors shall automatically reduce lighting power within each controlled area to an unoccupied setpoint of not more than 50 percent within 20 minutes after all occupants have left the controlled area.
3. Lights which are not turned off by occupant sensors shall be turned off by time schedule sweep to turn lighting off within 20 minutes of all occupants leaving the space, or comply with Section C405.2.2 to turn lighting off when the building is vacant.
4. Restore lighting to full power or target light level when occupants enter the space.
5. A *manual* control shall be provided to allow occupants to turn off lights in the space.

**C405.2.1.3 Occupant sensor control function in open plan office areas**. Occupant sensor controls in open plan office spaces less than 300 square feet (28 $m^2$) in area shall comply with Section C405.2.1.1. Occupant sensor controls in all other open plan office spaces shall be configured to comply with all of the following:

1. General lighting is controlled separately in control zones with floor areas not greater than 600 square feet (55 $m^2$) within the open plan office space.
2. *General lighting* in each control zone shall be permitted to automatically turn on upon occupancy within the control zone. *General lighting* in other unoccupied zones within the open plan office space shall be permitted to turn on to not more than 20 percent of full power or remain unaffected.
3. Automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.
4. *General lighting* in each control zone shall turn off or uniformly reduce lighting power to an unoccupied setpoint of not more than 20 percent of full power within 20 minutes after all occupants have left the control zone.
5. Lighting controls in open plan office areas larger than 5,000 square feet (464.5 $m^2$) must also comply with Section C405.2.8.

**C405.2.1.4 Occupant sensor control function in enclosed fire rated stairways.** Occupant sensor controls shall be configured to automatically reduce lighting power by not less than 50 percent when no occupants have been detected in the stairway for a period not exceeding 20 minutes and restore lighting to full power when occupants enter the stairway. All portions of stairways shall remain illuminated to meet the requirements of Sections 1008 and 1025 of the *International Building Code* when the lighting power is reduced.

**C405.2.1.5 Occupant sensor control function in corridors.** Occupant sensor controls in *corridors* shall uniformly reduce lighting power to an unoccupied setpoint of not more than 50 percent of full power within 20 minutes after all occupants have left the space.

**Exception:** *Corridors* provided with less than two foot-candles of illumination on the floor at the darkest point with all lights on.

**C405.2.2 Time switch controls.** Each area of the building that is not provided with *occupant sensor controls* complying with Section C405.2.1.1 shall be provided with time switch controls complying with Section C405.2.2.1.

**Exceptions:**

1. Luminaires which are required to have specific application controls in accordance with Section C405.2.6 unless specifically required to comply with this section by Section C405.2.6.
2. Spaces where patient care is directly provided.
3. ~~Spaces where an *automatic* shutoff would endanger occupant safety or security.~~
4. ~~Lighting intended for continuous operation.~~
5. ~~Shop and laboratory classrooms.~~

**C405.2.2.1 Time switch control function.** Time switch controls shall comply with the following:

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

**Commented [DJ81]:** Why are these three exceptions deleted? Are they handled in a table someplace?

**Commented [BK(82R81]:** The "security" part is taken care of in C405.2. For the other two, here is the rationale: "Lighting intended for continuous operation" has always been problematic. "Intended" by whom? Since it is quite rare for an authority to have such a requirement, this is usually interpreted to mean that a building owner "requires" (i.e."wants") the lighting to be operated continuously. If an authority has such a requirement, then that requirement would supercede this code (per C101.3). But even if this is an owner "requirement" at the time the space is built, requirements change over time. A store which is intended to be 24-hour operation may well change to 18-hour operation during an economic downturn, or close and be reopened by someone else who runs a 12-hour operation. "Shop and laboratory classrooms" – if there is a safety concern then the proposed Exception 1 to C405.2 would provide an exemption. It should be noted, however, that in practice many spaces of this type are currently provided with occupant sensors.

5. Include an override switching device that complies with the following:

~~5.1~~6.1 The override switch shall be a manual control.

~~5.2~~6.2 The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.

~~5.3~~6.3 Any individual override switch shall control the lighting for an area not larger than 5,000 square feet (465 $m^2$).

7. Time switch controls are allowed to automatically turn on lighting to full power in corridors, lobbies, restrooms, storage rooms less than 50 square feet, and medical areas of healthcare facilities. In all other spaces, time switch controls are allowed to automatically turn on the lighting to not more than 50 percent power.

~~6.~~8. For spaces where schedules are not available, *time switch controls* are programmed to a schedule that turns off lights not less than 12 hours per day.

**Exception:** Within mall concourses, auditoriums, sales areas, manufacturing facilities, pools, gymnasiums, skating rinks, and sports arenas:

1. The time limit shall be permitted to be greater than 2 hours provided the switch is a captive key device.
2. The area controlled by the override switch shall not be limited to 5,000 square feet (465 $m^2$) provided that such area is less than 20,000 square feet (1860 $m^2$).

**C405.2.3 Manual controls.** All lighting shall have manual controls complying with the following:

1. They shall be in a location with *ready access* to occupants.
2. They shall be located where the controlled lights are visible, or shall identify the area served by the lights and indicate their status.
3. Each control device shall control an area no larger than a single room or 2,500 square feet, whichever is less, if the room area is less than or equal to 10,000 square feet; or one-quarter of the room or 10,000 square feet, whichever is less, if the room area is greater than 10,000 square feet.

**Exceptions:**

1. A manual control may be installed in a remote location for the purpose of safety or security provided each remote control device has an indicator pilot light as part of or next to the control device and the light is clearly labeled to identify the controlled lighting.
2. Restrooms.

**C405.2.4 ~~Light-reduction controls~~Dimming controls.** ~~Where not provided with occupant sensor controls complying with Section C405.2.1.1, *general lighting* shall be provided with light-reduction controls complying with Section C405.2.4.1~~ Dimming controls complying with Section C405.2.4.1 are required for *general lighting* in the following space types:

1. Classroom/lecture hall/training room.
2. Conference/multipurpose/meeting room.
3. In a dining area for bar/lounge or liesure, family dining.
4. Laboratory.
5. Lobby.
6. Lounge/break room.
7. Offices.
8. Gymnasium/fitness center.
9. Library reading room.
10. In a healthcare facility for imaging rooms, exam rooms, nursery and nurses' station.
11. ~~1.~~ Spaces not provided with occupant sensor controls complying with Section C405.2.1.1.

**Exception~~s~~:**

~~Luminaires controlled by daylight responsive controls complying with Section C405.2.5.~~

Luminaires controlled by specific application controls complying with Section C405.2.6.

~~1. Where provided with manual control, the following areas are not required to have light reduction control:~~

~~1.1. Spaces that have only one luminaire with a rated power of less than 60 watts.~~

~~1.2. Spaces that use less than 0.45 watts per square foot (4.9 W/$m^2$).~~

**Commented [DJ83]:** We should check the proposed Seattle language for any edits that might be useful here

~~1.3. Corridors, lobbies, electrical rooms and/or mechanical rooms.~~

**C405.2.4.1 ~~Light reduction~~Dimming control function.** *Manual* controls shall be configured to provide ~~light reduction~~ dimming controls that ~~allows the occupant to reduce the connected lighting load by not less than 50 percent in a reasonably uniform illumination pattern with an intermediate step in addition to full on or off, or with continuous dimming control, by using one of the following or another *approved* method:~~allow lights to be dimmed from full output to 10 percent of full power or lower with continuous dimming, as well as turning off lights. *Manual* control shall be provided within each room to dim lights.

~~1. Continuous dimming of all luminaires from full output to less than 20 percent of full power.~~

~~2. Switching all luminaires to a reduced output of not less than 30 percent and not more than 70 percent of full power.~~

~~3. Switching alternate rows of luminaires or alternate luminaires to achieve a reduced output of not less than 30 percent and not more than 70 percent of full power.~~

**Exception:** *Manual* dimming control is not required in spaces where *high-end trim* lighting controls are provided that comply with the following:

1. The calibration adjustment equipment is located for ready *access* only by authorized personnel.
2. Lighting controls with ready *access* for users cannot increase the lighting power above the maximum level established by the *high-end trim* controls.

**C405.2.5 Daylight responsive controls.** *Daylight responsive controls* complying with Section C405.2.5.1 shall be provided to control the *general lighting* within *daylight zones* in the following spaces:

1. Spaces with a total of more than 75 watts of *general lighting* within *primary sidelit daylight zones* complying with Section C405.2.5.2.
2. Spaces with a total of more than 150 watts of *general lighting* within combined *primary* and *secondary daylight zones* complying with Section C405.2.5.2.
3. Spaces with a total of more than 75 watts of *general lighting* within *toplit daylight zones* complying with Section C405.2.5.3.

**Exception:** Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. *Sidelit daylight* zones on the first floor above grade in Group A-2 or M occupancies where the fenestration adjoins a sidewalk or other outdoor pedestrian area, provided that the light fixtures are controlled separately from the general area lighting.

**C405.2.5.1 Daylight responsive controls 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 *primary sidelit daylight* zones shall be controlled independently of lights in *secondary sidelit daylight* zones in accordance with Section C405.2.5.2.
2. Lights in *toplit daylight* zones in accordance with Section C405.2.5.3 shall be controlled independently of lights in *sidelit daylight* zones in accordance with Section C405.2.5.2.
3. *Daylight responsive controls* within each space shall be configured so that they can be calibrated from within that space by authorized personnel.
4. Calibration mechanisms shall be in a location with *ready access*.
5. *Daylight responsive controls* shall dim lights continuously from full light output to 15 percent of full light output or lower
6. *Daylight responsive controls* shall be configured to completely shut off all controlled lights in that zone.
7. When occupant sensor controls have reduced the lighting power to an unoccupied setpoint in accordance with Sections C405.2.1.2 through C405.2.1.4, *daylight responsive controls* shall continue to adjust electric light levels in response to available daylight but shall be configured to not increase the lighting power above the specified unoccupied setpoint.
8. Lights in *sidelit daylight zones* in accordance with Section C405.2.5.2 facing different cardinal orientations (i.e., within 45 degrees of due north, east, south, west) shall be controlled independently of each other.

   **Exception:** Up to 75 watts of *general lighting* are permitted to be controlled together with lighting in a daylight zone facing a different cardinal orientation.

9. Incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes.
10. The maximum area a single daylight responsive control device serves shall not exceed 2,500 square feet (232 $m^2$).
11. Occupant override capability of daylight dimming controls is not permitted, other than a reduction of light output from the level established by the daylighting controls.

**C405.2.5.1.1 Dimming.** *Daylight responsive controls* shall be configured to automatically reduce the power of *general lighting* in the daylight zone in response to available daylight, while maintaining *uniform illumination* in the space through one of the following methods:

1. Continuous dimming using dimming ballasts/dimming drivers and daylight-sensing controls. The system shall reduce lighting power continuously to less than 15 percent of rated power at maximum light output.
2. Stepped dimming using multi-level switching and daylight-sensing controls. The system shall provide a minimum of two steps of uniform illumination between 0 percent and 100 percent of rated power at maximum light output. Each step shall be in equal increments of power, plus or minus 10 percent.

General lighting within daylight zones in offices, classrooms, laboratories, and library reading rooms shall use the continuous dimming method. Stepped dimming is not allowed as a method of daylight zone control in these spaces.

**C405.2.5.2 Sidelit daylight zone.** The *sidelit daylight zone* is the floor area adjacent to *vertical fenestration* which complies with the following:

1. Where the *fenestration* is located in a wall, the *primary* sidelit *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 0.5 times the height from the floor to the top of the *fenestration*, whichever is less, as indicated in Figure C405.2.5.2(1).
2. Where the *fenestration* is located in a wall, the *secondary sidelit daylight zone* id directly adjacent to the *primary* sidelit *daylight zone* and shall extend laterally to 2.0 times the height from the floor to the top of the *fenestration* or to the nearest full height wall, whichever is less, and longitudinally from the edge of the *fenestration* to the nearest full height wall or up to 2 feet, whichever is less, as indicated in Figure C405.2.5.2(1).
3. Where *clerestory fenestration* is located in a wall, the *sidelit daylight zone* includes a lateral area twice the depth of the *clerestory fenestration* height, projected upon the floor at a 45 degree angle from the center of the *clerestory fenestration*. The longitudinal width of the *sidelit daylight zone* is calculated the same as for *fenestration* located in a wall. Where the 45 degree angle is interrupted by an obstruction greater than 0.7 times the ceiling height, the *sidelit daylight zone* shall remain the same lateral area but be located between the clerestory and the obstruction, as indicated in Figure C405.2.5.2(2).
4. Where the fenestration is located in a rooftop monitor, the primary *sidelit 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 *fenestration*, 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 C405.2.5.2(3) and C405.2.5.2(4).
5. If the rough opening area of a *vertical fenestration* assembly is less than 10 percent of the calculated *primary sidelit daylight zone* area for this *fenestration*, it does not qualify as a *sidelit daylight zone*.
6. The visible transmittance of the *fenestration* is no less than 0.20.
7. The projection factor (determined in accordance with Equation ~~4-5~~4-4) for any overhanging projection which is shading the *fenestration* is not greater than 1.0 for *fenestration* oriented 45 degrees or less from true north, and not greater than 1.5 for all other orientations.

**FIGURE C405.2.5.2(1)**
**SIDELIT DAYLIGHT ZONE ADJACENT TO FENESTRATION IN A WALL**

**Commented [BK(84]:** Not sure how to coordinate this section with C405.2.4.1

**Commented [DJ85R84]:** Our C405.2.4.1 language is better, and gets rid of the stepped dimming provision. However, we might want to move that section down here to preserve the IECC formatting

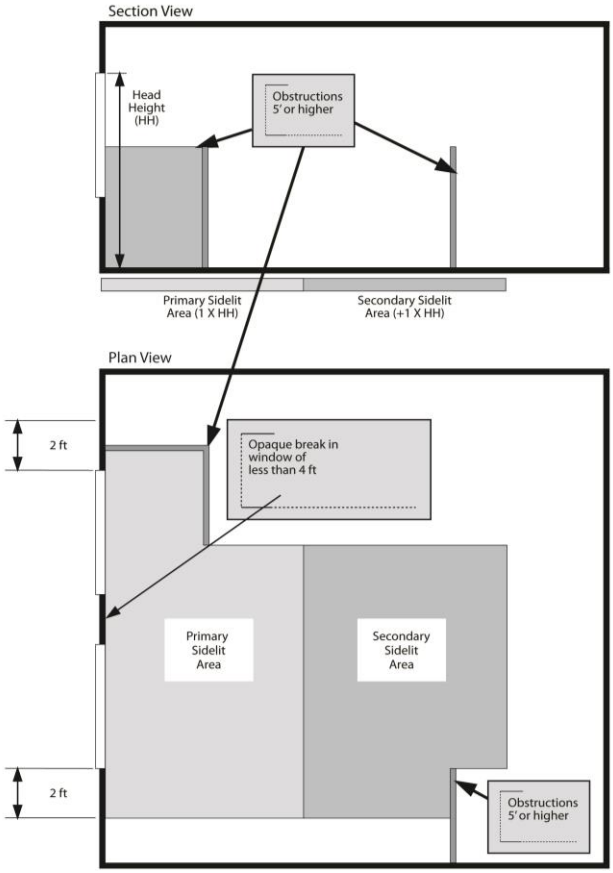
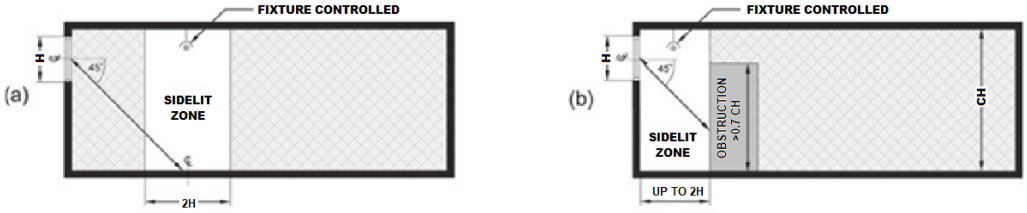
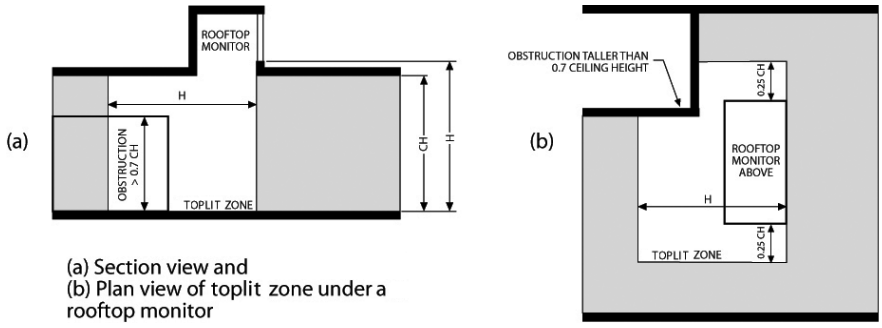



**FIGURE C405.2.5.2(2)**
**SIDELIT DAYLIGHT ZONE ADJACENT TO CLERESTORY FENESTRATION IN A WALL**



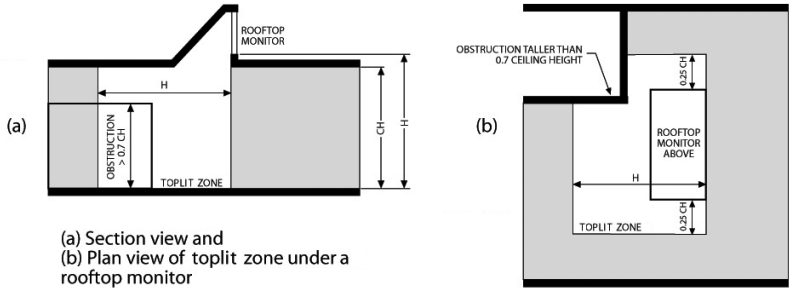

**(a) Section view**
**(b) Section view with obstruction**

**FIGURE C405.2.5.2(3)**
**SIDELIT DAYLIGHT ZONE UNDER A ROOFTOP MONITOR**




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

**FIGURE C405.2.5.2(4)**
**SIDELIT DAYLIGHT ZONE UNDER A SLOPED ROOFTOP MONITOR**



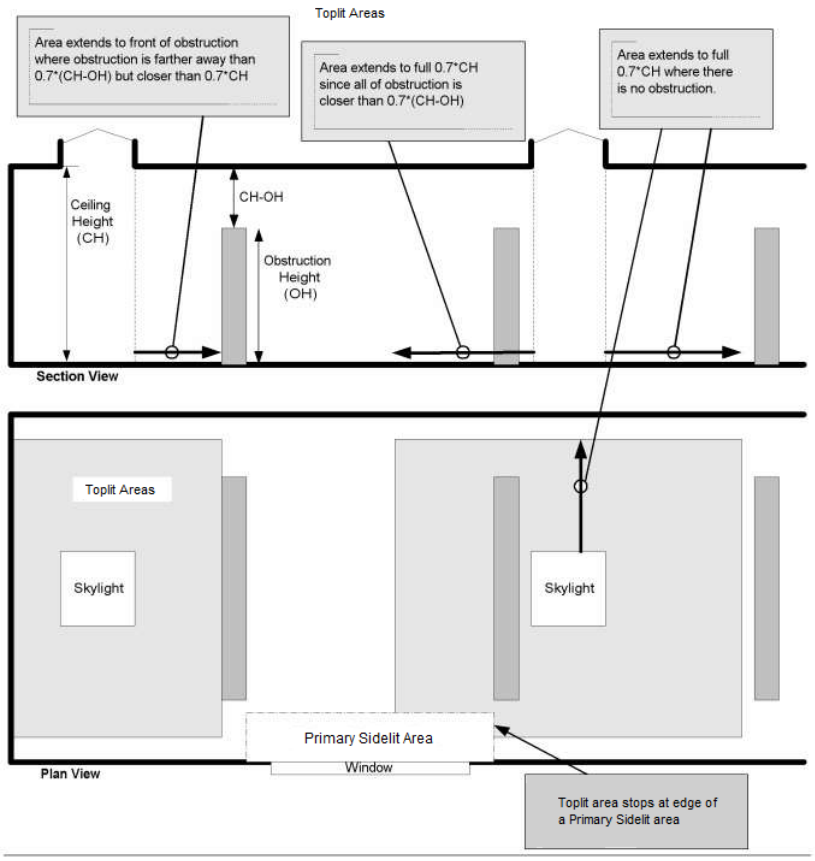

(a) Section view and
(b) Plan view of toplit zone under a rooftop monitor

**C405.2.5.3 Toplit daylight zone.** The *toplit daylight zone* is the floor area underneath a roof fenestration assembly which complies with the following:

1. The *toplit 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 C405.2.5.3(1).
2. Where *toplit daylight zones* overlap with *sidelit daylight zones*, lights within the overlapping area shall be assigned to the *toplit daylight zone*.
3. 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 *toplit daylight zone* is no less than 0.008.
4. Where located under atrium fenestration, the *toplit daylight zone* shall include the bottom floor area directly beneath the atrium *fenestration*, and the top floor directly under the atrium *fenestration*, as indicated in Figure C405.2.5.4. The *toplit daylight zone* area at the top floor is calculated the same as for a *toplit daylight zone*. Intermediate levels below the top floor that are not directly beneath the atrium are not included.

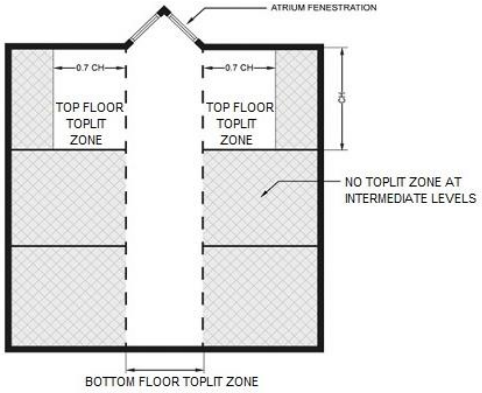
**FIGURE C405.2.5.3(1)**

**TOPLIT DAYLIGHT ZONE UNDER A ROOFTOP FENESTRATION ASSEMBLY**




**C405.2.5.4 Atriums.** Daylight zones at atrium spaces shall be established at the top floor surrounding the atrium and at the floor of the atrium space, and not on intermediate floors, as indicated in Figure C405.2.5.4.

**FIGURE C405.2.5.4**
**TOPLIT DAYLIGHT ZONE UNDER ATRIUM FENESTRATION**




**C405.2.6 Additional lighting controls.** Specific application lighting shall be provided with controls, in addition to controls required by other sections, for the following:

1. The following lighting shall be controlled by an occupant sensor complying with Section C405.2.1.1 or a time-switch control complying with Section C405.2.2.1 In addition, a *manual* control shall be provided to control such lighting separately from the *general lighting* in the space:
   1.1. Luminaires for which additional lighting power is claimed in accordance with Section C405.4.2.2.1.
   1.2. Display and accent, including lighting in display cases.
   ~~1.3. Lighting in display cases.~~
   ~~1.4.~~1.3. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting.
   ~~1.5.~~1.4. Lighting equipment that is for sale or demonstration in lighting education.
   ~~1.6. Display lighting for exhibits in galleries, museums and monuments that is in addition to *general lighting*.~~

~~2. *Sleeping units* shall have control devices or systems configured to automatically switch off all permanently installed luminaires and switched receptacles within 20 minutes after all occupants have left the unit.~~

~~3. **Exceptions:**~~

~~4. 1. Lighting and switched receptacles controlled by card key controls.~~

~~5.~~2. ~~2. Spaces where patient care is directly provided.~~

~~6.~~3. Lighting for life support of nonhuman life forms and food warming, shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space. Each control zone shall be no greater than the area served by a single luminaire or 4,000 square feet (327 $m^2$), whichever is larger.

4. Task lighting for medical and dental purposes that is in addition to *general lighting* shall be provided with a manual control.

~~7.~~5. Lighting integrated into range hoods and exhaust fans shall be controlled independently of fans.

~~8.~~6. Luminaires serving the exit access and providing means of egress illumination required by Section 1008.2 of the *International Building Code*, including luminaires that function as both normal and emergency means of egress illumination, shall be controlled by a combination of listed emergency relay and occupancy sensors, or signal from another building control system, that automatically shuts off the lighting when the areas served by that illumination are unoccupied.

**Exception:** Means of egress illumination serving the exit access that does not exceed 0.01 watts per square foot (0.108 $W/m^2$) of building area is exempt from this requirement.

**C405.2.7 Area controls.** The maximum lighting power that may be controlled from a single switch or *automatic* control device shall not exceed that which is provided by a 20 ampere circuit loaded to not more than 80 percent. A master control may be installed provided the individual switches retain their capability to function independently. Circuit breakers may not be used as the sole means of switching.

**Exception:** Areas less than 5 percent of the building footprint for footprints over 100,000 $ft^2$.

**C405.2.8 Advanced lighting controls.** Any contiguous open office area larger than 5,000 square feet shall have its *general lighting* controlled by either:

1. *Luminaire-level lighting controls* (LLLC) conforming to the requirements of Section C405.2.8.1.
2. Networked lighting control (NLC) conforming to the requirements of Section C405.2.8.2.

**C405.2.8.1 Luminaire-level lighting controls.** Where *luminaire-level lighting controls* are required, they shall be configured to provide the controls or equivalent control function specified in Sections C405.2.1, C405.2.3, and C405.2.5. In addition, each LLLC luminaire shall be independently configured to:

1. Provide for continuous full range dimming.
2. Monitor occupant activity to brighten or dim lights when occupied or unoccupied, respectively.
3. Monitor ambient lighting, both electric and daylight, and brighten or dim artificial light to maintain desired light level. A maximum of 8 fixtures are permitted to be controlled together to maintain uniform light levels within a single daylight zone.
4. Allow configuration and reconfiguration of performance parameters for each control strategy including: High trim and low trim setpoints, timeouts, dimming fade rates, and sensor sensitivity adjustment.
5. Construction documents shall include a submittal of a sequence of operations including a specification outlining each of the functions required by this section.
6. Luminaires shall be configured with high end trim in accordance with Section C405.2.8.3.

**C405.2.8.2 Networked lighting control (NLC).** Where NLC are required, they shall be configured to provide controls and minimum function as specified in Section C405.2. In addition, each NLC luminaire shall be independently configured to:

1. Provide for continuous full range dimming.
2. Each luminaire shall be individually addressed.
   **Exceptions to Item 2:**
   2.1. Multiple luminaires mounted on no more than 12 linear feet of a single lighting track and addressed as a single luminaire.
   2.2. Multiple linear luminaires that are ganged together to create the appearance of a single longer fixture and addressed as a single luminaire, where the total length of the combined luminaires is not more than 12 feet.
3. Monitor occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.
4. Monitor ambient lighting, both electric and daylight, and brighten or dim artificial light to maintain desired light level. A maximum of 8 fixtures are permitted to be controlled together to maintain uniform light levels within a single daylight zone.
5. Allow configuration and reconfiguration of performance parameters for each control strategy including: High trim and low trim setpoints, timeouts, dimming fade rates, and sensor sensitivity adjustment.
6. Allow for demand response load shed.
7. Construction documents shall include a submittal of a sequence of operations including a specification outlining each of the functions required by this section.
8. Luminaires shall be configured with high end trim in accordance with Section C405.2.8.3.

**C405.2.8.3 High end trim.** Luminaires subject to high end trim shall be initially configured with the following:

1. Programmed to limit the initial maximum lumen output or maximum lighting power to 85 percent or less of full light output or full power or to meet the target light level documented in project sequence of operations using the least amount of power.
2. High end trim power levels are allowed to automatically reset to accommodate lumen maintenance.
3. High end trim controls shall be accessible only to authorized personnel.

**C405.2.9 Exterior lighting controls.** Exterior lighting systems shall be provided with controls that comply with Sections C405.2.9.1 through C405.2.9.4.

**Exceptions:**

1. Lighting for covered vehicle entrances ~~or exits from~~ to buildings ~~or parking structures~~ where required for safety, security or eye adaption.
2. Lighting controlled from within dwelling units.

**C405.2.9.1 Daylight shutoff.** Lights shall be configured to automatically turn off when daylight is present and satisfies the lighting needs.

**C405.2.9.2 Facade and landscape lighting shutoff**. Building façade and landscape lighting shall be configured to automatically shut off for a minimum of 6 hours per night or from not later than one hour after *building* or business closing to not earlier than one hour before *building* or business opening, whichever is less.

**Exception:** Areas where an *automatic* shutoff would endanger safety or security.

**C405.2.9.3 Lighting setback**. Lighting that is not controlled in accordance with Section C405.2.9.2 shall comply with the following:

1. Luminaires serving ~~outdoor~~ exterior parking areas and having a rated input wattage of greater than 40 watts and a mounting height of 24 feet (7315 mm) or less above the ground shall also be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent during any time where activity has not been detected for 15 minutes or more. Not more than 1,500 watts of lighting power shall be controlled together.
2. All other lighting shall be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent by selectively switching off or dimming luminaires at one of the following times:
   2.1. From not later than 12 midnight to 6 a.m.
   2.2. From not later than one hour after *building* or business closing to not earlier than one hour before *building* or business opening.
   2.3. During any period when no activity has been detected for 15 minutes or more.

~~**C405.2.9.4**~~**C405.2.10.4 Exterior time-switch control functions**. Time switch controls for exterior lighting shall comply with the following:

1. They shall have a clock capable of being programmed for not fewer than 7 days.
2. They shall be capable of being set for seven different day types per week.
3. They shall incorporate an *automatic* holiday setback feature.
4. They shall have program backup capabilities that prevent the loss of program and time settings for a period of at least 10 hours in the event that power is interrupted.

**C405.2.11 Demand responsive lighting controls function.** Demand responsive controls for lighting shall be capable of the following:

1. Automatically reducing the output of controlled lighting to 80 percent or less of full power or light output upon receipt of a *demand response signal*.
2. Where *high-end trim* has been set, automatically reducing the output of controlled lighting to 80 percent or less of the *high-end trim* setpoint upon receipt of a *demand response signal*.
3. Dimming controlled lights gradually and continuously over a period of not longer than 15 minutes to achieve their demand response setpoint.
4. Returning controlled lighting to its normal operational settings at the end of the demand response period.

**Exception:** Storage rooms and warehouse storage areas shall be permitted to switch off 25 percent or more of general lighting power rather than dimming.

~~**C405.2.10**~~**C405.2.11** ~~**Parking garage lighting control**~~**Interior parking area lighting control**. ~~Parking garage~~ Interior parking area lighting shall be controlled by an *occupant sensor* complying with Section C405.2.1.1 or a *time-switch control* complying with Section C405.2.2.1. Additional lighting controls shall be provided as follows:

1. Lighting power of each luminaire shall be automatically reduced by not less than 30 percent when there is no activity detected within a lighting zone for 20 minutes. Lighting zones for this requirement shall be not larger than 3,600 square feet (334.5 $m^2$).
2. Where lighting for eye adaptation is provided at ~~covered~~ vehicle entrances ~~and exits from~~ to buildings ~~and parking structures~~, such lighting shall be separately controlled by a device that automatically reduces lighting power by at least 50 percent from sunset to sunrise.
3. The power to luminaires within 20 feet (6096 mm) of perimeter wall openings shall automatically reduce in response to daylight by at least 50 percent.

**Commented [BK(86]:** This section was added to support a load management credit option in C406. We don't have a lighting load management credit option at the moment…..
And placement seems a little off
So, just here for reference at the moment.

**Commented [DJ87R86]:** Suggest we keep this temporarily in case the TAG decides to add lighting load management as mandatory or as a credit

**Exceptions to Item 3:**

3.1. Daylight transition lighting for covered vehicle entrances and exits from buildings and parking structures; each transition zone shall not exceed a depth of 66 feet inside the structure and a width of 50 feet.

3.2. Where permanent screens or architectural elements obstruct more than 50 percent of the opening.

3.3. Where the top of any existing adjacent structure or natural object is at least twice as high above the openings as its horizontal distance from the opening.

**C405.2.12 Sleeping unit and dwelling unit lighting and switched receptacle controls.** *Sleeping units* and *dwelling units* shall be provided with lighting controls and switched receptacles as specified in **Sections C405.2.10.1** and **C405.2.10.2**.

**C405.2.12.1 Sleeping units and dwelling units in hotels, motels and vacation timeshare properties.** *Sleeping units* and *dwelling units* in hotels, motels and vacation timeshare properties shall be provided with the following:

1. Not less than two 125V, 15- and 20-amp switched receptacles in each room, except for bathrooms, kitchens, foyers, hallways and closets.
2. Lighting controls that automatically turn off all lighting and switched receptacles within 20 minutes after all occupants have left the unit.

**Exception:** *Automatic* shutoff is not required where *captive key override* controls all lighting and switched receptacles in units with five or fewer permanently installed lights and switched receptacles.

**C405.2.12.2 Sleeping units in congregate living facilities.** *Sleeping units* in *congregate living facilities* shall be provided with the following controls:

1. Lighting in bathrooms shall be controlled by an *occupant sensor control* that automatically turns off lights within 20 minutes after all occupants have left the space.
2. Each unit shall have a *manual* control by the entrance that turns off all lighting and switched receptacles in the unit, except for lighting in bathrooms and kitchens. The *manual* control shall be marked to indicate its function.

**C405.3 ~~Lighting for plant growth and maintenance~~Horticultural lighting.** ~~All~~ Permanently installed luminaires ~~used for plant growth and maintenance~~ shall have a *photosynthetic photon efficacy* measured at the lamp for luminaires with serviceable or removable lamps or at the luminaire for integrated, nonserviceable luminaires of not less than 1.7 µmol/J for *horticultural lighting* in greenhouses and not less than 1.9 µmol/J for all other ~~*indoor growing spaces as defined in accordance with ANSI/ASABE S640*~~*horticultural lighting*. Luminaires for *horticultural lighting* in greenhouses shall be controlled by a device that automatically turns off the luminaire when sufficient daylight is available. Luminaires for *horticultural lighting* shall be controlled by a device that automatically turns off the luminaire at specific programmed times.

**Exception:** Buildings with no more than 10 kW of aggregate horticultural lighting load.

**C405.4 Interior lighting power requirements.** A building complies with this section if its total connected interior lighting power calculated under Section C405.4.1 is no greater than the interior lighting power allowance calculated under Section C405.4.2.

**C405.4.1 Total connected interior lighting power.** The total connected interior lighting power shall be determined in accordance with Equation ~~4-13~~4-12.

**(Equation 4-~~13~~12)**

$$TCLP = [LVL + BLL + TRK + POE + \text{Other}]$$

**Where:**

*TCLP* = Total connected lighting power (watts)

*LVL* = For luminaires with lamps connected directly to building power, such as line voltage lamps, the rated wattage of the lamp, which must be minimum 60 lumen/watt.

*BLL* = For luminaires incorporating a ballast or transformer, the rated input wattage of the ballast or transformer when operating the lamp.

*TRK* = For lighting track, cable conductor, rail conductor and plug-in busway systems that allow the addition and relocation of luminaires without rewiring, the wattage shall be one of the following:

1. The specified wattage of the luminaires, but not less than 16 W/lin. ft. (52 W/lin. m).
2. The wattage limit of the permanent current-limiting devices protecting the system.
3. The wattage limit of the transformer supplying the system.

*POE* = For other modular lighting systems served with power supplied by a driver, power supply or transformer, including but not limited to low-voltage lighting systems, the wattage of the system shall be the maximum rated input wattage of the driver, power supply or transformer published in the manufacturer's catalogs, as specified by UL 2108 or 8750. For power-over-Ethernet lighting systems, power provided to installed non-lighting devices may be subtracted from the total power rating of the power-over-Ethernet system.

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

The connected power associated with the following lighting equipment and applications is not included in calculating total connected lighting power

~~1. Television broadcast lighting for playing areas in sports arenas~~

~~2.~~1. Emergency lighting automatically off during normal building operation.

~~3.~~2. Lighting in spaces specifically designed for use by occupants with special lighting needs including those with visual impairment and other medical and age-related issues.

~~4. Casino gaming areas.~~

~~5.~~3. General area lighting power in industrial and manufacturing occupancies dedicated to the inspection or quality control of goods and products.

~~6.~~4. Mirror lighting in makeup or dressing ~~rooms~~areas used for video broadcasting, video or film recording, or live theatrical and music performance.

~~7.~~5. Task lighting for medical and dental purposes that is in addition to *general lighting*.

~~8.~~6. Display lighting for exhibits in galleries, museums and monuments that is in addition to *general lighting*.

~~9.~~7. Lighting ~~for theatrical purposes, including performance, stage, film production and video production~~in any location that is specifically used for video broadcasting, video or film recording, or live theatrical and music performance.

~~10.~~8. Lighting for photographic processes.

~~11.~~9. Lighting integral to equipment or instrumentation and installed by the manufacturer.

~~12.~~10. Task lighting for plant growth or maintenance where the lamp efficacy is not less than 90 lumens per watt.

~~13.~~11. Advertising signage or directional signage.

~~14.~~12. Lighting for food warming.

~~15.~~13. Lighting equipment that is for sale.

~~16.~~14. Lighting demonstration equipment in lighting education facilities.

~~17.~~15. Lighting *approved* because of safety considerations.

~~18.~~16. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.

~~19.~~17. Furniture mounted supplemental task lighting that is controlled by *automatic* shutoff.

~~20.~~18. Exit signs.

~~21.~~19. Lighting used for aircraft painting.

20. Antimicrobial lighting used for the sole purpose of disinfecting a space.
21. Lighting in *sleeping units* and *dwelling units*.
22. For exit access and exit stairways, including landings, where the applicable code requires an illuminance of 10 footcandles or more on the walking surface, the power in excess of the allowed power calculated according to Section C405.3.2.2 is not included.

**C405.4.2 Interior lighting power allowance.** The total interior lighting power allowance (watts) for an entire building shall be determined according to Table C405.4.2(1) using the Building Area Method, or Table C405.4.2(2) using the Space-by-Space Method. The interior lighting power allowance for projects that involve only portions of a building shall be determined according to Table C405.4.2(2) using the Space-by-Space Method. Buildings with unfinished spaces hall use the Space-by-Space Method.

**TABLE C405.4.2(1)**
**INTERIOR LIGHTING POWER ALLOWANCES: BUILDING AREA METHOD**

| Building Area Type | LPD (w/ft$^2$) |
|---|---|
| Automotive facility | 0.64 |
| Convention center | 0.64 |
| Court house | ~~0.79~~0.75 |
| Dining: Bar lounge/leisure | ~~0.79~~0.74 |
| Dining: Cafeteria/fast food | ~~0.72~~0.70 |
| Dining: Family | ~~0.71~~0.65 |
| Dormitory | 0.46 |
| Exercise center | 0.67 |
| Fire station | 0.54 |
| Gymnasium | 0.75 |
| Health care clinic | 0.70 |
| Hospital | 0.84 |
| Hotel | ~~0.56~~0.53 |
| Library | 0.83 |
| Manufacturing facility | 0.82 |
| Motion picture theater | ~~0.44~~0.43 |
| Multiple family | 0.41 |
| Museum | 0.55 |
| Office | ~~0.64~~0.62 |
| Parking garage | 0.14 |
| Penitentiary | 0.65 |
| Performing arts theater | ~~0.84~~0.82 |
| Police station | ~~0.66~~0.62 |
| Post office | ~~0.65~~0.64 |
| Religious building | ~~0.67~~0.66 |
| Retail | ~~0.84~~0.78 |
| School/university | 0.70 |
| Sports arena | 0.62 |
| Town hall | ~~0.69~~0.67 |
| Transportation | 0.50 |
| Warehouse | 0.40 |
| Workshop | ~~0.91~~0.86 |

**TABLE C405.4.2(2)**

**Commented [DJ88]:** I'm not wild about this idea of changing all the LPA values around. We should look at the overall change in lighting power across all the major space types to see what kind of reduction we've got. These tables got a lot more rational the last time that they were re-worked by ASHRAE.
Maybe another working group to evaluate? Maybe a percentage reduction below IECC.

## INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

| COMMON SPACE-BY-SPACE TYPES[a,j] | LPD (w/ft²) |
|---|---|
| Atrium - Less than 20 feet in height | ~~0.39~~ 0.32 |
| Atrium – 20 to 40 feet in height | ~~0.48~~ 0.41 |
| Atrium - Above 40 feet in height | ~~0.60~~ 0.51 |
| Audience/seating area - Permanent | |
| In an auditorium | ~~0.61~~ 0.57 |
| In a gymnasium | 0.23 |
| In a motion picture theater | 0.27 |
| In a penitentiary | ~~0.67~~ 0.56 |
| In a performing arts theater | ~~1.16~~ 1.09 |
| In a religious building | 0.72 |
| In a sports arena | ~~0.33~~ 0.27 |
| Otherwise | 0.23 |
| Banking activity area | ~~0.61~~ 0.56 |
| Breakroom (see Lounge/breakroom) | |
| Classroom/lecture hall/training room | |
| In a penitentiary | ~~0.89~~ 0.74 |
| Otherwise[h] | 0.71 |
| Computer room, data center | ~~0.94~~ 0.75 |
| Conference/meeting/multipurpose | ~~0.97~~ 0.88 |
| Confinement cell | ~~0.70~~ 0.60 |
| Copy/print room | 0.31 |
| Corridor | |
| In a facility for the visually impaired (and not used primarily by the staff)[b] | 0.71 |
| In a hospital | ~~0.71~~ 0.61 |
| In a manufacturing facility | 0.41 |
| Otherwise[c,i] | 0.41 |
| Courtroom[c] | ~~1.20~~ 1.08 |
| Dining area | |
| In a penitentiary | ~~0.42~~ 0.35 |
| In a facility for the visually impaired (and not used primarily by the staff)[b] | ~~1.27~~ 1.22 |
| In a bar/lounge or leisure dining[i] | ~~0.86~~ 0.76 |
| In cafeteria or fast food dining | ~~0.40~~ 0.36 |
| In a family dining area[i] | ~~0.60~~ 0.52 |
| Otherwise | ~~0.43~~ 0.42 |
| Electrical/mechanical | 0.43 |
| Emergency vehicle garage | ~~0.52~~ 0.51 |
| Food preparation | 1.09 |
| Guest room[a,b] | 0.41 |
| Laboratory | |
| In or as a classrooms | ~~1.11~~ 1.05 |
| Otherwise | ~~1.33~~ 1.21 |
| Laundry/washing area | ~~0.53~~ 0.51 |
| Loading dock, interior | 0.88 |

**Commented [BK(89]:** This value is from ASHRAE 90.1

**Commented [BK(90]:** From ASHRAE 90.1

| COMMON SPACE-BY-SPACE TYPES[a,j] | LPD (w/ft²) |
|---|---|
| Lobby[c] | |
| In a facility for the visually impaired (and not used primarily by the staff)[b] | ~~1.69~~ 1.44 |
| For an elevator | ~~0.65~~ 0.64 |
| In a hotel | ~~0.51~~ 0.48 |
| In a motion picture theater | ~~0.23~~ 0.20 |
| In a performing arts theater | ~~1.25~~ 1.21 |
| Otherwise | ~~0.84~~ 0.80 |
| Locker room | ~~0.52~~ 0.43 |
| Lounge /breakroom[i] | |
| In a health care facility[c,i] | 0.42 |
| Mother's wellness room | 0.68 |
| Otherwise[i] | ~~0.59~~ 0.55 |
| Office | |
| ~~Enclosed~~ Offices ≤ ~~250~~150 ft² | ~~0.74~~ 0.73 |
| ~~Enclosed~~ Offices >~~250~~150 and ≤ 300 ft² | 0.66 |
| ~~Open plan~~ Offices > 300 ft² | ~~0.61~~ 0.56 |
| Parking area daylight transition zone | 1.06 |
| Parking area, interior | ~~0.15~~ 0.11 |
| Pharmacy area | ~~1.66~~ 1.59 |
| Restroom | |
| In a facility for the visually impaired (and not used primarily by the staff)[b] | ~~1.26~~ 0.96 |
| Otherwise[i] | 0.63 |
| Sales area | ~~1.05~~ 0.85 |
| Seating area, general | ~~0.23~~ 0.21 |
| Security screening general areas | 0.64 |
| Security screening in transportation facilities | 0.93 |
| Security screening transportation waiting area | 0.56 |
| Stairway (See space containing stairway) | |
| Stairwell[c,i] | ~~0.49~~ 0.47 |
| Storage room | |
| < 50 ft² | ~~0.51~~ 0.49 |
| 50-100 ft² | ~~0.38~~ 0.35 |
| All other storage | ~~0.38~~ 0.35 |
| Vehicular maintenance | ~~0.60~~ 0.59 |
| Workshop | ~~1.26~~ 1.17 |

**Commented [BK(91)]:** From ASHRAE 90.1

**Commented [BK(92)]:** From ASHRAE 90.1

**Commented [BK(93)]:** From ASHRAE 90.1

**Commented [BK(94)]:** From ASHRAE 90.1

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

| BUILDING SPECIFIC SPACE-BY-SPACE TYPES[a] | LPD (w/ft²) |
|---|---|
| Automotive (see vehicular maintenance) | |
| Convention center - Exhibit space[i] | ~~0.61~~ 0.50 |
| Dormitory living quarters[a,b] | ~~0.50~~ 0.48 |
| Facility for the visually impaired[b] | |

| BUILDING SPECIFIC SPACE-BY-SPACE TYPES[a] | LPD (w/ft$^2$) |
|---|---|
| In a chapel (and not used primarily by the staff) | ~~0.70~~ 0.58 |
| In a recreation room (and not used primarily by the staff) | ~~1.77~~ 1.20 |
| Fire stations | |
| Sleeping quarters | 0.23 |
| Gaming establishments | |
| High limits game | 1.68 |
| Slots | 0.54 |
| Sportsbook | 0.82 |
| Table games | 1.09 |
| Gymnasium/fitness center | |
| In an exercise area | ~~0.90~~ 0.82 |
| In a playing area | ~~0.85~~ 0.82 |
| Health care facility[c,i] | |
| In an exam/treatment room | ~~1.40~~ 1.33 |
| In an imaging room | 0.94 |
| In a medical supply room | ~~0.62~~ 0.56 |
| In a nursery | ~~0.92~~ 0.87 |
| In a nurse's station | ~~1.17~~ 1.07 |
| In an operating room | 2.26 |
| In a patient room | 0.68 |
| In a physical therapy room | ~~0.91~~ 0.82 |
| In a recovery room | ~~1.25~~ 1.18 |
| In a telemedicine room | 1.44 |
| Library | |
| In a reading area [i] | ~~0.96~~ 0.86 |
| In the stacks | 1.10 |
| Manufacturing facility | |
| In a detailed manufacturing area | ~~0.80~~ 0.75 |
| In an equipment room | ~~0.76~~ 0.73 |
| In an extra high bay area (> 50-foot floor-ceiling height) | ~~1.42~~ 1.36 |
| In a high bay area (25 - 50-foot floor-ceiling height) | 1.24 |
| In a low bay area (< 25-foot floor-ceiling height) | 0.86 |
| Museum | |
| In a general exhibition area[i] | 0.31 |
| In a restoration room | 1.10 |
| Performing arts theater dressing/fitting room | ~~0.41~~ 0.39 |
| Post office—Sorting area | ~~0.76~~ 0.71 |
| Religious building | |
| In a fellowship hall[i] | ~~0.54~~ 0.50 |
| In a worship pulpit/choir area[i] | ~~0.85~~ 0.75 |
| Retail | |
| In a dressing/fitting room | ~~0.51~~ 0.45 |
| Hair care | 0.65 |

| | |
|---|---|
| Nail care | 0.75 |
| In a mall concourse | ~~0.82~~ 0.57 |
| Sports arena—Playing area | |
| For a Class 1 facility[d] | ~~2.94~~ 2.86 |
| For a Class 2 facility[e] | ~~2.01~~ 1.98 |
| For a Class 3 facility[f] | ~~1.30~~ 1.29 |
| For a Class 4 facility[g] | 0.86 |
| Sports arena—Pools | |
| For a Class 1 facility[d] | 2.20 |
| For a Class 2 facility[e] | 1.47 |
| For a Class 3 facility[f] | 0.99 |
| For a Class 4 facility[g] | 0.59 |
| Transportation | |
| Airport hangar | 1.36 |
| In a baggage/carousel area | ~~0.39~~ 0.28 |
| In an airport concourse | 0.25 |
| At a terminal ticket counter[i] | ~~0.51~~ 0.40 |
| Passenger loading area | 0.71 |
| Warehouse—Storage area | |
| For medium to bulky palletized items | 0.33 |
| For smaller, hand-carried items | 0.69 |

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 11 W/m$^2$.

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.

b. 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.

c. Additional lighting power allowance of 0.2 watts per square foot for the purpose of highlighting art or exhibits. This additional power allowance shall be permitted only where the specified lighting is installed in addition to and controlled separately from *general lighting* in accordance with Section C405.2.6. This additional power allowance shall be used only for the specified luminaires and shall not be used for any other purpose and it shall not be added to any other space or the interior power allowance.

d. Class I facilities consist of professional facilities; and semi-professional, collegiate or club facilities with seating for 5,000 or more spectators.

e. Class II facilities consist of collegiate and semi-professional facilities with seating for fewer than 5,000 spectators; club facilities with seating between 2,000 and 5,000 spectators; and amateur league and high school facilities with seating for more than 2,000 spectators.

f. Class III facilities consist of club, amateur league and high school facilities with seating for 2,000 or fewer spectators.

g. Class IV facilities consist of elementary school and recreational facilities; and amateur league and high school facilities without provisions for spectators.

h. For classrooms, additional lighting power allowance of 4.5 W/lineal foot of white or chalk boards for directional lighting dedicated to white or chalk boards.

i. Additional lighting power allowance of 0.15 W/ft$^2$ for ornamental lighting. Qualifying ornamental lighting includes luminaires that are specifically used in a decorative manner. This additional power shall be permitted only where the specified lighting is installed in addition to and controlled separately from display or *general lighting* in accordance with Section C405.2.6. This additional power shall be used only for the specified luminaires and it shall not be added to any other space or the interior power allowance.

j. Where a space is designated as unfinished, neither the area nor the lighting power in the space shall be calculated as part of the LPA.

**C405.4.2.1 Building area method.** For the Building Area Method, the interior lighting power allowance is calculated follows:

1. For each building area type inside the building, determine the applicable building area type and the allowed lighting power density for that type from Table C405.4.2(1). For building area types not listed, select the building area type that most closely represents the use of 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.
2. Determine the floor area for each building area type listed in Table C405.4.2(1) and multiply this area by the applicable value from Table C405.4.2(1) to determine the lighting power (watts) for each building area type. *Sleeping units* and *dwelling units* are excluded from lighting power allowance calculations by application of Section C405.4.3. The area of *sleeping units* and *dwelling units* is not included in the calculation.
3. The total interior lighting power allowance (watts) for the entire building is the sum of the lighting power form each building type.

**C405.4.2.2 Space-by-space method.** Where a building has a space designated as unfinished, neither the area nor the lighting power in the space shall be calculated as part of the LPA. For the Space-by-Space Method, the interior lighting power allowance is calculated as follows:

1. For each area enclosed by partitions that are not less than 80 percent of the ceiling height, determine the applicable space type from Table C405.4.2(2). For space types not listed, select the space type that most closely represents the proposed use of the space. Where a space has multiple functions, that space shall be broken up into smaller subspaces, each using their own space type. If an entire space has multiple functions that necessitate a higher lighting power allowance in order to serve one of the primary functions, the higher allowance is permitted to be used.
2. Determine the total floor area of all of the spaces of each space type and multiply by the value for the space type in Table C405.4.2(2) to determine the allowed lighting power (watts) for each space type. *Sleeping units* and *dwelling units* are excluded from lighting power allowance calculations by application of Section C405.4.3. The area of *sleeping units* and *dwelling units* is not included in the calculation
3. The total interior lighting power allowance (watts) shall be the sum of the lighting power allowances for all space types.

**C405.4.2.2.1 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 in addition to and automatically controlled separately from *general lighting,* in accordance with Section C405.2.6. ~~This~~ These additional power allowances shall be used only for the ~~specified~~ luminaires serving the specific lighting function and shall not be used for any other purpose. An increase in the interior lighting power allowance is permitted for lighting equipment to be installed in sales areas specifically to highlight merchandise. The additional lighting power allowance shall be the connected ligting power of the luminaires specifically highlighting merchandise, ~~determined~~ calculated in accordance with Equation 4-10, or the additional power allowance calculated in accordance with Equation ~~4-14~~4-13~~:~~, whichever is less.

Additional interior lighting power allowance = 500 watts + (Retail Area 1 x 0.45 W/ft$^2$) + (Retail Area 2 x 0.45 W/ft$^2$) + (Retail Area 3 x 1.05 W/ft$^2$) + (Retail Area 4 x 1.87 W/ft$^2$)

**(Equation ~~4-14~~4-13)**

**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 requirement is *approved* by the *code official*.

**C405.4.3 Lighting power for sleeping units and dwelling units.** *Sleeping units* in Group I-2 occupancies that are patient rooms shall comply with Sections C405.4.1 and C405.4.2. For all other *sleeping units* and *dwelling units*, permanently installed lighting, including lighting integrated into range hoods and exhaust fans, shall be provided by lamps capable of operating with an efficacy of not less than 65 lumens per watt or luminaires capable of operating with an efficacy of not less than 45 lumens per watt.

**Exceptions:**

1. Lighting integral to other appliances.
2. Antimicrobial lighting used for the sole purpose of disinfecting.
3. Luminaires with an input rating of less than 3 watts.

**C405.5 Exterior lighting power requirements.** The total connected exterior lighting power calculated in accordance with Section C405.5.2 shall not be greater than the exterior lighting power allowance calculated in accordance with Section C405.5.3.

**C405.5.1 Exterior ~~building grounds~~ lighting.** All exterior ~~building grounds~~ luminaires that operate at greater than 25 watts shall have a minimum efficacy of 100 lumens per watt.

**Commented [BK(95]:** This is WA language that I attempted to correlate with the language changes in the following section.

**Exceptions:**

1. Luminaires controlled by a motion sensor.
2. Luminaires that qualify for one of the exceptions under Section C405.5.2.

**C405.5.2 Total connected exterior ~~building~~ lighting power.** The total exterior connected lighting power shall be the total maximum rated wattage of all exterior lighting that is powered through the energy service for the building and building site lighting or which the *building owner* is responsible.

**Exception:** Lighting used for the following applications shall not be included:

1. Lighting approved because of safety considerations.
2. Emergency lighting automatically off during normal business operation.
3. Exit signs.
4. Specialized signal, directional and marker lighting associated with transportation.
5. Advertising signage or directional signage.
6. Integral to equipment or instrumentation and is installed by its manufacturer.
7. ~~Theatrical purposes, including performance, stage, film production and video production~~Lighting in any location that is specifically used for video broadcasting, video or film recording, or live theatrical and music performances.
8. Athletic playing areas.
9. Temporary lighting.
10. Industrial production, material handling, transportation sites and associated storage areas.
11. Theme elements in theme/amusement parks.
12. Lighting integrated within or used to highlight features of art, public monuments and the national flag.
13. Lighting for water features and swimming pools.
14. Lighting that is controlled from within *sleeping* units and *dwelling units*~~, where the lighting complies with Section R404.1~~.

~~14.~~15. Lighting of the exterior means of egress as required by the *International Building Code*.

**C405.5.3 Exterior lighting power allowance.** The exterior lighting power allowance (watts) is calculated as follows:

1. Determine the Lighting Zone (LZ) for the building according to Table C405.5.3(1), unless otherwise specified by the *code official*.
2. For each exterior area that is to be illuminated by lighting that is powered through the energy service for the *building* and building site lighting for which the *building owner* is responsible, determine the applicable area type from Table C405.5.3(2). For area types not listed, select the area type that most closely represents the proposed use of the area. Covered parking garage lighting is not considered exterior lighting for the purposes of this calculation.
3. Determine the total area or length of each type and multiply by the value for the area type in Table

C405.5.3(2) to determine the lighting power (watts) allowed for each area type.

4. The total exterior lighting power allowance (watts) is the sum of the base site allowance determined according to Table C405.5.3(2), plus the watts from each area type.

**TABLE C405.5.3(1)**
**EXTERIOR LIGHTING ZONES**

| LIGHTING ZONE | DESCRIPTION |
|---|---|
| 1 | Developed areas of national parks, state parks, forest land, and rural areas |
| 2 | Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas |
| 3 | All other areas 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 |

**TABLE C405.5.3(2)**
**LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS**

| | LIGHTING ZONES | | | |
|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** |
| Base Site Allowance | 160 W | 280 W | 400W | 560 W |
| **Uncovered Parking Areas** | | | | |
| Parking areas and drives | 0.015 W/ft$^2$ | 0.026 W/ft$^2$ | 0.037 W/ft$^2$ | 0.052 W/ft$^2$ |
| **Building Grounds** | | | | |
| Walkways and ramps less than 10 feet wide | 0.04 W per linear foot | ~~0.07~~ 0.05 W per linear foot | 0.10 W per linear foot | 0.14 W per linear foot |
| Walkways and ramps 10 feet wide or greater, plaza areas special feature areas | ~~0.04~~ 0.028 W/ft$^2$ | ~~0.07~~ 0.049 W/ft$^2$ | ~~0.10~~ 0.070 W/ft$^2$ | ~~0.14~~ 0.098 W/ft$^2$ |
| Dining areas | 0.156 W/ft$^2$ | 0.273 W/ft$^2$ | 0.390 W/ft$^2$ | 0.546 W/ft$^2$ |
| Stairways | Exempt | Exempt | Exempt | Exempt |
| Pedestrian tunnels | 0.063 W/ft$^2$ | 0.110 W/ft$^2$ | 0.157 W/ft$^2$ | 0.220 W/ft$^2$ |
| Landscaping | 0.014 W/ft$^2$ | 0.025 W/ft$^2$ | 0.036 W/ft$^2$ | 0.050 W/ft$^2$ |
| **Building Entrances and Exits** | | | | |
| Pedestrian and vehicular entrances and exists | 5.6 W per linear foot of opening | 9.8 W per linear foot of opening | 14.0 W per linear foot of opening | 19.6 W per linear foot of opening |
| Entry canopies | 0.072 W/ft$^2$ | 0.126 W/ft$^2$ | 0.180 W/ft$^2$ | 0.252 W/ft$^2$ |
| Loading docks | 0.104 W/ft$^2$ | 0.182 W/ft$^2$ | 0.260 W/ft$^2$ | 0.364 W/ft$^2$ |
| **Sales Canopies** | | | | |
| Free-standing and attached | 0.20 W/ft$^2$ | 0.35 W/ft$^2$ | 0.50 W/ft$^2$ | 0.70 W/ft$^2$ |
| **Outdoor Sales** | | | | |
| Open areas (including vehicle sales lots) | 0.072 W/ft$^2$ | 0.126 W/ft$^2$ | 0.180 W/ft$^2$ | 0.252 W/ft$^2$ |
| Street frontage for vehicle sales lots in addition to “open area” allowance | No allowance | 7 W per linear foot | 10.3 W per linear foot | 14.4 W per linear foot |

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 10.76 W per m$^2$.

**TABLE C405.5.3(3)**

**Commented [BK(96]:** The IECC has this at 0.55 W/linear foot. This is also the ASHRAE value.

**Commented [BK(97]:** The IECC has this at 0.60 W/linear foot. This is also the ASHRAE value.

**Commented [BK(98]:** ASHRAE/IECC value is 7.2 W/linear foot.

**INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS**

| | LIGHTING ZONES | | | |
|---|---|---|---|---|
| | **Zone 1** | **Zone 2** | **Zone 3** | **Zone 4** |
| Building facades | No Allowance | 0.075 W/ft$^2$ of gross above-grade wall area | 0.113 W/ft$^2$ of gross above-grade wall area | 0.150 W/ft$^2$ of gross above-grade wall area |
| Automated teller machines (ATM) and night depositories | 80 W per location plus 25 W per additional ATM per location | 80 W per location plus 25 W per additional ATM per location | 80 W per location plus 25 W per additional ATM per location | 80 W per location plus 25 W per additional ATM per location |
| Uncovered entrances and gatehouse inspection stations at guarded facilities | 0.144 W/ft$^2$ | 0.252 W/ft$^2$ | 0.360 W/ft$^2$ | 0.504 W/ft$^2$ |
| Uncovered loading areas for law enforcement, fire, ambulance and other emergency service vehicles | 0.104 W/ft$^2$ | 0.182 W/ft$^2$ | 0.260 W/ft$^2$ | 0.364 W/ft$^2$ |
| Drive-up windows/doors | 53 W per drive-through | 92 W per drive-through | 132 W per drive-through | 185 W per drive-through |
| Parking near 24-hour retail entrances | 80 W per main entry | 140 W per main entry | 200 W per main entry | 280 W per main entry |

**Commented [BK(99]:** ASHRAE/IECC value is 90 W/ft2 + 35 W

**C405.5.3.1 Additional exterior lighting power.** Additional exterior lighting power allowances are available for the specific lighting applications listed in Table C405.5.3(3). These additional power allowances shall be used only for the luminaires serving these applications and shall not be used to increase any other lighting power allowance.

**C405.5.4 Gas lighting.** Gas-fired lighting appliances shall not be equipped with continuously burning pilot ignition systems.

**C405.6 Electrical transformers.** Low-voltage dry-type distribution electric transformers shall meet the minimum efficiency requirements of Table C405.6 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 certification program or, where no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the transformer manufacturer.

**Exception:** The following transformers are exempt in accordance with the DOE definition of Distribution Transformers found in 10 CFR 431.192:

~~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 provided in DOE 10 CFR 431.~~

~~3.~~1. ~~Transformers that meet the Energy Policy Act of 2005 exclusions with multiple voltage taps where the highest tap is not less than 20 percent more than the lowest tap~~Transformers with a tap range of 20 percent or more.

~~4.~~2. Drive (isolation) transformers.

~~5.~~3. Rectifier transformers.

~~6.~~4. Auto-transformers.

~~7.~~5. Uninterruptible power system transformers.

~~8.~~6. ~~Impedance~~ Special impedance transformers.

~~9.~~7. Regulating transformers.

~~10.~~8. Sealed ~~and nonventilating~~ transformers.

~~11.~~9. Machine tool (control) transformers.

~~12.~~10. Welding transformers.

~~13.~~11. Grounding transformers.

12. Testing transformers.

~~14.~~13. Nonventilated transformers.

**TABLE C405.6**
**MINIMUM NOMINAL EFFICIENCY LEVELS FOR 10 CFR 431 LOW VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS**

| Single Phase Transformers | | Three Phase Transformers[a] | |
|---|---|---|---|
| kVA[a~~b~~] | Efficiency (%)[b~~c~~] | ~~kVA[a]~~ kVA[b] | Efficiency (%)[b~~c~~] |
| 15 | 97.70 | 15 | 97.89 |
| 25 | 98.00 | 30 | 98.23 |
| 37.5 | 98.20 | 45 | 98.40 |
| 50 | 98.30 | 75 | 98.60 |
| 75 | 98.50 | 112.5 | 98.74 |
| 100 | 98.60 | 150 | 98.83 |
| 167 | 98.70 | 225 | 98.94 |
| 250 | 98.80 | 300 | 99.02 |
| 333 | 98.90 | 500 | 99.14 |
| | | 750 | 99.23 |
| | | 1000 | 99.28 |

a. A low-voltage dry-type distribution transformer with a kVA rating not listed in the table shall have its minimum efficiency level determined by linear interpolation of the kVA and efficiency values listed in the table immediately above and below its kVA rating. Extrapolation shall not be used below the minimum values or above the maximum values shown for single-phase transformers and three-phase transformers.

~~a.~~ b. kiloVolt-Amp rating.

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

**C405.7 Dwelling unit electrical energy consumption.** Each dwelling unit located in a Group R-2 building shall have a separate electrical meter. A utility tenant meter meets this requirement. See Section C409 for additional requirements for energy metering and energy consumption management.

**Exception:** Dwelling units in other than Group R-2 apartment and live/work units are not required to provide a separate electrical metering at each dwelling unit where electrical usage is metered separately for each of the following building end uses:

1. Dwelling units.
2. Sleeping units.
3. Commercial kitchens.
4. Central laundries.

**C405.7.1 Electric receptacles at dwelling unit gas appliances.** Where *dwelling unit* appliances are served by natural gas, an electrical receptacle or junction box and circuit shall be provided at each gas appliance with sufficient capacity to serve a future electric appliance in the same location. The receptacles and circuits shall be included in the electrical service load calculation and shall meet the requirements of items 1 through 3 below. The receptacle or junction box for each gas appliance shall be located within 12 inches of the appliance and without obstructions between the appliance and the outlet. An electric receptacle is not required for a decorative gas fireplace.

1. Each gas range, cooktop, or oven, or combination appliance, location shall be served by a dedicated 240/208-volt, 40-amp receptacle connected to the *dwelling unit* electric panel with a 3-conductor branch circuit complying with 210.19(A)(3) of the NEC as adopted by Washington state and a minimum included load of 9600 VA for 240-volt systems or 8000 VA for 208-volt systems.
2. Each gas clothes dryer location shall be served by a dedicated 240/208-volt, 30-amp receptacle connected to the *dwelling unit* electric panel with a 3-conductor branch circuit and a minimum included load of 5000 VA.

3. The location of each gas domestic water heater installed within a *dwelling unit* shall be served by a dedicated 240/208-volt, 30-amp junction box connected to the *dwelling unit* electrical panel with a 3-conductor branch circuit and a minimum included load of 4500 VA.

**C405.8 Electric motor efficiency.** All electric motors, fractional or otherwise, shall meet the minimum efficiency requirements of Tables C405.8(1) through C405.8(4) when tested and rated in accordance with DOE 10 CFR. The efficiency shall be verified through certification under an approved certification program, or, where no certification program exists, the equipment efficiency rating shall be supported by data furnished by the motor manufacturer.

**Exception:** The standards in this section shall not apply to the following exempt electric motors:

1. Air-over electric motors.
2. Component sets of an electric motor.
3. Liquid-cooled electric motors.
4. Submersible electric motors.
5. Inverter-only electric motors.
6. Definite-purpose machines within the scope of ANSI/NEMA MG1, Part 18.

Fractional hp fan motors that are 1/12 hp or greater and are less than 1 hp (based on output power) which are not covered by Tables C405.8(3) and C405.8(4) shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent when 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. Belt-driven fans may use sheave adjustment for airflow balancing in lieu of a varying motor speed.

**Exceptions:**

1. Motors that are an integral part of specialized process equipment.
2. Where the motor is integral to a listed piece of equipment for which no complying motor has been approved.
3. Motors used as a component of the equipment meeting the minimum efficiency requirements of Section C403.3.2 and Tables C403.3.2(1) through C403.3.2(16), provided that the motor input is included when determining the equipment efficiency.
4. Motors in the airstream within fan coils and terminal units that operate only when providing heating to the space served.
5. Fan motors that are not covered by Tables C405.8(1) through C405.8(4) and are used to power heat recovery ventilators, energy recovery ventilators, or local exhaust fans in Group R subject to the efficacy requirements of Section C403.8.4.
6. Domestic clothes dryer booster fans, range hood exhaust fans, and domestic range booster fans that operate intermittently.
7. Radon and contaminated soil exhaust fans.
8. Group R heat recovery ventilator and energy recovery ventilator fans that are less than 400 cfm.

**TABLE C405.8(1)**
**MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N MOTORS (EXCLUDING FIRE PUMP) ELECTRIC MOTORS AT 60 HZ[a,b]**

| Motor horsepower (Standard kilowatt equivalent) | Nominal full-load efficiency (%) as of June 1, 2016 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 pole | | 4 pole | | 6 pole | | 8 pole | |
| | Enclosed | Open | Enclosed | Open | Enclosed | Open | Enclosed | Open |
| 1 (0.75) | 77.0 | 77.0 | 85.5 | 85.5 | 82.5 | 82.5 | 75.5 | 75.5 |
| 1.5 (1.1) | 84.0 | 84.0 | 86.5 | 86.5 | 87.5 | 86.5 | 78.5 | 77.5 |
| 2 (1.5) | 85.5 | 85.5 | 86.5 | 86.5 | 88.5 | 87.5 | 84.0 | 86.5 |
| 3 (2.2) | 86.5 | 85.5 | 89.5 | 89.5 | 89.5 | 88.5 | 85.5 | 87.5 |
| 5 (3.7) | 88.5 | 86.5 | 89.5 | 89.5 | 89.5 | 89.5 | 86.5 | 88.5 |
| 7.5 (5.5) | 89.5 | 88.5 | 91.7 | 91.0 | 91.0 | 90.2 | 86.5 | 89.5 |
| 10 (7.5) | 90.2 | 89.5 | 91.7 | 91.7 | 91.0 | 91.7 | 89.5 | 90.2 |
| 15 (11) | 91.0 | 90.2 | 92.4 | 93.0 | 91.7 | 91.7 | 89.5 | 90.2 |
| 20 (15) | 91.0 | 91.0 | 93.0 | 93.0 | 91.7 | 92.4 | 90.2 | 91.0 |
| 25 (18.5) | 91.7 | 91.7 | 93.6 | 93.6 | 93.0 | 93.0 | 90.2 | 91.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 30 (22) | 91.7 | 91.7 | 93.6 | 94.1 | 93.0 | 93.6 | 91.7 | 91.7 |
| 40 (30) | 92.4 | 92.4 | 94.1 | 94.1 | 94.1 | 94.1 | 91.7 | 91.7 |
| 50 (37) | 93.0 | 93.0 | 94.5 | 94.5 | 94.1 | 94.1 | 92.4 | 92.4 |
| 60 (45) | 93.6 | 93.6 | 95.0 | 95.0 | 94.5 | 94.5 | 92.4 | 93.0 |
| 75 (55) | 93.6 | 93.6 | 95.4 | 95.0 | 94.5 | 94.5 | 93.6 | 94.1 |
| 100 (75) | 94.1 | 93.6 | 95.4 | 95.4 | 95.0 | 95.0 | 93.6 | 94.1 |
| 125 (90) | 95.0 | 94.1 | 95.4 | 95.4 | 95.0 | 95.0 | 94.1 | 94.1 |
| 150 (110) | 95.0 | 94.1 | 95.8 | 95.8 | 95.8 | 95.4 | 94.1 | 94.1 |
| 200 (150) | 95.4 | 95.0 | 96.2 | 95.8 | 95.8 | 95.4 | 94.5 | 94.1 |
| 250 (186) | 95.8 | 95.0 | 96.2 | 95.8 | 95.8 | 95.8 | 95.0 | 95.0 |
| 300 (224) | 95.8 | 95.4 | 96.2 | 95.8 | 95.8 | 95.8 | | |
| 350 (261) | 95.8 | 95.4 | 96.2 | 95.8 | 95.8 | 95.8 | | |
| 400 (298) | 95.8 | 95.8 | 96.2 | 95.8 | | | | |
| 450 (336) | 95.8 | 96.2 | 96.2 | 96.2 | | | | |
| 500 (373) | 95.8 | 96.2 | 96.2 | 96.2 | | | | |

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

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula 1 kW = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with 1 or 2, whichever applies.

**TABLE C405.8(2)**
**MINIMUM NOMINAL FULL-LOAD EFFICIENCY**
**FOR NEMA DESIGN C AND IEC DESIGN H MOTORS AT 60HZ[a,b]**

| Motor horsepower (Standard kilowatt equivalent) | Nominal full-load efficiency (%) as of June 1, 2016 | | | | | |
|---|---|---|---|---|---|---|
| | 4 pole | | 6 pole | | 8 pole | |
| | Enclosed | Open | Enclosed | Open | Enclosed | Open |
| 1 (0.75) | 85.5 | 85.5 | 82.5 | 82.5 | 75.5 | 75.5 |
| 1.5 (1.1) | 86.5 | 86.5 | 87.5 | 86.5 | 78.5 | 77.5 |
| 2 (1.5) | 86.5 | 86.5 | 88.5 | 87.5 | 84.0 | 86.5 |
| 3 (2.2) | 89.5 | 89.5 | 89.5 | 88.5 | 85.5 | 87.5 |
| 5 (3.7) | 89.5 | 89.5 | 89.5 | 89.5 | 86.5 | 88.5 |
| 7.5 (5.5) | 91.7 | 91.0 | 91.0 | 90.2 | 86.5 | 89.5 |
| 10 (7.5) | 91.7 | 91.7 | 91.0 | 91.7 | 89.5 | 90.2 |
| 15 (11) | 92.4 | 93.0 | 91.7 | 91.7 | 89.5 | 90.2 |
| 20 (15) | 93.0 | 93.0 | 91.7 | 92.4 | 90.2 | 91.0 |
| 25 (18.5) | 93.6 | 93.6 | 93.0 | 93.0 | 90.2 | 91.0 |
| 30 (22) | 93.6 | 94.1 | 93.0 | 93.6 | 91.7 | 91.7 |
| 40 (30) | 94.1 | 94.1 | 94.1 | 94.1 | 91.7 | 91.7 |
| 50 (37) | 94.5 | 94.5 | 94.1 | 94.1 | 92.4 | 92.4 |
| 60 (45) | 95.0 | 95.0 | 94.5 | 94.5 | 92.4 | 93.0 |
| 75 (55) | 95.4 | 95.0 | 94.5 | 94.5 | 93.6 | 94.1 |
| 100 (75) | 95.4 | 95.4 | 95.0 | 95.0 | 93.6 | 94.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 125 (90) | 95.4 | 95.4 | 95.0 | 95.0 | 94.1 | 94.1 |
| 150 (110) | 95.8 | 95.8 | 95.8 | 95.4 | 94.1 | 94.1 |
| 200 (150) | 96.2 | 95.8 | 95.8 | 95.4 | 94.5 | 94.1 |

NR - No requirement.

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

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula 1 kW = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with 1 or 2, whichever applies.

**TABLE C405.8(3)**
**MINIMUM AVERAGE FULL LOAD EFFICIENCY FOR POLYPHASE SMALL ELECTRIC MOTORS[a]**

| | OPEN MOTORS | | |
|---|---|---|---|
| **NUMBER OF POLES ►** | **2** | **4** | **6** |
| **SYNCHRONOUS SPEED (RPM) ►** | **3600** | **1800** | **1200** |
| **MOTOR HORSEPOWER ▼** | | | |
| 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 C405.8(4)**
**MINIMUM AVERAGE FULL LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS[a]**

| | OPEN MOTORS | | |
|---|---|---|---|
| NUMBER OF POLES ► | 2 | 4 | 6 |
| SYNCHRONOUS SPEED (RPM) ► | 3600 | 1800 | 1200 |
| MOTOR HORSEPOWER ▼ | | | |
| 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.

**C405.9 Data centers and computer rooms.** Electrical equipment in *data centers* and *computer rooms* shall comply with this section.

**C405.9.1 Data centers.** Transformers, uninterruptable power supplies, motors and electrical power processing equipment in *data centers* shall comply with Section 8 of ASHRAE 90.4 in addition to this code.

**C405.9.2 Computer rooms.** Uninterruptable power supplies in *computer rooms* shall comply with the requirements in Tables 8.5 and 8.6 of ASHRAE 90.4 in addition to this code.

**Exception:** AC-output UPS that utilizes standardized NEMA 1-15P or NEMA 5-15P input plud, as specified in ANSI/NEMA WD-6.

~~C405.9~~C405.10 **Vertical and horizontal transportation systems and equipment.** Vertical and horizontal transportation systems and equipment shall comply with this section.

~~C405.9.1~~C405.10.1 **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 consume 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.

~~C405.9.2~~C405.10.2 **Escalators and moving walks.** Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have *automatic* controls that reduce speed as permitted in accordance with ASME A17.1/CSA B44 and applicable local code when not conveying passengers.

**Exception**: A variable voltage drive system that reduces operating voltage in response to light loading conditions may be provided in lieu of the variable speed function.

~~C405.9.3~~C405.10.3 **Energy recovery.** Escalators shall be designed to recover electrical energy when resisting overspeed in the down direction.

~~C405.10~~C405.11 **Automatic receptacle control.** The following shall have automatic receptacle control complying with Section C405.10.1:

1. At least 50 percent of all 125V, 15- and 20-amp receptacles installed in enclosed offices, conference rooms, rooms used primarily for copy or print functions, breakrooms, classrooms and individual workstations, including those installed in modular partitions and module office workstation systems.
2. At least 50 percent of branch circuit feeders installed for modular furniture not shown on the construction documents.

~~C405.10.1~~C405.11.1 **Automatic receptacle control function.** Automatic receptacle controls shall comply with the following:

1. Either split controlled receptacles shall be provided with the top receptacle controlled, or a controlled receptacle shall be located within 12 inches (304.8 mm) of each uncontrolled receptacle.

2. One of the following methods shall be used to provide control:
   2.1. A scheduled basis using a time-of-day operated control device that turns receptacle power off at specific programmed times and can be programmed separately for each day of the week. The control device shall be configured to provide an independent schedule for each portion of the building of not more than 5,000 square feet (464.5 $m^2$) and not more than one floor. The occupant shall be able to manually override an area for not more than 2 hours. Any individual override switch shall control the receptacles of not more than 5,000 feet (1524 m).
   2.2. An occupant sensor control that shall turn off receptacles within 20 minutes of all occupants leaving a space.
   2.3. An automated signal from another control or alarm system that shall turn off receptacles within 20 minutes after determining that the local area is unoccupied.
3. All controlled receptacles shall be permanently marked in accordance with NFPA 70 and be uniformly distributed throughout the space.
4. Plug-in devices shall not comply.

**Exception**: Automatic receptacle controls are not required for the following:

1. Receptacles specifically designated for equipment requiring continuous operation (24 hours per day, 365 days per year).
2. Spaces where an automatic control would endanger the safety or security of the room or building occupants.
3. Within a single modular office workstation, noncontrolled receptacles are permitted to be located more than 12 inches (304.8 mm), but not more than 72 inches (1828 mm) from the controlled receptacles serving that workstation.

~~C405.11~~C405.12 **Voltage drop.** The total *voltage drop* across the combination of customer-owned service conductors, feeder conductors and branch circuit conductors shall not exceed five percent.

~~C405.12~~C405.13 **Alternating current-output uninterruptible power supplies (AC-output UPS).** *AC-output UPS* systems serving a *computer room* shall meet or exceed the calculation and testing requirements identified in ENERGY STAR Program Requirements for Uninterruptible Power Supplies (UPSs) – Eligibility Criteria Version 2.0.

**Exception:** AC-output UPC that utilizes standardized NEMA-1-15P or NEMA 5-15P input plug, as specified in ANSI/NEMA WD 6.

**C405.14 Inverters.** Direct-current-to-alternating-current inverters serving on-site renewable energy systems or on-site electrical energy storage systems (ESS) shall be compliant with IEEE 1547 and UL 1741.

~~C405.13~~C405.15 **Commissioning.** Controlled receptacles and lighting systems shall be commissioned in accordance with Section C408.

## SECTION C406
## EFFICIENCY PACKAGES

**C406.1 Additional energy efficiency and load management measures credit requirements.** The project as defined in the building permit shall meet the following requirements as applicable:

1. New buildings, changes in space conditioning category, change of occupancy group, and building additions in accordance with Chapter 5 shall comply with sufficient measures from Section C406.2 so as to achieve the minimum number required efficiency credits shown in Table C406.1.
2. New buildings greater than 5000 gross square feet of floor area shall comply with sufficient measures from Section C406.3 so as to achieve the minimum number of required load management credits shown in Table C406.1.
3. Tenant spaces shall comply in accordance with Section C406.1.1.
4. Projects using discrete area credit weighting shall comply in accordance with Section C406.1.2.

**Exceptions:**

1. Low energy spaces in accordance with Section C402.1.1.1, equipment buildings in accordance with Section C402.1.2, unconditioned spaces, open parking garages, and enclosed parking garages that comply with sufficient measures from Table C406.2(1) to achieve a minimum of 50 percent of the efficiency credits required for new construction. Such projects shall be exempt from the load management requirements in Table C406.1.
2. Building additions that have less than 1,000 square feet of *conditioned floor area* that comply with sufficient measures from Table C406.2(1) to achieve a minimum of 50 percent of the efficiency credits required for additions.
3. Warehouses are exempt from the load management credit requirements in Table C406.1.

**TABLE C406.1**
**ENERGY MEASURE CREDIT REQUIREMENTS**

| Required Credits for Projects | Section | Occupancy Group | | | | | |
|---|---|---|---|---|---|---|---|
| | | Group R-1 | Group R-2 | Group B | Group E | Group M | All Other |
| New building energy efficiency credit requirement | C406.2 | 54 | 41 | 42 | 48 | 74 | 49 |
| Building additions energy efficiency credit requirement | C406.2 | 27 | 20 | 21 | 23 | 36 | 21 |
| New building load management credit requirement | C406.3 | 12 | 15 | 27 | 15 | 13 | 26 |

**C406.1.1 Tenant spaces.** An Initial tenant improvement shall comply with sufficient measures from Table C406.2(1) to achieve a minimum of efficiency credits required in Table C406.1 and are not required to achieve any load management credits. In projects with multiple tenant spaces, each tenant space is permitted to apply for different measures provided the weighted average of all areas in the project comply with the overall efficiency credit requirement in Table C406.1. Whole building or addition energy credits shall be allocated to tenant spaces in accordance with Sections C406.1.1.1 and C406.1.1.2.

**Exceptions:**

1. An initial tenant improvement where the core and shell building complied via Section C407 in 2018 or later edition of the Washington State Energy Code.
2. Previously occupied tenant spaces in existing buildings that complies with this code in accordance with Section C501.

**C406.1.1.1 Applicable envelope, renewable and elevator energy credits.** Where an entire building or building addition complies with Section C406.2.5, C406.2.12, C406.2.10, or C406.2.18, under an initial tenant improvement permit, tenant spaces within the building qualify for the number of credits assigned to the occupancy group of the tenant space in accordance with Table C406.2(1). Where prior energy credits were achieved under the 2018 Washington State Energy Code, they shall be multiplied by 6 for applicability to this code.

**C406.1.1.2 Applicable HVAC and service water heating credits**. Where HVAC and service water heating systems and services are installed and comply with Section C406.2.2, C406.2.8, C406.2.9, orC406.2.10 under an initial tenant improvement permit, those systems and services shall be considered a part of the tenant space. Tenant spaces qualify for the credits assigned to the occupancy group of the tenant space in accordance with Table C406.2(1) if the tenant space includes the distribution system and equipment that the central HVAC systems or service water heating systems were designed to support.

**C406.1.2 Discrete area-weighted project compliance.** Discrete building areas are permitted to select different packages of measures provided that the whole project complies with both the energy and load management credit requirements. Compliance shall be determined as follows:

1. Required project credits shall be prorated on an area-weighted basis for each occupancy group by multiplying the occupancy group floor area by the number of credits required, and then dividing this value by the total area of all the occupancy groups combined. Where one occupancy group is less than 10 percent of the floor area of the project, use the primary occupancy group for those credits.
2. Occupancies are permitted to be subdivided into discrete areas, with required and achieved credits for each area prorated on an area-weighted basis as required for the occupancy group.
3. Where envelope or lighting power credits in Section C406.2.3.1, C406.2.3.2, or C406.2.3.12 are applied, the lighting power or envelope UA percentage reduction shall be calculated for the project as a whole to determine achieved credits.
4. Determine total project credits achieved by area-weighting the achieved credits by occupancy group in the same manner as for required project credits.
5. A project complies when the achieved number of area-weighted energy and load management credits are equal to or greater than the required area-weighted number of credits.

**C406.2 Additional energy efficiency credit measures.** Each energy efficiency credit measure used to meet credit requirements for the project shall include efficiency that is greater than the energy efficiency required for the building type and configuration requirements in Sections C402 through C405. Measures installed in the project that meet the requirements in Sections C406.2.1 through C406.2.14 shall achieve the credits listed for the measure and occupancy group in Table C406.2(1) or Table C406.2(2) or where calculations required by Sections C406.2.1 through C406.2.14 create or modify the table credits, the credits achieved shall be based upon the section calculations.

Projects that chose to comply with the fossil fuel pathway in Section C401.3 shall use Table C406.2(2) to achieve credits.

For mixed fuel space heating systems, the number of space heating energy efficiency credits available for measures with a prorating flag "Heat" are calculated using ~~the following~~ equation 4-14:

$$C_{SH} = CHP_{SH} \times B/C + CFF_{SH} \times (1 - B/C) \quad \textbf{(Equation 4-14)}$$

Where:

| | | |
|---|---|---|
| $C_{SH}$ | = | Blended credits for mixed fuel systems. |
| $CHP_{SH}$ | = | Credits available in Table C406.2(1). |
| $CFF_{SH}$ | = | Credits available in Table C406.2(2). |
| B | = | Installed space heating capacity in kBTU/h of space heating appliances that comply with any of the exceptions to Section C403.1.4. |
| C | = | Total installed space heating capacity in kBTU/h of all space heating appliances. |

For mixed fuel service water heating systems, the number of service water heating energy efficiency credits available for measures with a prorating flag "SWH" are calculated using ~~the following~~ equation 4-15:

$$C_{WH} = CHP_{WH} \times B/C + CFF_{WH} \times (1 - B/C) \quad \textbf{(Equation 4-15)}$$

Where:

| | | |
|---|---|---|
| $C_{WH}$ | = | Blended credits for mixed fuel systems. |
| $CHP_{WH}$ | = | Credits available in Table C406.2(1). |

$CFF_{WH}$ = Credits available in Table C406.2(2).

B = Installed service water heating capacity in kBTU/h of service water heating appliances that comply with any of the exceptions to Section C404.2.1.

C = Total installed service water heating capacity in kBTU/h of all service water heating appliances.

**TABLE C406.2(1)**
**EFFICIENCY MEASURE CREDITS**

| Measure Title | Applicable Section | Prorating Flag | Occupancy Group | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Group R-1 | Group R-2 | Group B | Group E | Group M | All Other |
| 1. Dwelling unit HVAC control | C406.2.1 | Heat | NA | 7 | NA | NA | NA | NA |
| 2. Improved HVAC TSPR[a] | C406.2.2.1 | Heat | NA | 8 | 11 | 17 | 22 | NA |
| 3. Improve cooling and fan efficiency | C406.2.2.2 | Heat | 2 | 2 | 3 | 4 | 3 | 2 |
| 4. Improve heating efficiency | C406.2.2.3 | Heat | 2 | 3 | 3 | 10 | 16 | 7 |
| 5. Improved low-carbon district energy system (10% better) | C406.2.2.4 | | 3 | 3 | 4 | 11 | 17 | 8 |
| 6. Improved low-carbon district energy system (20% better)[b] | C406.2.2.5 | | 9 | 10 | 12 | 33 | 52 | 24 |
| 7. High performance DOAS | C406.2.2.6 | Heat | 31 | 31 | 21 | 39 | 40 | 21/ (A) 40[c] |
| 8. Fault detection & diagnostics (FDD) | C406.2.2.7 | Heat | 2 | 2 | 2 | 6 | 9 | 4 |
| 9. 10% reduced lighting power | C406.2.3.1 | Heat | 7 | 4 | 18 | 16 | 20 | 15 |
| 10. 20% reduced lighting power[d] | C406.2.3.2 | Heat | 13 | 8 | 36 | 32 | 40 | 29 |
| 11. Lamp efficacy improvement | C406.2.3.3 | Heat | 5 | 6 | NA | NA | NA | NA |
| 12. Residential lighting control | C406.2.4.1 | Heat | NA | 8 | NA | NA | NA | NA |
| 13. Enhanced lighting control | C406.2.4.2 | Heat | 1 | 1 | 6 | 6 | 11 | 6 |
| 14. Renewable energy | C406.2.5 | | 7 | 12 | 13 | 13 | 10 | 11 |
| 15. Shower drain heat recovery | C406.2.6.1 | SWH | 9 | 30 | NA | 3 | NA | NA |
| 16. Service water heat recovery | C406.2.6.2 | SWH | 35 | 111 | 13 | 14 | (Grocery) 41[e] | NA |
| 17. Heat pump water heating | C406.2.6.3 | SWH | 72 | 54 | 1 | 13 | (Grocery) 5[e] | 29[f] |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 18. High efficiency service water heating, gas-fired | C406.2.6.4 | SWH | NA | NA | NA | NA | NA | NA |
| 19. Heat trace system | C406.2.7.1 | SWH | 6 | 13 | 4 | 1 | NA | 6 |
| 20. Point of use water heater | C406.2.7.2 | SWH | NA | NA | 19 | 5 | NA | NA |

*-Continued-*

**TABLE C406.2(1) - Continued**
**EFFICIENCY MEASURE CREDITS**

| Measure Title | Applicable Section | Prorating Flag | Occupancy Group | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Group R-1 | Group R-2 | Group B | Group E | Group M | All Other |
| 21. Service hot water distribution right sizing | C406.2.8 | | 13 | 42 | NA | NA | NA | NA |
| 22. High performance service hot water temperature maintenance system | C406.2.9 | | 6 | 13 | 4 | 1 | NA | 6 |
| 23. High efficiency service hot water circulation system | C406.2.10 | | 3 | 6 | 2 | 1 | NA | 4 |
| 24. Low flow residential showerheads | C406.2.11 | SWH | 3 | 3 | NA | NA | NA | NA |
| 25. Enhanced envelope performance[g] | C406.2.12 | Heat | 24 | 20 | 13 | 5 | 19 | 14 |
| 26. Base reduced air leakage[g] | C406.2.13.1 | | 29 | 24 | 6 | 3 | 9 | 11 |
| 27. Enhanced reduced air leakage[g] | C406.2.13.2 | Heat | 53 | 44 | 11 | 5 | 16 | 20 |
| 28. Enhanced commercial kitchen equipment | C406.2.14 | Heat | 30[h] | 18[h] | 18[h] | 30[h] | 30[h] | 31[h] |
| 29. Enhanced residential kitchen equipment | C406.2.15 | Heat | 12 | 19 | NA | NA | NA | NA |
| 30. Enhanced residential laundry equipment | C406.2.16 | Heat | NA | 6 | NA | NA | NA | NA |
| 31. Heat pump clothes dryers | C406.2.17 | Heat | 6 | 6 | NA | NA | NA | NA |
| 32. Efficient elevator equipment | C406.2.18 | Heat | 3 | 5 | 5 | 5 | 4 | 4 |

a. Projects using Item 2 shall not use Items 3, 4 or 7.

b. Projects using C406.2.2.5 shall not use C406.2.2.4.

c. For C406.2.2.6, occupancy Group A achieves 40 credits while other occupancy groups within the "all other" category achieve 21 credits.

d. Projects using C406.2.3.2 shall not use C406.2.3.1.

e. Service water heat recovery and heat pump water heating are available in Group M only for grocery stores larger than 10,000 $ft^2$. Large mixed retail with full grocery and butcher sections shall achieve half the credits. This credit is not available where refrigeration recovery to heat service hot water is used to meet the requirements of Section C403.9.2.3.

f. Heat pump water heating efficiency credits are available in the "all other" category only for Group A-2.

g. Buildings or building areas that are exempt from the thermal envelope requirements in accordance with Sections C402.1.1 and C402.1.2, do not qualify for this package.

h. Additional energy efficiency credits, up to the maximum shown in Table C406.2(1), shall be calculated according to Section C406.2.14.

**TABLE C406.2(2)**
**EFFICIENCY MEASURE CREDITS FOR USE WITH**
**FOSSIL FUEL COMPLIANCE PATH**

| Measure Title | Applicable Section | Prorating Flag | Occupancy Group | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Group R-1 | Group R-2 | Group B | Group E | Group M | All Other |
| 1. Dwelling unit HVAC control | C406.2.1 | Heat | NA | 8 | NA | NA | NA | NA |
| 2. Improved HVAC TSPR[a] | C406.2.2.1 | Heat | NA | 9 | 12 | 19 | 24 | NA |
| 3. Improve cooling and fan efficiency | C406.2.2.2 | Heat | 12 | 8 | 14 | 8 | 10 | 10 |
| 4. Improve heating efficiency | C406.2.2.3 | Heat | 2 | 3 | 3 | 11 | 18 | 8 |
| 5. Improved low-carbon district energy system (10% better) | C406.2.2.4 | | 3 | 3 | 4 | 12 | 19 | 9 |
| 6. Improved low-carbon district energy system (20% better)[b] | C406.2.2.5 | | 10 | 11 | 13 | 36 | 57 | 26 |
| 7. High performance DOAS | C406.2.2.6 | Heat | 34 | 34 | 23 | 43 | 44 | 23/ (A) 40[c] |
| 8. Fault detection & diagnostics (FDD) | C406.2.2.7 | Heat | 2 | 2 | 2 | 6 | 9 | 4 |
| 9. 10% reduced lighting power | C406.2.3.1 | Heat | 7 | 4 | 18 | 16 | 20 | 15 |
| 10. 20% reduced lighting power[d] | C406.2.3.2 | Heat | 13 | 8 | 36 | 32 | 40 | 29 |
| 11. Lamp efficacy improvement | C406.2.3.3 | Heat | 5 | 6 | NA | NA | NA | NA |
| 12. Residential lighting control | C406.2.4.1 | Heat | NA | 8 | NA | NA | NA | NA |
| 13. Enhanced lighting control | C406.2.4.2 | Heat | 1 | 1 | 6 | 6 | 11 | 6 |
| 14. Renewable energy | C406.2.5 | | 7 | 12 | 13 | 13 | 10 | 11 |
| 15. Shower drain heat recovery | C406.2.6.1 | SWH | 10 | 33 | NA | 3 | NA | NA |
| 16. Service water heat recovery | C406.2.6.2 | SWH | 35 | 111 | 13 | 14 | (Grocery) 41[e] | NA |
| 17. Heat pump water heating | C406.2.6.3 | SWH | 135 | 163 | 17 | 33 | (Grocery) 95[e] | (A-2) 95[f] |
| 18. High efficiency service water heating, gas-fired | C406.2.6.4 | SWH | 59 | 65 | 6 | 11 | 18 | 32 |
| 19. Heat trace system | C406.2.7.1 | SWH | 6 | 13 | 4 | 1 | NA | 6 |

**TABLE C406.2(2) - continued**
**EFFICIENCY MEASURE CREDITS FOR USE WITH FOSSIL FUEL COMPLIANCE PATH**

| Measure Title | Applicable Section | Prorating Flag | Occupancy Group | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Group R-1 | Group R-2 | Group B | Group E | Group M | All Other |
| 20. Point of use water heater | C406.2.7.2 | SWH | NA | NA | 19 | 5 | NA | NA |
| 21. Service hot water distribution right sizing | C406.2.8 | | 13 | 42 | NA | NA | NA | NA |
| 22. High performance service hot water temperature maintenance system | C406.2.9 | | 6 | 13 | 4 | 1 | NA | 6 |
| 23. High efficiency service hot water circulation system | C406.2.10 | | 3 | 6 | 2 | 1 | NA | 4 |
| 24. Low flow residential showerheads | C406.2.11 | SWH | 3 | 3 | NA | NA | NA | NA |
| 25. Enhanced envelope performance[g] | C406.2.12 | Heat | 24 | 20 | 13 | 5 | 19 | 14 |
| 26. Base reduced air leakage[g] | C406.2.13.1 | | 29 | 24 | 6 | 3 | 9 | 11 |
| 27. Enhanced reduced air leakage[g] | C406.2.13.2 | Heat | 53 | 44 | 11 | 5 | 16 | 20 |
| 28. Enhanced commercial kitchen equipment | C406.2.14 | Heat | 30[h] | 18[h] | 18[h] | 30[h] | 30[h] | 31[h] |
| 29. Enhanced residential kitchen equipment | C406.2.15 | Heat | 12 | 19 | NA | NA | NA | NA |
| 30. Enhanced residential laundry equipment | C406.2.16 | Heat | NA | 6 | NA | NA | NA | NA |
| 31. Heat pump clothes dryers | C406.2.17 | Heat | 6 | 6 | NA | NA | NA | NA |
| 32. Efficient elevator equipment | C406.2.18 | Heat | 3 | 5 | 5 | 5 | 4 | 4 |

a. Projects using Item 2 shall not use Items 3,4 or 7.

b. Projects using C406.2.2.5 shall not use C406.2.2.4.

c. For C406.2.2.6, occupancy Group A achieves 40 credits while other occupancy groups within the "all other" category achieve 21 credits.

d. Projects using C406.2.3.2 shall not use C406.2.3.1.

e. Service water heat recovery and heat pump water heating are available in Group M only for grocery stores larger than 10,000 $ft^2$. Large mixed retail with full grocery and butcher sections shall achieve half the credits. This credit is not available where refrigeration recovery to heat service hot water is used to meet the requirements of Section C403.9.2.3.

f. Heat pump water heating efficiency credits are available in the "all other" category only for Group A-2.

g. Buildings or building areas that are exempt from the thermal envelope requirements in accordance with Sections C402.1.1 and C402.1.2, do not qualify for this package.

h. Additional energy efficiency credits, up to the maximum shown in Table C406.2(2), shall be calculated according to Section C406.2.14.

**C406.2.1 Dwelling unit HVAC controls.** HVAC systems serving *dwelling units* or *sleeping units* shall be controlled with a programmable *thermostat* that is configured to automatically activate a setback condition of at least 5°F (3°C) for both heating and cooling. The programmable *thermostat* shall be configured to provide setback during occupied sleep periods. The unoccupied setback mode shall be configured to operate in conjunction with one of the following:

1. A manual main control device by each *dwelling unit* main entrance that initiates setback for all HVAC units in the *dwelling unit* and is clearly identified as "Heating/Cooling Master Setback."
2. Occupancy sensors in each room of the *dwelling unit* combined with a door switch to initiate setback for all HVAC units in the dwelling within 20 minutes of all spaces being vacant immediately following a door switch operation. Where separate room HVAC units are used, an individual occupancy sensor on each unit that is configured to provide setback shall meet this requirement.
3. An advanced learning thermostat that senses occupant presence and automatically creates a schedule for occupancy and provides a dynamic setback schedule based on when the spaces are generally unoccupied.
4. An automated control and sensing system that uses geographic sensing connected to the *dwelling unit* occupants' cell phones and initiates the setback condition when all occupants are away from the building.

**C406.2.2 More efficient HVAC system performance.** All heating and cooling systems shall meet the minimum requirements of Section C403 and efficiency improvements shall be referenced to the minimum efficiency requirements listed in the tables in Section C403.3.2. Where multiple efficiency requirements are listed, equipment shall meet the seasonal efficiencies including SEER, EER/IEER, IPLV or AFUE. Equipment that is larger than the maximum capacity range indicated in the tables in Section C403.3.2 shall utilize the values listed for the largest capacity equipment for the associated equipment type shown in the table. Where multiple individual heating or cooling systems serve the project, the improvement shall be the weighted average improvement based on individual system capacity.

For occupancies and systems required to comply with Section C403.1.1, credits are permitted to be achieved by meeting the requirements of Section C406.2.2.1. Other systems are permitted to achieve credits by meeting the requirements of either:

1. Section C406.2.2.2, More efficient HVAC equipment cooling and fan performance.
2. Section C406.2.2.3, More efficient HVAC equipment heating performance.
3. Section C406.2.2.6, High performance dedicated outdoor air system (DOAS).
4. Any combination of Sections C406.2.2.2, C406.2.2.3, and C406.2.2.6.

In addition, energy credits are permitted to be achieved for Section C406.2.2.7, Fault detection and diagnostics, where not otherwise required by Section C403.2.3 or C403.6.10(15).

**C406.2.2.1 Improved HVAC TSPR.** For systems required to comply with Section C403.1.1, the *HVAC TSPR* shall exceed the minimum requirement by five percent. If improvement is greater, the credits in Table C406.2(1) are permitted to be prorated up to a 20 percent improvement.

**C406.2.2.2 More efficient HVAC equipment cooling and fan performance.** No less than 90 percent of the total HVAC capacity serving the total *conditioned floor area* of the entire building, building addition or tenant space in accordance with Section C406.1.1 shall comply with Sections C406.2.2.2.1 through C406.2.2.2.3. Where individual equipment efficiencies vary, weigh them based on capacity.

**C406.2.2.2.1 HVAC system selection.** Equipment installed shall be types that are listed in the tables in Section C403.3.2.

**C406.2.2.2.2 Cooling equipment efficiency.** Equipment shall exceed the minimum cooling efficiency requirements listed in the tables in Section C403.3.2 by at least 5 percent. Where equipment exceeds the

minimum annual cooling efficiency and heat rejection efficiency requirements by more than 5 percent, energy efficiency credits for cooling shall be determined using Equation ~~4-15~~4-16, rounded to the nearest whole number.

**(Equation ~~4-15~~4-16)**

$$\mathrm{EEC_{HEC}} = \mathrm{EEC_5} \times \left[1 + \frac{\mathrm{CEI} - 0.05\mathrm{t}}{0.05}\right]$$

Where:

$\mathrm{EEC_{HEC}}$ = Energy efficiency credits for cooling efficiency improvement

$\mathrm{EEC_5}$ = Section C406.2.2.2 credits from Table C406.2(1)

CEI = The lesser of the improvement above minimum cooling efficiency requirements, minimum heat rejection efficiency requirements, or 20 percent (0.20). Where cooling efficiency varies by system, use the capacity weighted average efficiency improvement for all cooling equipment combined. The CEI expressed as a fraction shall be determined one of the following ways:

For metrics that increase as efficiency increases, CEI shall be calculated as follows:

$$CEI = \frac{CM_{DES}}{CM_{MIN}} - 1$$

For metrics that decrease as efficiency increases, CEI shall be calculated as follows:

$$CEI = \frac{CM_{MIN}}{CM_{DES}} - 1$$

Where:

$\mathrm{CM_{DES}}$ = Design cooling efficiency metric, part-load or annualized where available.

$\mathrm{CM_{MIN}}$ = Minimum required cooling efficiency metric, part-load or annualized where available from Section C403.3.2.

For data centers using ASHRAE 90.4, CEI shall be calculated as follows:

$$CEI = \frac{AMLC_{MAX}}{AMLC_{DES}} - 1$$

Where:

$\mathrm{AMLC_{DES}}$ = As-designed annualized mechanical load component calculated in accordance with ASHRAE 90.4 Section 6.5.

$\mathrm{AMLC_{MAX}}$ = Maximum annualized mechanical load component from ASHRAE 90.4 Table 6.5.

**C406.2.2.2.3 Minimum fan efficiency.** Where fan energy is not included in packaged equipment rating or it is and the fan size has been increased from the as-rated equipment condition, fan power or horsepower shall be less than 95 percent of the allowed fan power in Section C403.8.1.

**C406.2.2.3 More efficient HVAC equipment heating performance.** No less than 90 percent of the total HVAC capacity serving the total *conditioned floor area* of the entire building, building addition or tenant space in accordance with Section C406.1.1 shall comply with Sections C406.2.2.3.1 through C406.2.2.3.2.

**C406.2.2.3.1 HVAC system selection.** Equipment installed shall be types that are listed in the tables in Section C403.3.2. Electric resistance heating shall be limited to 20 percent of system capacity, with the exception of heat pump supplemental heating.

**C406.2.2.3.2 Heating equipment efficiency.** Equipment shall exceed the minimum heating efficiency requirements of the tables in Section C403.3.2 by at least 5 percent. Where equipment exceeds the minimum annual heating efficiency requirements by more than 5 percent, energy efficiency credits for heating shall be determined using Equation ~~4-16~~4-17, rounded to the nearest whole number.

**(Equation ~~4-16~~4-17)**

$$EEC_{HEH} = EEC_5 \times \left[1 + \frac{HEI - 0.05}{0.05}\right]$$

Where:

$\mathrm{EEC_{HEH}}$ = Energy efficiency credits for heating efficiency

improvement.

$EEC_5$ = Section C406.2.2.2 credits from Table C406.2(1).

HEI = The lesser of the improvement above minimum heating efficiency requirements or 20 percent (0.20). Where heating efficiency varies by system, use the capacity weighted average percentage for all heating equipment combined. For metrics that increase as efficiency increases, HEI shall be calculated as follows:

$$HEI = \frac{HM_{DES}}{HM_{MIN}} - 1$$

Where:

$HM_{DES}$ = Design heating efficiency metric, part-load or annualized where available.

$HM_{MIN}$ = Minimum required heating efficiency metric, part-load or annualized where available from Section C403.3.2.

**Exception:** In low energy spaces complying with Section C402.1.1 and *semi-heated spaces* complying with Section C402.1.1.2, no less than 90 percent of the installed heating capacity is provided by electric infrared or gas-fired radiant heating equipment for localized heating applications. Such spaces shall achieve credits for $EEC_5$.

**C406.2.2.4 Improved low-carbon district energy systems (10 percent better).** Not less than 90 percent of the annual service hot water and space heating load, or not less than 90 percent of the annual service hot water, space heating, and space cooling load shall meet the criteria of Section C406.2.2.4.1 or C406.2.2.4.2.

Documentation for the low-carbon district system that is operational prior to the final inspection shall be provided to demonstrate that the definition as modified in Section C406.2.2.4.1 or C406.2.2.4.2 of *low-carbon district energy exchange system* is satisfied.

**C406.2.2.4.1 Improved low-carbon district energy exchange systems (10 percent better).** Low-carbon district energy exchange systems must demonstrate the following:

1. Forty-five percent of the annual district-system-net-load-met (sum of heating and cooling energy provided to attached buildings) comes from heat recovery between connected buildings, waste heat, or renewable energy resources; and
2. No more than 25 percent of the annual heat input to the system comes from fossil fuel or electric-resistance sources.

**C406.2.2.4.2 Improved low-carbon district energy heating and cooling or heating only systems (10 percent better).** Distribution losses must be accounted for and may not exceed 5 percent of the annual load delivered to buildings served by the system. *Low-carbon district energy heating and cooling or heating only systems* must demonstrate the following:

1. Forty-five percent of the annual district-system-net-load-met (sum of heating and cooling energy provided to attached buildings) comes from heat recovery between connected buildings, waste heat, or renewable energy resources and no more than 25 percent of the annual heat input to the system comes from fossil fuel or electric-resistance sources; or
2. No more than 10 percent of the system annual heat input to the system comes from fossil fuels or electric-resistance sources. The remaining annual heat input must be provided using heat pump technology with a minimum annual operating COP of 3.0.

**C406.2.2.5 Improved low-carbon district energy systems (20 percent better).** Not less than 90 percent of the annual service hot water and space heating load, or not less than 90 percent of the annual service hot water, space heating, and space cooling load shall meet the criteria of Section C406.2.2.5.1 or C406.2.2.5.2.

Documentation for the low-carbon district system that is operational prior to the final inspection shall be provided to demonstrate that the definition as modified in Section C406.2.2.4.1 or C406.2.2.4.2 of *low-carbon district energy exchange system* is satisfied.

**C406.2.2.5.1 Improved low-carbon district energy exchange systems (20 percent better).** Low-carbon district energy exchange systems must demonstrate the following:

1. Fifty percent of the annual district-system-net-load-met (sum of heating and cooling energy provided to attached buildings) comes from heat recovery between connected buildings, waste heat, or renewable energy resources; and
2. No more than 10 percent of the annual heat input to the system comes from fossil fuel or electric-resistance sources.

**C406.2.2.5.2 Improved low-carbon district energy heating and cooling or heating only systems (20 percent better).** Distribution losses must be accounted for and may not exceed 5 percent of the annual load delivered to buildings served by the system. *Low-carbon district energy heating and cooling or heating only systems* must demonstrate the following:

1. Fifty percent of the annual district-system-net-load-met (sum of heating and cooling energy provided to attached buildings) comes from heat recovery between connected buildings, waste heat, or renewable energy resources and no more than 10 percent of the annual heat input to the system comes from fossil fuel or electric-resistance sources; or
2. No more than 10 percent of the system annual heat input to the system comes from fossil fuels or electric-resistance sources. The remaining annual heat input must be provided using heat pump technology with a minimum annual operating COP of 4.0.

**C406.2.2.6 High performance dedicated outdoor air system (DOAS).** No less than 90 percent of the total conditioned floor area of the whole project, excluding floor area of unoccupied spaces that do not require ventilation as specified by the *International Mechanical Code*, shall be served by DOAS installed in accordance with Section C403.3.5 with the following adjustments:

1. Minimum heat recovery sensible effectiveness of 80 percent, calculated in accordance with Section C403.3.5.1.
2. Where design outdoor airflow is greater than 500 cfm (250 L/s), the DOAS shall be equipped with an economizer bypass, damper control, or wheel speed control that is active between 55°F (13°C) and 75°F (24°C) outdoor air temperature and minimizes energy recovery or maintains an appropriate DOAS leaving air temperature when the building is generally in cooling, based either on outdoor air temperature or a DDC zone-based cooling system reset.
3. DOAS total combined fan power shall be less than either:
   3.1. 0.769 W/cfm (1.55 W/L/s) when calculated in accordance with Section C403.3.5.2.
   3.2. Eighty percent of fan power allowance for a constant volume system when calculated in accordance with Section C403.8.1.

This option is not available to areas served by systems utilizing Section C403.2.2.1 exception 5.

**C406.2.2.7 Fault detection and diagnostics system.** A project not required to comply with Section C403.2.3 or C403.6.10(16) shall achieve energy credits for installing a fault detection and diagnostics system to monitor the HVAC system's performance and automatically identify faults. The installed system shall comply with items 1 through 6 in Section C403.2.3.

**C406.2.3 Reduced lighting power.** Interior lighting within the whole project shall achieve credits by complying with Section C406.2.3.1 or C406.2.3.2. In Group R-1 and Group R-2 occupancies, dwelling and sleeping units shall comply with Section C406.2.3.3 and all other areas shall comply with section C406.2.3.1 or C406.2.3.2. Credits apply to the whole Group R-1 or Group R-2 area.

**C406.2.3.1 Reduced lighting power option 1.** The total connected interior lighting power calculated in accordance with Section C405.4.1 shall be 90 percent or less of the lighting power values specified in Table C405.4.2(1) times the floor area for the building types, or 90 percent or less of the total interior lighting power allowance calculated in accordance with Section C405.4.2.

**C406.2.3.2 Reduced lighting power option 2.** The total connected interior lighting power calculated in accordance with Section C405.4.1 shall be 80 percent or less of the lighting power values specified in Table C405.4.2(1) times the floor area of the building types, or 80 percent or less of the total interior lighting power allowance calculated in accordance with Section C405.4.2.

**C406.2.3.3 Lamp efficacy.** No less than 95 percent of the permanently installed light fixtures in dwelling

units and sleeping units shall be provided by lamps with a minimum efficacy of 90 lumens per watt.

**C406.2.4 Lighting controls.** For buildings with nontransient *dwelling units* and *sleeping units*, energy credits shall be achieved by installation of systems that comply with the requirements of Section C406.2.4.1. All other buildings shall achieve energy credits by complying with Section C406.2.4.2. For buildings with mixed occupancies, credits shall be prorated based on floor area.

**C406.2.4.1 Residential building lighting control.** In buildings with nontransient dwelling units and sleeping units, lighting controls shall be configured to meet the following:

1. Each *dwelling unit* or *sleeping unit* shall have a main control by the main entrance that turns off all the lights and switched receptacles in the unit. The main control shall be permitted to have two controls, one for permanently wired lighting and one for switched receptacles. The main controls shall be clearly identified as "lights master off" and "switched outlets master off."
2. Switched receptacles shall be clearly identified and all switched receptacles shall be located within 12 inches of an unswitched receptacle. Each room shall have a minimum of two switched receptacles except bathrooms, kitchens, and closets.

**C406.2.4.2 Enhanced digital lighting controls.** Measure credits shall be achieved where no less than 50 percent of the gross floor area within the project has luminaires and lighting controls that include high end trim in compliance with Section C405.2.8.3 and either *luminaire-level lighting controls* in compliance with Section C405.2.8.1 or networked lighting controls in accordance with Section C405.2.8.2. Where *general lighting* in more than 50 percent of the gross floor area complies, the base credits from Table C406.2(1) shall be prorated as follows:

[Floor area with high end trim, %] x [Base energy credits for C406.2.4.2] / 50%

**C406.2.5 On-site and off-site renewable energy.** Projects installing on-site or off-site renewable energy systems with a capacity of at least 0.1 watts per gross square foot (1.08 W/m$^2$) of building area in addition to the renewable energy capacity required elsewhere in this code shall achieve energy credits for this measure. Renewable energy systems achieving energy credits shall not be used to satisfy other requirements of this code. Off-site renewable energy systems shall comply with Sections C411.2.2 and C411.2.3. Credits shall be prorated from the table value in accordance with Equation ~~4-17~~4-18.

**(Equation ~~4-17~~4-18)**

$$AEC_{RRa} = AEC_b \times \frac{\sum(REF \times RR_t) - RR_r}{RR_b \times PGFA}$$

Where:

| | | |
|---|---|---|
| $AEC_{RRa}$ | = | Section C406.2.5 achieved energy credits for this project as calculated in accordance with Equation ~~4-17~~4-18, limited to 50 percent of the required credits in Section C406.1. |
| $RR_t$ | = | Actual total rating of on-site and off-site renewable energy systems (W) for each type of renewable energy source in Table C411.2.1. |
| $RR_r$ | = | Rating of renewable energy systems required by Section C411.1, other sections in this code, or used to qualify for exceptions in this code (W). |
| $RR_b$ | = | 0.1 W/square foot (1.08 W/m$^2$) |
| PGFA | = | Project gross floor area, square feet (m$^2$) |
| $AEC_b$ | = | Section C406.2.5 base credits from Table C406.2. |
| REF | = | Renewable Energy Factor from Table C411.2.1. |

*Informative Note*: *On-site renewable energy may include thermal service water heating or pool water heating, in which case ratings in Btu/h can be converted to W where W = Btu/h / 3.413.*

**C406.2.6 Reduced energy use in service water heating.** Buildings with service hot water heating equipment that serves the whole building, building addition or tenant space shall achieve credits through compliance with:

1. Section C406.2.6.1, C406.2.6.2, or C406.2.6.3.
2. Sections C406.2.6.1 and C406.2.6.2.
3. Sections C406.2.6.1 and C406.2.6.3.

**C406.2.6.1 Shower drain heat recovery.** Shower drain heat recovery units shall comply with Section C404.10 and preheat cold water supply to the showers. Potable waterside pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. The efficiency of drain water heat recovery units shall be 54 percent in accordance with CSA B55.1. Full credits are applicable to the following building use types: Multi-family, hotel, motel, dormitory, and schools with locker room showers. Where not all showers in the project have drain heat recovery, the credit is adjusted based on the following:

[Section C406.2.6.1 table credits] x [Showers with drain recovery] / [Total number of showers]

**C406.2.6.2 Service water heating energy recovery.** Not less than 30 percent of the annual service hot water heating energy use, or not less than 70 percent of the annual service hot water heating energy use in buildings with condenser water systems subject to the requirements of Section C403.9.2.1 or qualifying for one of its exceptions, shall be provided by one or more of the following:

1. Waste heat recovery from service hot water, heat recovery chillers, building equipment, process equipment, or other *approved* system. Qualifying heat recovery must be above and beyond heat recovery required by other sections of this code.
2. On-site renewable energy water-heating systems where not used to meet other requirements or to obtain other energy credits.

**C406.2.6.3 Heat pump water heating.** Projects shall achieve credits through compliance with Section C406.2.6.3.1.

**C406.2.6.3.1 Heat pump water heater.** Credit shall be achieved where the primary heat pump service water heating system is sized to deliver no less than 100 percent of the net calculated demand for service water production during the peak demand period with entering dry bulb or wet bulb outdoor air temperatures at 40°F (4°C) for air-source heat pumps, or 44°F (7°C) ground temperature for ground-source heat pumps, as calculated suing the equipment manufacturer's selection criteria or another *approved* methodology. For this credit, the net calculated demand shall be the gross building demand less any portion of the demand complying with the exceptions to Section C404.2.1. Supplemental heating is permitted in accordance with Section C404.2.1, but cannot use fossil fuels. Heat pump water heaters shall comply with one of the following:

1. The COP rating shall be a minimum COP of 3.0 reported at the design leaving heat pump water temperature with an entering air temperature of 60°F (16°C) or lower. For water-source equipment, the COP rating will be reported at the design leaving load water temperature with an entering load water temperature of 74°F (23°C) or lower.
2. The uniform energy factor (UEF) shall be a minimum of 3.40 rated based on U.S. Department of Energy requirements.

**C406.2.6.4 High efficiency service water heating, gas-fired.** The credit achieved shall be from Table C406.2(2) where hot water is supplied by gas-fired equipment with minimum efficiency of 0.91 UEF.

**C406.2.7 Improved service hot water temperature maintenance.** For buildings with gross floor area greater than 10,000 square feet, credit shall be achieved when hot water temperature maintenance is installed in accordance with Section C406.2.7.1 or C406.2.7.2.

**C406.2.7.1 Self-regulated heat trace system.** The credit achieved shall be from Table C406.2(1). This system shall include self-regulating electric heat cables, connection kits and electronic controls. The cable shall be installed directly on the hot water supply pipes underneath the insulation to replace standby losses.

**C406.2.7.2. Point of use water heater.** The credit achieved shall be from Table C406.2(1) where any fixtures requiring hot water shall be supplied from a localized electric source of hot water with no recirculation or heat trace and limited to 2 kW and 6 gallons of storage. The supply pipe length from the point of use water heater to the termination of the fixture supply pipe shall be no more than 20 feet.

**C406.2.8 Service hot water distribution right sizing.** To achieve this credit, where Group R-1 and R-2 occupancies are served by a central service hot water system, the distribution system serving *dwelling units*, *sleeping units* and guestrooms shall be sized using Appendix M of the *Uniform Plumbing Code*.

**C406.2.9 High performance service hot water temperature maintenance system.** Systems with multiple riser service hot water circulation systems shall use only heat pump technology for temperature maintenance. The heat pump technology shall have a minimum COP of 3.0 or UEF of 3.4. For air-source equipment, the COP rating will be reported at the design leaving heat pump water temperature with an entering dry bulb air

temperature of 60°F (16°C) or lower and a relative humidity of 50 percent or lower. For water-source equipment, the COP rating will be reported at the design leaving load side water temperature with an entering source side water temperature of 74°F (23°C) or lower. The system shall comply with the requirements of Section C404.7.1.

**C406.2.10 High efficiency service hot water circulation system.** Multiple riser service hot water circulation systems shall use a variable volume circulation pump controlled to vary the pump speed based on system demand and shall include self-actuated thermostatic balancing valves to control the system flow at each riser.

**C406.2.11 Low flow showerheads for Group R-1 and R-2 occupancies.** All showerheads installed in Group R-1 and R-2 *dwelling units* or *sleeping units* shall have a maximum listed flowrate of 1.25 gallons per minute or less at 80 psi operating pressure for fixed showerheads and a maximum listed flowrate of 1.50 gallons per minute or less at 80 psi operating pressure for handheld showerheads. When a shower is served by more than one showerhead, including handheld showerheads, the combined flow rate of all showerheads and/or other shower outlets controlled by a single valve shall not exceed 1.25 gallons per minute or less for fixed or 1.5 gallons per minute or less for handheld, or the shower shall be designed to allow only one shower outlet to be in operation at a time.

**C406.2.12 Enhanced envelope performance.** The Proposed Total UA of the thermal envelope of the project shall be 15 percent lower than the Allowable Total UA determined in accordance with Section C402.1.5 and Equation 4-2.

**C406.2.13 Reduced air leakage.** Energy credits shall be achieved where measured air leakage of the total *conditioned floor area* of the whole building, fully isolated building addition or tenant space is determined in accordance with Section C402.5.1.2 and complies with the maximum leakage in either Section C406.2.13.1 or C406.2.13.2.

**C406.2.13.1 Base reduced air leakage.** Measured air leakage shall not exceed 68 percent of the maximum leakage allowed by Section C402.5.1.2.

**C406.2.13.2 Enhanced reduced air leakage.** Measured air leakage shall not exceed 33 percent of the maximum leakage allowed by Section C402.5.1.2.

**C406.2.14 Enhanced commercial kitchen equipment.** For buildings or areas designated as Group A-2, or facilities whose primary business type involves the use of a commercial kitchen with at least one gas or electric fryer, all fryers, dishwashers, steam cookers and ovens shall comply with all of the following:

1. Achieve the ENERGY STAR label in accordance with the specifications current as of January 1, 2022.
2. Be installed prior to the issuance of the certificate of occupancy.
3. Have the ENERGY STAR qualified model number listed on the construction documents submitted for permitting.

Energy efficiency credits for efficient commercial kitchen equipment shall be determined based on Equation 4-19, rounded to the nearest whole number.

**(Equation 4-19)**

$$AEEC_K = 20 \times \frac{Area_K}{Area_B}$$

Where:

$AEEC_K$ = Section C406.2.14 table credits, to a maximum of those allowed in Table C406.2(1) for this option.

$Area_K$ = Floor area of full-service kitchen ($ft^2$ or $m^2$).

$Area_B$ = Gross floor area of building ($ft^2$ or $m^2$).

**C406.2.15 Residential kitchen equipment.** For projects with Group R-1 and R-2 occupancies, energy credits shall be achieved where not less than 90 percent of dishwashers, refrigerators, and freezers comply with all of the following:

1. Achieve the ENERGY STAR Most Efficient label in accordance with the 2021 specifications.
2. Be installed prior to the issuance of the certificate of occupancy.

For Group R-1 where only some guestrooms are equipped with both refrigerators and dishwashers, the table

credits shall be prorated as follows:

[Section C406.2.15 table credits] x [Floor area of guestrooms with kitchens] / [Total guestroom floor area]

**C406.2.16 Residential laundry appliances.** For projects with Group R-2 occupancies, energy credits shall be achieved where not less than 90 percent of clothes washers and dryers in the project meet the following requirements:

1. Each dwelling unit contains in-unit washing washer and dryer equipment that meets the following requirements:
   1.1. Achieve the ENERGY STAR Most Efficient label in accordance with the 2021 specifications.
   1.2. Be installed prior to the issuance of the certificate of occupancy.
2. Where only some dwelling units are equipped with both washers and dryers, the table credits shall be prorated as follows:

   [Section C406.2.16 table credits] x [Floor area of dwelling units with laundry] / [Total dwelling unit floor area]

**C406.2.17 Heat pump clothes dryers.** Not less than 90 percent of domestic clothes dryers located in Group R-1 and R-2 of the whole project are ENERGY STAR rated heat pump dryers. Credit applies only to buildings where laundry facilities are provided either within each residential dwelling or sleeping units or grouped together in central multi-family use laundry rooms, or a mix of the two.

To claim this credit, the building permit drawings shall specify the appliance type and provide documentation of ENERGY STAR compliance. At the time of inspection, all appliances shall be installed and connected to utilities.

**C406.2.18 Efficient elevator equipment.** Qualifying elevators in the building shall be Energy Efficient Class A in accordance with ISO 25745-2, Table 7. Only buildings three or more floors above grade shall be permitted to use this credit. Credits shall be prorated based on Equation ~~4-18~~4-20, rounded to the nearest whole credit. Projects with a compliance ratio ($CR_e$ in Equation 4-18) below 0.5 do not qualify for this credit.

**(Equation ~~4-18~~4-20)**

$$EC_e = EC_t \times CR_e$$

Where:

$EC_e$ = Elevator energy credit achieved for building.

$EC_t$ = Section C406.2.18 table energy credit.

$CR_e$ = $\frac{F_A}{F_B}$

$F_A$ = Sum of floors served by Class A elevators.

$F_B$ = Sum of floors served by all building elevators and escalators.

**C406.3 Load management credits.** Load management measures installed in the building that meet the requirements in Sections C406.3.1 through C406.3.7 shall achieve the credits listed for the occupancy group in Table C406.3 or where calculations required by Sections C406.3.1 through C406.3.7 create or modify the table credits the credits achieved will be based upon the section calculations.

Each load management measure shall require automatic controls activated by either utility demand response, utility price response signal, peak price period time control, or local building demand monitoring. Controls shall be capable of and configured to provide the required load management sequences. As used in this section, "peak period" shall be either the coincident peak building load period, the peak price period, the peak utility load period, or the peak building demand period. The following additional requirements apply to these measures:

1. Where credit is taken for C406.3.6, service water heating energy storage, the equipment shall be provided with controls that comply with ANSI/CTA 2045-B.
2. For load management measures in Sections C406.3.1 through C406.3.5:
   2.1. Where the serving utility has a real-time demand response or pricing program, an interface compliant with serving utility requirements shall be installed.
   2.2. Where the serving utility does not have a real-time demand response or pricing program, a digital input to the system to support future utility programs shall be installed and building demand monitoring shall be installed and integrated into the load management sequence.
   2.3. All equipment involved in the required load management sequence shall have controls connected to a central DDC system.

**TABLE C406.3**
**LOAD MANAGEMENT MEASURE CREDITS**

| Measure Title | Applicable Section | Occupancy Group | | | | | |
|---|---|---|---|---|---|---|---|
| | | Group R-1 | Group R-2 | Group B | Group E | Group M | All Other |
| 1. Lighting load management | C406.3.1 | 12 | 15 | 27 | 15 | NA | NA |
| 2. HVAC load management | C406.3.2 | 29 | 24 | 42 | 23 | 13 | 26 |
| 3. Automated shading | C406.3.3 | NA | 7 | 12 | 16 | NA | NA |
| 4. Electric energy storage | C406.3.4 | 41 | 50 | 126 | 72 | 37 | 65 |
| 5. Cooling energy storage | C406.3.5 | 13 | 10 | 14 | 19 | NA | 14 |
| 6. Service hot water energy storage | C406.3.6 | 31 | 248 | 59 | 8 | 5 | 70 |
| 7. Building thermal mass | C406.3.7 | NA | NA | 50 | 95 | 96 | 80 |

**C406.3.1 Lighting load management.** Automatic controls shall be capable of gradually reducing general lighting power with continuous dimming in 75 percent of the building area by at least 20 percent during peak demand periods. Where less than 75 percent, but at least 50 percent, of the building area lighting is controlled, the credits from Table C406.3 shall be prorated as follows:

$$\frac{[\textit{Area of building with lighting load management}, \%] \times [\textit{Table credits for } \text{C406.3.1}]}{75\%}$$

**Exception:** Warehouse or retail storage building areas shall be permitted to achieve this credit by switching off at least 25 percent of lighting power in 75 percent of the building area without dimming.

**C406.3.2 HVAC load management.** Automatic controls shall:

1. Where electric cooling is used, be configured to gradually increase, over a minimum of three hours, the cooling setpoint by at least 3°F during the summer peak periods.
2. Where electric heating is used, be configured to gradually reduce, over a minimum of three hours, the heating setpoint by at least 3°F during winter peak periods.

**C406.3.3 Automated shading load management.** Where fenestration on south and west exposures exceeds 20 percent of the wall area, automatic controls shall be configured to operate movable exterior shading devices or dynamic glazing to reduce solar gain through sunlit fenestration on southern and western exposures by at least 50 percent during summer peak periods.

*Informative Note: This credit can be met by exterior roller, movable blind or movable shutter shading devices; however, fixed overhang, screen or shutter shading will not meet the requirement. Roller shades that reject solar gain but still allow a view are allowed as long as they provide an effective 50 percent reduction in net solar gain (e.g., have a shading coefficient of less than 0.5 for the shading material itself). Interior shading devices will not meet the requirement. Electrochromatic windows that achieve 50 percent of SHGC would qualify.*

**C406.3.4 Electric energy storage.** Automatic controls shall store electricity in electric storage devices during nonpeak periods and use stored energy during peak periods. Electric storage devices shall have a minimum capacity of 5 Wh/ft$^2$ (58 Wh/m$^2$) of gross building area. For greater storage capacity up to 15 Wh/ft$^2$ (160 Wh/m$^2$), credits shall be prorated as follows:

[Installed electric storage capacity, Wh/ft$^2$] × [C406.3.4 credits from Table C406.3]

**C406.3.5 Cooling energy storage.** Automatic controls shall be capable of activating ice or chilled water storage to reduce peak period electric demand. Credits shown in Table C406.3 are based on storage capacity of 2 ton-hours per design day ton of cooling load (2 kWh per design day kW) with a 1.15 sizing factor. Credits

shall be prorated for installed storage systems sized between 0.5 and 3.5 ton-hours per design day ton (kWh per design day kW) of cooling load rounded to the nearest whole credit. The storage tank shall have no more than 1.5 percent of storage capacity standby loss per day.

**C406.3.6 Service hot water energy storage.** To achieve this credit, where service hot water is heated by electricity, automatic controls shall preheat stored service hot water before the peak period and suspend electric water heating during the peak period. Storage capacity shall be provided by either:

1. Preheating water above 140°F (60°C) delivery temperature with at least 1.34 kWh of energy storage per kW of water heating capacity. Tempering valves shall be provided at the water heater delivery location.
2. Providing additional heated water tank storage capacity above peak service hot water demand with equivalent peak storage capacity to item 1.

**C406.3.7 Building thermal mass.** To achieve this credit, the building shall have both additional passive interior mass and a night-flush control of the HVAC system.

1. Interior to the *building thermal envelope* insulation, provide 15 pounds of passive thermal mass per square foot of building floor area. Mass construction shall be in the building interior and the indoor facing portion of the exterior wall, and interior floor construction. Mass construction shall have mass surfaces in direct contact with the air in conditioned spaces with directly attached wall board or hard surface flooring allowed. Mass with carpet or furred wallboard shall not be counted toward the building mass required. For integral insulated concrete block walls complying with ASTM C90, only the mass of the interior face shall be counted toward the building mass required.
2. When summer mode is active and indoor average temperature is 5°F (3°C) or more above outdoor temperature and between 10:00 p.m. and 6:00 a.m., *automatic* night flush controls shall operate outdoor air economizers at low fan speed less than 66 percent during the unoccupied period until the average indoor air temperature falls to the occupied heating setpoint. Summer mode shall be activated when outdoor air exceeds 70°F (21°C) and continues until deactivated when outdoor air falls below 45°F (7°C). Another night flush strategy shall be permitted where demonstrated to be effective, avoids added morning heating and is *approved* by the *code official*.

*Informative Note: The simplified night flush sequence described will operate in "summer mode" below the 70°F outdoor air trigger temperature down until outdoor air of 45°F is hit when the "summer mode" is deactivated until the outdoor air temperature rises above 70°F again. Other strategies may be implemented that cool the space below the heating setpoint and adjust the morning heating setpoint to avoid morning reheating.*

## SECTION C407
## ~~TOTAL~~ SIMULATED BUILDING PERFORMANCE

**C407.1 Scope.** This section establishes criteria for compliance using ~~total~~ simulated building performance. All systems and loads shall be included in determining the ~~total~~ simulated building performance including, but not limited to: Heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads.

**Exception:** Energy used to recharge or refuel vehicles that are used for on-road and off-site transportation purposes.

**C407.2 Mandatory requirements.** Compliance with Section C407 also requires compliance with those sections shown in Table C407.2.

The building permit application for projects utilizing this method shall include in one submittal all building and mechanical drawings and all information necessary to verify that the *building* thermal *envelope* and mechanical design for the project corresponds with the annual energy analysis. If credit is proposed to be taken for lighting energy savings, then an electrical permit application shall also be submitted and approved prior to the issuance of the building permit. If credit is proposed to be taken for energy savings from other components, then the corresponding permit application (e.g., plumbing, boiler, etc.) shall also be submitted and approved prior to the building permit application. Otherwise, components of the project that would not be approved as part of a building permit application shall be modeled in the baseline in accordance with ANSI/ASHRAE/IESNA 90.1 Appendix G and in the proposed model in accordance with the requirements of the Washington State Energy Code.

**TABLE C407.2**
**MANDATORY COMPLIANCE MEASURES FOR ~~TOTAL~~ SIMULATED BUILDING PERFORMANCE METHOD**

| Section[a] | Title | Comments |
|---|---|---|

| | | |
|---|---|---|
| **Envelope** | | |
| C401 | Thermal envelope certificate | |
| C402.2.7 | Airspaces | |
| C402.5 | Air Leakage | |
| **Mechanical** | | |
| C403.1.2 | Calculation of heating and cooling loads | |
| C403.1.3 | Data centers | |
| C403.2 | System design | |
| C403.3.1 | Equipment and system sizing | |
| C403.3.2 | HVAC equipment performance requirements | |
| C403.3.3 | Hot gas bypass limitation | |
| C403.3.4.4 | Boiler turndown | |
| C403.4.1 | Thermostatic controls | |
| C403.4.2 | Off-hour controls | |
| C403.4.7 | Combustion heating equipment controls | |
| C403.4.8 | Group R-1 hotel/motel guestrooms | See Section C403.7.4 |
| C403.4.9 | Group R-2 and R-3 dwelling units | |
| C403.4.10 | Group R-2 sleeping units | |
| C403.4.11 | Direct digital control systems, | |
| C403.5.5 | Economizer fault detection and diagnostics (FDD) | |
| C403.7 | Ventilation and exhaust systems | Except for C403.7.6 |
| C403.8 | Fan and fan controls | |
| C403.9.1.1 | Variable flow controls | For cooling tower fans ≥ 7.5 hp |
| C403.9.1.2 | Limitation on centrifugal fan cooling towers | For open cooling towers |
| C403.10 | Construction of HVAC elements | |
| C403.11 | Mechanical systems located outside of the building thermal envelope | |
| C403.14 | Commissioning | |
| **Service Water Heating** | | |
| C404 | Service Water Heating | Except for C404.2.1 |
| **Lighting and Electrical** | | |
| C405 | Electrical power and lighting systems | |
| **Other Requirements** | | |
| C407 | ~~Total~~ Simulated Building Performance | |
| C408 | System commissioning | |
| C409 | Energy metering | |
| C410 | Refrigeration requirements | |
| C411[b] | Renewable energy | |
| C412 | Compressed air systems | |

a. Reference to a code section includes all the relative subsections except as indicated in the table.
b. Compliance with any of these sections includes compliance with any exception to that section.

**C407.3 Performance-based compliance.** Compliance with this section requires compliance with ASHRAE Standard 90.1 Appendix G, Performance Rating Method, in accordance with Standard 90.1 Section 4.2.1 with the following modifications.

1. The mandatory requirements of the Washington State Energy Code as required to be met, instead of those of Section G1.2.1a of Standard 90.1.
2. Compliance with Section C407 requires meeting both a regulated site energy target and a total site energy reduction target in accordance with the following:

2.1. Regulated site energy target. The regulated site energy target is focused on regulated load energy efficiency, thus shall be met only via regulated load savings without consideration of the contribution of on-site or off-site renewable energy or unregulated load savings. Adjustments to the PCI, to account for the contribution of renewable energy found in ANSI/ASHRAE/IESNA 90.1 Section 4.2.1.1 shall not be used. References to energy cost in Section 4.2.1.1 and Appendix G shall be replaced by site energy use. Heating or cooling energy provided by a district energy system may utilize coefficient of performance (COP) ratios acceptable to the *code official* for the respective district energy sources. The building performance factors in Table 4.2.1.1 of ANSI/ASHRAE/IESNA 90.1 shall be replaced with those in Table C407.3(2).

2.2. Total site energy target. The total site energy performance target shall be met including the contributions of on-site or off-site renewable energy as described in Section C411.2 as well as the contributions of improvements in unregulated loads as allowed by Section C407.3.4. The annual on-site and off-site renewable energy production (as adjusted by the factors in Table C411.2.1) shall be subtracted from the proposed building annual site energy use. Compliance with the site energy performance target requires that the proposed building site energy use/baseline building site energy use is less than or equal to the site energy performance target from Table C407.3(3).

3. Documentation requirements in Section G1.3.2.d shall be replaced by a list showing compliance with the mandatory provisions of Table C407.2.

4. Forms demonstrating compliance with Appendix G developed by the U.S. Department of Energy shall be completed and submitted to the *code official*. The forms are available at energycodes.gov/ashrae-standard-901-performance-based-compliance-form.

5. References to yet-to-be-designed future building components in the Proposed Building Performance column of Table G3.1 shall be modified to reference the corresponding sections of the Washington State Energy Code in lieu of the requirements of ANSI/ASHRAE/IESNA 90.1 in the following sections of the table:

5.1. No. 1, Design Model, subclause c.

5.2. No. 6, Lighting, subclause c.

5.3. No. 11, Service Water Heating System, subclause c.

5.4. No. 12, Receptacle and Other Loads, subclause b.

6. HVAC systems, subclauses c and d of Table G3.1, shall meet the following requirements:

6.1. For yet-to-be-designed systems in office, retail, library, education, and multifamily buildings and occupancies subject to the TSPR requirements of Section C403.1.1, the system type and efficiency parameters in the proposed model shall meet but not exceed those shown in Table D602.11 Standard Reference Design HVAC Systems.

6.2. For all other buildings and occupancies, the system type shall be the same as the system modeled in the baseline design and shall comply with but not exceed the requirements of Section C403 in lieu of ANSI/ASHRAE/IESNA 90.1.

6.3. For HVAC systems serving future tenant spaces, where the current building permit applies to only a portion of an HVAC system, and future components will receive HVAC services from systems included in the current building permit, those future components shall be modeled as the type required to complete the HVAC system portions under the current permit and shall meet but not exceed the requirements found in Section C403.

7. The requirements for proposed and baseline building lighting system shall be modified in accordance with Addendum af to ANSI/ASHRAE/IESNA 90.1.

8. Energy modeler qualifications. The energy analyst in responsible charge of the Section C407 submittal shall meet at least one of the following:

8.1. ASHRAE Building Energy Modeling Professional (BEMP) certification.

8.2. Association of Energy Engineer's Building Energy Simulation Analyst (BESA) certification.

8.3. Successful completion of at least five projects modeled following any version of ANSI/ASHRAE/IESNA 90.1 Appendix G within the last three years that were reviewed and approved by a *code official* or rating authority.

**TABLE C407.3(1) Reserved**

**TABLE C407.3(2)**
**BUILDING PERFORMANCE FACTORS (BPF) TO BE USED FOR COMPLIANCE WITH SECTION C407.3**

| Building Area Type | Building Performance Factor |
|---|---|
| Multifamily | 0.51 |
| Healthcare/hospital | 0.70 |
| Hotel/motel | 0.51 |
| Office | 0.44 |
| Restaurant | 0.33 |
| Retail | 0.41 |
| School | 0.35 |
| Warehouse | 0.18 |
| All Others | 0.43 |

**TABLE C407.3(3)**
**SITE ENERGY PERFORMANCE TARGETS TO BE USED FOR COMPLIANCE WITH SECTION C407.3**

| Building Area Type | Building Performance Factor |
|---|---|
| Multifamily | 0.59 |
| Healthcare/hospital | 0.72 |
| Hotel/motel | 0.62 |
| Office | 0.58 |
| Restaurant | 0.59 |
| Retail | 0.46 |
| School | 0.52 |
| Warehouse | 0.29 |
| All Others | 0.55 |

**C407.3.1 Limits on non-mandatory measures.** The Proposed Total UA of the proposed building shall be no more than 20 percent higher than the Allowed Total UA as defined in Section C402.1.5.

**C407.3.2 On-site and off-site renewable energy accounting for use with Appendix G.** Qualifying on-site and off-site renewable energy delivered or credited to the building project to comply with Section C407.3 item 2.2 shall meet the requirements of Section C411.2.

**C407.3.3 Low-carbon district energy use with Appendix G.** Qualifying *low-carbon district heating and cooling or heating only systems* and *low-carbon district energy exchange systems* shall meet the requirements of Section C407.3.3.1 or C407.3.3.2, as applicable.

**C407.3.3.1 Utilization of low-carbon district heating and cooling or heating only systems.** Applicable if heating and cooling or heating only is provided to the *proposed building* from a *low-carbon district heating and cooling or heating only system* that is fully operational prior to the final inspection. Proposed model shall account for all on-site HVAC and service hot water related equipment, such as circulation pump energy and heat-exchanger efficiency.

1. The following modifications shall be applied to Appendix G of ANSI/ASHRAE/IESNA 90.1 in addition to what is described in Section C407.3:
   1.1. For low-carbon district heating and cooling systems, strike the text of Sections G3.1.1.1, G3.1.1.2, G3.1.1.3.1, G3.1.1.3.3 and G3.1.1.3.4. Baseline system shall be selected based on unmodified versions of Tables G3.1.1-3 and G3.1.1-4, comparing energy use to determine compliance.

1.2. For low-carbon district heating only systems, strike the text of Sections G3.1.1.1, G3.1.1.3.1, and G3.1.1.3.4. Baseline system shall be selected based on unmodified versions of Tables G3.1.1-3 and G3.1.1-4, comparing energy use to determine compliance.

2. Any heating or cooling energy provided by the *low-carbon district heating and cooling or heating only system* shall utilize a calculated energy use reduction factor acceptable to the *code official* to account for energy use reduction from those end uses.
3. Energy "credit" for any waste/recoverable heat exported to the *low-carbon district heating and cooling or heating only systems* shall be accounted for in the proposed design by multiplying the quantity of heat exported by the appropriate seasonal utilization factor in Items 3.1 and 3.2 below. This energy "credit" is subtracted from the total proposed design energy use calculated in accordance with ASHRAE 90.1 Section 4.2.1.1.
   3.1. Fifty percent of the waste heat exported to the *low-carbon district heating and cooling or heating only systems* during the months of October through December and January through March.
   3.2. Twenty-five percent of the waste heat exported to the *low-carbon district heating and cooling or heating only systems* during the months of April through September.

**Exception:** Waste heat exported from the building to the *low-carbon district heating and cooling or heating only system* shall not be subtracted from the proposed design energy use if they are already accounted for in the calculation of energy use from the district heating or cooling plant as part of the *district energy efficiency factor*.

Documentation for the low-carbon district system that is operational prior to the final inspection shall be provided to demonstrate the following:

1. Distribution losses must be accounted for and may not exceed 10 percent of the annual load delivered to buildings served by the system.
2. Twenty-five percent of the annual district-system-net-load-met (sum of heating and cooling energy provided to attached buildings) comes from heat recovery between connected buildings, waste heat or renewable energy resources and no more than 25 percent of the annual heat input to the system comes from fossil fuel or electric-resistance sources, or not more than 10 percent of the system annual heat input to the system comes from fossil fuel or electric-resistance sources.

**C407.3.3.2 Utilization of low-carbon district energy exchange systems.** Applicable if heating or cooling is provided to the *proposed building* from a *low-carbon district energy exchange system* that is fully operational prior to the final inspection. Proposed model shall account for all on-site HVAC and service hot water related equipment, such as circulation pump energy and heat-exchanger efficiency.

1. The following modifications shall be applied to Appendix G of ANSI/ASHRAE/IESNA 90.1 in addition to what is described in Section C407.3:
   1.1. Strike the text of Sections G3.1.1.1, G3.1.1.2, G3.1.1.3, G3.1.1.3.1, G3.1.1.3.2, G3.1.1.3.3, and G3.1.1.3.4. Baseline system shall be selected based on unmodified versions of Tables G3.1.1-3 and G3.1.1-4.
2. Any heating or cooling energy provided by a low-carbon district energy exchange system shall utilize a calculated energy use reduction factor acceptable to the *code* official to account for the reduction in the proposed model.
3. Energy "credit" for any waste/recoverable heating exported to the *low-carbon district energy exchange system* shall be accounted for in the proposed design by multiplying the quantity of heat exported by the appropriate seasonal utilization factor in Items 3.1 and 3.2 below. This energy "credit" is subtracted from the total proposed design energy use calculated in accordance with ASHRAE 90.1 Section 4.2.1.1.
   3.1. Fifty percent of the waste heat exported to the *low-carbon district energy exchange system* during the months of October through December and January through March.
   3.2. Twenty-five percent of the waste heat exported to the *low-carbon district energy exchange system* during the months of April through September.

**Exception:** Waste heat exported from the building to the *low-carbon district heating and cooling or heating only system* shall not be subtracted from the proposed design energy use if they are already accounted for in the calculation of energy use from the district heating or cooling plant as part of the *district energy efficiency factor*.

Documentation for the low-carbon district system that is operational prior to the final inspection shall be provided to demonstrate that the definition of *low-carbon district energy exchange system* is satisfied.

**C407.3.4 Credit for improvements in unregulated loads when using Appendix G.** When calculating savings for site energy targets in accordance with Section C407.3 item 2.2, but not when calculating savings for emissions targets in accordance with Section C407.3 item 2.1, differences in the simulation of unregulated loads and equipment modeled in the baseline building design from those in the *proposed design* shall be approved by the *code official* based on documentation that the equipment installed in the *proposed design* represents a significant verifiable departure from documented current conventional practice. All unregulated equipment for which savings is claimed must be installed by the time of final inspection. The burden of this documentation is to demonstrate that accepted conventional practice would result in baseline building equipment different from that installed in the *proposed design*. Occupancy and occupancy schedules shall not be changed.

## SECTION C408
## SYSTEM COMMISSIONING

**C408.1 General.** A building commissioning process led by a *certified commissioning professional* and functional testing requirements shall be completed for mechanical systems in Section C403; service water heating systems in Section C404; controlled receptacle and lighting control systems in Section C405; equipment, appliance and systems installed to comply with Section C406 or C407; energy metering in Section C409; and refrigeration systems in Section C410.

**Exception:** Buildings, or portions thereof, which are exempt from Sections C408.2 through C408.7 may be excluded from the commissioning process.

1. Mechanical systems that are not required to comply with Section C403.3.5 are exempt from the commissioning process where the installed total mechanical equipment capacity is less than 180,000 Btu/h (15 tons) cooling capacity and less than 240,000 Btu/h (20 tons) heating capacity and energy recovery ventilation (ERV) equipment is less than 300 cfm capacity.
2. Service water heating systems are exempt from the commissioning process in buildings where the largest service water heating system capacity is less than 200,000 Btu/h and where there are any of the following:
   2.1. No pools or permanent spas.
   2.2. No solar thermal water heating.
   2.3. No recirculation pumps.
   2.4. No heat pump water heaters, except fully-packaged for individual residential dwelling unit use.
3. Lighting control systems are exempt from the commissioning process in buildings where both the total installed lighting load is less than 10 kW and the lighting load controlled by occupancy sensors or *automatic* daylighting controls is less than 5 kW.
4. Refrigeration systems are exempt from the commissioning process if they are limited to self-contained units.

**C408.1.1 Commissioning in construction documents.** Construction documents shall clearly indicate provisions for commissioning process. The construction documents shall minimally include the following:

1. A narrative description of the activities that will be accomplished during the commissioning process. At a minimum, the commissioning process is required to include:
   1.1. Development and execution of the commissioning plan, including all subsections of Section C408.1.2;
   1.2. The *certified commissioning professional*'s review of the building documentation and close out submittals in accordance with Section C103.6; and
   1.3. The commissioning report in accordance with Section C408.1.3.
2. Roles, responsibilities and required qualifications of the *certified commissioning professional*.
3. A listing of the specific equipment, appliances or systems to be tested.

**C408.1.2 Commissioning plan.** A *commissioning plan* shall be developed by the project's *certified*

*commissioning professional* and shall outline the organization, schedule, allocation of resources, and documentation requirements of the commissioning process. The plan shall also include the following:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities, systems testing and balancing, functional performance testing, and verification of the building documentation requirements in Section C103.6.
2. Roles and responsibilities of the commissioning team, including the name and statement of qualifications of the *certified commissioning professional*.
3. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.

**C408.1.2.1 In-house commissioning disclosure and conflict management plan.** Where the *certified commissioning professional's* contract or employment is other than directly with the building owner, an in-house commissioning disclosure and conflict management plan shall be a part of the commissioning process. A copy shall be included in the commissioning plan. This plan shall disclose the *certified commissioning professional's* contractual relationship with other team members and provide a conflict management plan demonstrating that the *certified commissioning professional* is free to identify any issues discovered and report directly to the owner.

**C408.1.2.2 Functional performance testing.** Functional performance testing shall be conducted for mechanical systems in Sections C403; service water heating systems in Section C404; controlled receptacles and lighting control systems in Section C405; equipment, appliances and systems installed to comply with Section C406 or C407; energy metering in Section C409; and refrigeration systems in Section C410. Written procedures which clearly describe the individual systematic test procedures, the expected system response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion shall be followed. This testing shall include control systems which will be tested to document that control devices, components, equipment, and systems are calibrated and adjusted to operate in accordance with approved construction documents. Testing shall affirm the conditions required within Sections C408.2 through C408.7 under system testing.

**C408.1.2.3 Functional performance testing - sampling.** For projects with seven or fewer similar systems, each system shall be tested. For projects with more than seven systems, testing shall be done for each unique combination of controls type. Where multiples of each unique combination of control types exist, no fewer than 20 percent of each combination shall be tested unless the *code official* or design professional requires a higher percentage to be tested. Where 30 percent or more of the tested system fail, all remaining identical combinations shall be tested.

**C408.1.2.4 Deficiencies.** Deficiencies found during testing shall be resolved including corrections and retesting.

**C408.1.3 Commissioning report.** A commissioning report shall be completed and certified by the *certified commissioning professional* and delivered to the building owner or owner's authorized agent. The report shall be organized with mechanical, service water heating, controlled receptacle and lighting control systems, energy metering, and refrigeration findings in separate sections to allow independent review. The report shall record the activities and results of the commissioning process and be developed from the final commissioning plan with all of its attached appendices. The report shall include:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.
4. Commissioning plan.
5. Testing, adjusting and balancing report.

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

**C408.1.4 Commissioning process completion requirements.** Prior to the final mechanical, plumbing and electrical inspections or obtaining a certificate of occupancy, the *certified commissioning professional* shall provide evidence of *building commissioning* in accordance with the provisions of this section.

**C408.1.4.1 Commissioning compliance.** Buildings, or portions thereof, shall not be considered acceptable for a final inspection pursuant to Section C104.2.6 until the *code official* has received a letter of transmittal from the building owner or owner's representative acknowledging that the building owner or owner's authorized agent has received the Commissioning Report. Completion of Commissioning Compliance Checklist (Figure C408.1.4.1) is deemed to satisfy this requirement. Phased acceptance of Commissioning Compliance Checklist for portions of the work specific to the trade that is being inspected is permissible where accepted by the *code official* and where the *certified commissioning professional* remains responsible for completion of the commissioning process. If there are unresolved deficiencies when the final inspection is scheduled, the Commissioning Report shall be submitted and shall describe the unresolved deficiencies.

**C408.1.4.3 Copy of report.** The *code official* shall be permitted to require that a copy of the Commissioning Report be made available for review by the *code official*.

**C408.2 Mechanical systems commissioning.** Mechanical equipment and controls subject to Section C403 shall be included in the commissioning process required by Section C408.1. The commissioning process shall minimally include all energy code requirements for which the code states that equipment or controls shall "be capable of" or "configured to" perform specific functions.

**Exception:** Mechanical systems are exempt from the commissioning process where the installed total mechanical equipment capacity is less than 240,000 Btu/h cooling capacity and less than 300,000 Btu/h heating capacity.

**C408.2.1 Reserved.**

**FIGURE C408.1.4.1**
**COMMISSIONING COMPLIANCE CHECKLIST**

| | |
|---|---|
| **Project Information** | **Project Name:** |
| | **Project Address:** |
| | **Certified Commissioning Professional:** |
| | **Type of ISO Certification and Number:** |
| **Supporting Documents** | ❑ **Manuals, record documents and training have been completed or are scheduled** (Section C103.6)<br>• Building operations and maintenance information (C103.6.2) have been submitted to the owner or scheduled date: _____<br>• Manuals (C103.6.2.1) have been submitted to the owner or scheduled date: _____<br>• Compliance documentation (C103.6.3) has been provided to the owner or scheduled date: _____<br>• System operation training (C103.6.4) has been provided to the owner or scheduled date: _____ |
| **Commissioning Plan** | ❑ **Commissioning Plan was used during construction** (Section C408.1.2) |
| **Commissioning Report** | ❑ **Commissioning Report has been submitted** (Section C408.1.3) |
| **Commissioned Systems** | ❑ **Mechanical Systems were included in the commissioning process** (Section C408.2)<br>❑ Testing, adjusting and balancing is complete (Section C408.2.2) |
| | ❑ There are unresolved deficiencies with the mechanical systems. These are described in the attached Commissioning Report submitted to the Owner. |
| | ❑ **Service Water Heating Systems were included in the commissioning process** (Section C408.3)<br>❑ There are unresolved deficiencies with the service water heating systems. These are described in the attached Commissioning Report submitted to the Owner. |
| | ❑ **Controlled receptacles and lighting control systems were included in the commissioning process** (Section C408.4)<br>❑ There are unresolved deficiencies with the electrical power and/or automatic lighting controls. These are described in the attached Commissioning Report submitted to the Owner. |
| | ❑ **Additional systems were included in the commissioning process** (Section C408.5)<br>❑ There are unresolved deficiencies with systems required by C406 or C407. These are described in the attached Commissioning Report submitted to the Owner. |
| | ❑ **Metering systems were included in the commissioning process** (Section C408.6)<br>❑ There are unresolved deficiencies with the metering system. These are described in the attached Commissioning Report submitted to the Owner.<br>❑ **Refrigeration systems were included in the commissioning process** (Section C408.7)<br>❑ There are unresolved deficiencies with systems required by Section C410. These are described in the attached Commissioning Report submitted to the Owner. |
| **Certification** | ❑ I hereby certify that requirements for Section C408 System Commissioning have been completed in accordance with the Washington State Energy Code, including all items above.<br>---<br>*Certified Commissioning Professional* Date |
| | ❑ I hereby certify that requirements for Section C408 System Commissioning have been completed in accordance with the Washington State Energy Code, including all items above.<br>---<br>Building Owner or Owner's Representative Date |

**C408.2.2 Systems adjusting and balancing.** HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the project specifications. Test and balance activities shall include air system and hydronic system balancing.

**C408.2.2.1 Air systems balancing.** Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*. Discharge dampers used for air system balancing are prohibited on constant volume fans and variable volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp (0.74 kW), fan speed shall be adjusted to meet design flow conditions.

**Exception:** Fans with fan motors of 1 hp (0.74 kW) or less.

**C408.2.2.2 Hydronic systems balancing.** Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the capability to measure pressure across the pump, or test ports at each side of each pump.

**Exception:** The following equipment is not required to be equipped with means for balancing or measuring flow:

1. Pumps with pump motors of 5 hp (3.7 kW) or less.
2. Where throttling results in no greater than five percent of the nameplate horsepower draw above that required if the impeller were trimmed.

**C408.2.3 System testing.** Functional performance testing shall demonstrate the components, systems, and system-to-system interfacing relationships are installed and operate in accordance with approved construction documents. Testing shall include the *sequence of operation*, and be conducted under full-load, part-load and the following conditions:

1. All modes as described in the *sequence of operation*;
2. Redundant or *automatic* back-up mode;
3. Performance of alarms; and
4. Mode of operation upon a loss of power and restoration of power.

**C408.3 Service water heating systems commissioning.** Service water heating equipment and controls subject to Section C404 shall be included in the commissioning process required by Section C408.1. The commissioning process shall minimally include equipment and components installed to meet all energy code requirements for devices to “start,” “automatically turn off,” “automatically adjust,” “limit operation,” and “limit the temperature” and “be configured to.”

**C408.3.1 System testing.** Functional performance testing shall demonstrate that heaters, piping, distribution systems, and system-to-system interfacing relationships are installed and operate in accordance with approved construction documents. Testing shall include the *sequence of operation*, and be conducted under at least 50 percent water heating load, part-load and the following conditions:

1. Normal operation;
2. Redundant or *automatic* back-up mode;
3. Performance of alarms; and
4. Mode of operation upon a loss of power and restoration of power.

**C408.4 Controlled receptacle and lighting control system commissioning.** Controlled receptacles and lighting control systems subject to Section C405 shall be included in the commissioning process required by Section C408.1. The configuration and function of controlled receptacles and lighting control systems required by this code shall be tested and shall comply with Section C408.4.1.

**Exception:** Lighting control systems are exempt from the commissioning process in buildings where:

1. The total installed lighting load is less than 20 kW, and
2. The lighting load controlled by occupancy sensors or *automatic* daylighting controls is less than 10 kW.

**C408.4.1 System testing.** Functional performance testing shall demonstrate that occupant sensors, time switches, manual overrides, night sweep-off, daylight responsive control, and controlled receptacles are

installed and operate in accordance with approved construction documents. Testing shall include the *sequence of operation* and be conducted under the following conditions:

1. Normal operation;
2. Redundant or *automatic* back-up mode;
3. Performance of alarms; and
4. Mode of operation upon a loss of power and restoration of power.

**C408.5 Systems installed to meet Section C406 or C407.** Equipment, components, controls or configuration settings for systems which are included in the project to comply with Section C406 or C407 shall be included in the commissioning process required by Section C408.1.

**C408.5.1 System testing**. Functional performance testing for these appliances, equipment, components, controls and/or configuration settings shall demonstrate operation, function and maintenance serviceability for each of the commissioned systems in accordance with the approved construction documents.

**C408.6 Metering system commissioning.** Energy metering systems required by Section C409 shall comply with Section C408.6 and be included in the commissioning process required by Section C408.1. The commissioning process shall include all energy metering equipment and controls required by Section C409.

**C408.6.1 System testing.** Functional performance testing shall demonstrate that energy source meters, end-use meters, data acquisition systems, and energy displays are installed and operate in accordance with approved construction documents. . At a minimum, testing shall confirm that:

1. The metering system devices and components work properly under low and high load conditions.
2. The metered data is delivered in a format that is compatible with the data collection system.
3. The energy display is in a location with *access* to building operation and management personnel.
4. The energy display meets code requirements regarding views required in Section C409.4.3. The display shows energy data in identical units (e.g., kWh).

**C408.7 Refrigeration system commissioning.** All installed **r**efrigeration systems subject to Section C410 shall be included in the commissioning process required by Section C408.1.

**Exceptions:**

1. Self-contained refrigeration systems are exempt from the commissioning process.
2. Total installed capacity for refrigeration is equal to or less than 240 kBtu/h.

**C408.7.1 System Testing.** Functional performance testing shall demonstrate that compressors, heat exchangers, piping, distribution systems, and system-to-system interfacing relationships are installed and operate in accordance with approved construction documents. Testing shall include the *sequence of operation* and be conducted under full-load at, part-load and the following conditions:

1. Normal mode;
2. Redundant or *automatic* back-up mode;
3. Performance of alarms; and
4. Mode of operation upon a loss of power and restoration of power.

## SECTION C409
## ENERGY METERING AND ENERGY CONSUMPTION MANAGEMENT

**C409.1 General.** All new buildings and additions shall have the capability of metering all source energy usage in accordance with Section C409.2 in addition to the source energy for on-site renewable energy production in accordance with Section C409.2.4 and the end-use energy usage for electric vehicle charging in accordance with Section C409.3.4. New buildings and additions with a gross *conditioned floor area* ~~over 25,000~~not less than 10,000 square feet shall comply with Sections C409.2, C409.3, and C409.4.New buildings and additions shall be equipped to measure, monitor, record and display energy consumption data for each energy source and end use category per the provisions of this section, to enable effective energy management. Existing buildings shall comply with the energy metering provisions of Section C506.1.

**Exceptions:**

1. Tenant spaces smaller than ~~25,000~~5,000 square feet of *conditioned floor* area within buildings if the tenant space has its own utility service and utility meters shall comply with Section C409.2 and are exempt from the end-use metering, measurement devices, data acquisition system, and energy display requirements of Sections C409.3 and C409.4.
2. Buildings in which there is no gross *conditioned floor area* over ~~25,000~~10,000 square feet, including building common area, that is served by its own utility services and meters shall comply with Section C409.2 and are exempt from the end-use metering, measurement devices, data acquisition system, and energy display requirements of Sections C409.3 and C409.4.

**C409.1.1 Alternate metering methods.** Where approved by the building official, energy use metering systems may differ from those required by this section, provided that they are permanently installed and that the source energy measurement, end use category energy measurement, data storage and data display have similar accuracy to and are at least as effective in communicating actionable energy use information to the building management and users, as those required by this section.

**C409.1.2 Conversion factor.** Any threshold stated in kW shall include the equivalent BTU/h heating and cooling capacity of installed equipment at a conversion factor of 3,412 Btu per kW or 2,730 Btu per kVA.

**C409.1.3 Dwelling units.** See Sections C404.9 and C405.7 for additional metering requirements for Group R-2 *dwelling units*.

**C409.2 Energy source metering.** Buildings shall have a meter at each energy source. For each energy supply source listed in Section C409.2.1 through C409.2.4, meters shall collect data for the whole building or for each separately metered portion of the building where not exempted by the exception to Section C409.1.

**Exceptions:**

1. Energy source metering is not required where end use metering for an energy source accounts for all usage of that energy type within a building, and the data acquisition system accurately totals the energy delivered to the building or separately metered portion of the building.
2. Solid fuels such as coal, firewood or wood pellets that are delivered via mobile transportation do not require metering.

**C409.2.1 Electrical energy.** This category shall include all electrical energy supplied to the building and its associated site, including site lighting, parking, recreational facilities, and other areas that serve the building and its occupants.

**C409.2.2 Gas and liquid fuel supply energy.** This category shall include all natural gas, fuel oil, propane and other gas or liquid fuel energy supplied to the building and site.

**C409.2.3 District energy.** This category shall include all net energy extracted from district steam systems, district chilled water loops, district hot water systems, or other energy sources serving multiple buildings.

**C409.2.4 Site-generated renewable energy.** This category shall include all net energy generated from on-site solar, wind, geothermal, tidal or other natural sources. For buildings exempt from data collection systems, the data from these meters is permitted to either be stored locally using a manual totalizing meter or other means at the meter or fed into a central data collection system.

**C409.3 End-use metering.** Meters shall be provided to collect energy use data for each end-use category listed in Sections C409.3.1 through C409.3.7. These meters shall collect data for the whole building or for each separately metered portion of the building where not exempted by the exception to Section C409.1. Not more

than 10 percent of the total connected load of any of the end-use metering categories in Sections C409.3.1 through C409.3.6 is permitted to be excluded from that end-use data collection. Not more than 10 percent of the total connected load of any of the end-use metering categories in Sections C409.3.1 through C409.3.6 is permitted to consist of loads not part of that category. Multiple meters may be used for any end-use category, provided that the data acquisition system totals all of the energy used by that category. Full-floor tenant space submetering data shall be provided to the tenant in accordance with Section C409.7, and the data shall not be required to be included in other end-use categories.

**Exceptions:**

1. HVAC and service water heating equipment serving only an individual dwelling unit or sleeping unit does not require end-use metering.
2. Separate metering is not required for fire pumps, stairwell pressurization fans or other life safety systems that operate only during testing or emergency.
3. End use metering is not required for individual tenant spaces not exceeding 2,500 square feet in floor area when a dedicated source meter meeting the requirements of Section C409.4.1 is provided for the tenant space.
4. Healthcare facilities with loads in excess of 150 kVA are permitted to have submetering that measures electrical energy usage in accordance with the normal and essential electrical systems except that submetering is required for the following load categories:
   4.1. HVAC system energy use in accordance with the requirements of Section C409.3.1.
   4.2. Service water heating energy use in accordance with the requirements of Section C409.3.2.
   4.3. Process load system energy in accordance with the requirements of Section C409.3.6 for each significant facility not used in direct patient care, including but not limited to, food service, laundry and sterile processing facilities, where the total connected load of the facility exceeds 100 kVA.
5. End-use metering is not required for electrical circuits serving only Iand guest suites within Group R-1 occupancies. This exception does not apply to common areas or to equipment serving multiple sleeping rooms.

**C409.3.1 HVAC system energy use.** This category shall include all energy including electrical, gas, liquid fuel, district steam and district chilled water that is used by boilers, chillers, pumps, fans and other equipment used to provide space heating, space cooling, dehumidification and ventilation to the building, but not including energy that serves process loads, service water heating or miscellaneous loads as defined in Section C409.3. Multiple HVAC energy sources, such as gas, electric and steam, are not required to be summed together.

**Exceptions:**

1. 120 volt equipment.
2. An HVAC branch circuit where the total MCA of equipment served equates to less than 10 kVA.
3. Individual fans or pumps that are not on a variable frequency drive.

**C409.3.2 Service water heating energy use.** This category shall include all energy used for heating of domestic and service hot water, but not energy used for space heating.

**Exception:** Service water heating energy use less than 50 kVA does not require end-use metering.

**C409.3.3 Lighting system energy use.** This category shall include all energy used by interior and exterior lighting, including lighting in parking structures and lots, but not including plug-in task lighting.

**C409.3.4 Electric vehicle charging energy use.** This category shall include all energy used for electrical vehicle charging. For buildings exempt from data collection systems, the data from these meters is permitted to either be stored locally using a manual totalizing meter or other means at the meter or fed into a central data collection system.

**C409.3.5 Plug load system energy use.** This category shall include all energy used by appliances, computers, plug-in task lighting, and other equipment or equipment covered by other end-use metering categories listed in Section C409.3. In a building where the main service is 480/277 volt, each 208/120 volt panel is permitted to be assumed to serve only plug load for the purpose of Section C409, unless it serves nonresidential refrigeration or cooking equipment.

**Exception:** Where the total connected load of all plug load circuits is less than 50 kVA end-use metering is not required.

**C409.3.6 Process load system energy use.** This category shall include all energy used by any non-building process load, including but not limited to nonresidential refrigeration and cooking equipment, laundry equipment, industrial equipment and stage lighting.

**Exception:** Where the process load energy use is less than 50 kVA, end-use metering is not required.

**C409.3.7 Full-floor tenant space electrical submetering**. In a multi-tenant building where more than 90 percent of the leasable area of a floor is occupied by a single tenant, an electrical energy use display shall be provided to the tenant in accordance with the requirements of Section C409.4.3. Electrical loads from areas outside of the tenant space or from equipment that serves areas outside of the tenant space shall not be included in the tenant space submetering. A single display is permitted to serve multiple floors occupied by the same tenant.

**C409.4 Measurement devices, data acquisition system and energy display.**

**C409.4.1 ~~Meters~~Electric meters.** Meters and other measurement devices required by this section shall be configured to automatically communicate energy data to a data acquisition system and energy display. Source meters may be any digital-type meters. Current sensors or flow meters are allowed for end use metering, provided that they have an accuracy of +/- ~~5%~~2 percent. All required metering systems and equipment shall provide data that is fully integrated into the data acquisition and display system per the requirements of Section C409. Electrical meters shall be configured to communicate data to the data acquisition system and energy display for both consumption (e.g., kWh) and consumption rate (e.g., kW). Other meters and measurement devices shall be configured to communicate data to the data acquisition system for consumption. Nonintrusive load monitoring (NILM) packages that extract energy consumption data from detailed electric waveform analysis shall be permitted to substitute for individual meters if the equivalent data is available for collection in Section C409.4.2 and reporting in section C409.4.3.

**C409.4.2 ~~Data~~ Electrical energy data acquisition system.** The data acquisition system shall store the data from the required meters and other sensing devices in a single database for a minimum of 36 months. For each energy supply and end use category required by C409.2 and C409.3, it shall provide energy consumption rate logged in one-hour or less intervals and energy consumption rate logged in 10-minute or less intervals. Data from the data acquisition system shall be viewable via the energy display in accordance with the requirements of Section C409.4.3. The data acquisition system shall have the capacity of providing building total peak electric demand and the time(s) of day and time(s) per month at which peak occurs. Peak demand shall be integrated over the same time period as the underlying whole-building meter reading rate.

**C409.4.3 Energy display.** For each building subject to Section C409.2 and C409.3, either a single visible display in a location with *ready access*, or a single web page or other electronic document available for *access* ~~to~~ by building operation and management personnel or to a third-party energy data analysis service shall be provided in the building; for metering data acquisition system and energy displays monitored by a third-party energy data analysis service, building operation and management personnel shall retain access to the metering data acquisition system and energy display. The display shall numerically provide the current energy consumption rate and energy consumption total for each whole building energy source and each end use category. The energy display shall also graphically and numerically display logged data from the data acquisition system for energy consumption for each whole building energy source and energy consumption rate for whole building electrical use and each end use category for any selected day, week, month, or year.

**C409.4.4 Renewable energy.** On-site renewable energy sources shall be metered with no less frequency than nonrenewable energy systems in accordance with Section C409.4.1.

**C409.4.5 Nonelectrical energy submetering.** For all nonelectrical energy supplied to the *building* and its associated site that serves the *building* and its occupants, submeters or other measurement devices shall be provided to collect energy consumption data for each end-use category required by Section C409.4.6.

**Exceptions:**

1. HVAC and water heating equipment serving only an individual *dwelling unit* shall not require end-use submetering.
2. End-use submetering shall not be required for fire pumps, stairwell pressurization fans or any system that operates only during testing or emergency.

**Commented [BK(100]:** ICC broke this out into several sections: electrical, renewable, and nonelectrical. I integrated the requirements into our WSEC language, but further refinement will be necessary. See below

3. End-use submetering shall not be required for an individual tenant space having a floor area not greater than 2,500 square feet (232 m2) where a dedicated source meter complying with Section C409.4.7 is provided.
4. Equipment powered primarily by solid fuels serving loads other than *building* heating and service water heating loads.

**C409.4.6 End-use nonelectrical submetering categories.** Submeters or other *approved* measurement devices shall be provided to collect energy use data for each end-use category indicated in Table C409.4.6. Where multiple submeters are used to measure any end-use category, the data acquisition system shall total all of the energy used by that category. Not more than 5 percent of the design load for each of the end-use categories indicated in Table C405.13.8 shall be permitted to be from a load that is not within that category.

**TABLE C409.4.6**
**NONELECTRICAL ENERGY USE CATEGORIES**

| END USE CATEGORY | DESCRIPTION OF END USE |
|---|---|
| Total HVAC system | Heating and cooling systems, including but not limited to boilers, chillers and furnaces. District heating and cooling energy entering the building's distribution system shall be monitored at the point of entry to the building distribution system. |
| Process loads | Any single load that is not included in the HVAC or service water heating categories where the rated fuel gas or fuel oil input of the load and that is not less than 5 percent of the sum of the rated fuel gas or fuel oil input of all monitored equipment, including but not limited to manufacturing equipment, process equipment, commercial kitchens, and commercial laundry equipment. |
| Other miscellaneous loads | The remaining loads not included elsewhere in this table, including but not limited to fireplaces, swimming pools, spas, gas lighting, and snow-melt systems. |
| Service water heating | Fuel used to heat potable water.<br>**Exception:** Water heating with design capacity that is less than 10 percent of the sum of the rated fuel gas or fuel oil input of all monitored equipment. |

**Commented [BK(101]:** The IECC has a similar table for electrical use categories. We did not integrate that language for the 2021 WSEC, but relied on C409.3 to scope the categories which differ somewhat from these. Rather than use a table here, we could either refer back to C409.3 or incorporate it into text.

**C409.4.7 Nonelectrical submeters.** Submeters or other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the data acquisition system required by Section C409.4.8. Source submeters shall be allowed to be any digital-type meter that can provide a digital output to the data acquisition system. Required submetering systems and equipment shall be fully integrated into the data acquisition system and graphical energy report that updates at least hourly in accordance with Sections C409.4.8 and C409.4.9.

**C409.4.8 Nonelectrical energy data acquisition system.** A data acquisition system shall have the capability to store the data from the required submeters and other sensing devices for not less than 36 months. The data acquisition system shall have the capability to store real-time energy consumption data and provide hourly, daily, monthly and yearly logged data for each end-use category required by Section C409.4.6. The data acquisition system shall have the capability of providing building total nonelectrical peak demand and the time(s) of day and time(s) per month at which the peak occurs. Where applicable as determined by the authority having jurisdiction (AHJ), peak demand shall be integrated over the same time period as the underlying whole-building meter reading rate.

**C409.4.9 Graphical energy report.** A permanent and readily accessible reporting mechanism shall be provided in the *building* that is accessible by building operation and management personnel. The reporting mechanism shall have the capability to graphically provide the nonelectrical energy consumption for each end-use category required by Section C409.4.6 not less than every hour, day, month and year for the previous 36 months. The graphical report shall incorporate natural gas interval data from the submeter or the ability to enter gas utility bills into the report.

~~C409.4.4~~C409.4.10 **Commissioning.** Energy metering and energy consumption management systems shall be commissioned in accordance with Section C408.6.

## SECTION C410
## REFRIGERATION SYSTEM REQUIREMENTS

**C410.1 General**. Walk-in coolers, walk-in freezers, refrigerated warehouse coolers, refrigerated warehouse freezers, and refrigerated display cases shall comply with this Section.

**C410.2 Commercial refrigerators, freezers and refrigerator-freezers.** Refrigeration equipment, defined in DOE 10 C.F.R. Part 431.62, shall have an energy use in kWh/day not greater than the values of Table C410.2 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 C410.2**
**MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL REFRIGERATORS AND FREEZERS AND REFRIGERATION**

| Equipment Category | Condensing Unit Configuration | Equipment Family | Rating Temp. °F | Operating Temp. °F | Equipment Classification[c] | Maximum Daily Energy Consumption kWh/day[d,e] | Test Standard |
|---|---|---|---|---|---|---|---|
| Remote condensing commercial refrigerators and commercial freezers | Remote (RC) | Vertical open (VOP) | 38 (M) | ≥32 | VOP.RC.M | 0.64 × TDA + 4.07 | AHRI 1200 |
| | | | 0 (L) | <32 | VOP.RC.L | 2.20 × TDA + 6.85 | |
| | | Semivertical open (SVO) | 38 (M) | ≥32 | SVO.RC.M | 0.66 × TDA + 3.18 | |
| | | | 0 (L) | <32 | SVO.RC.L | 2.20 × TDA + 6.85 | |
| | | Horizontal open (HZO) | 38 (M) | ≥32 | HZO.RC.M | 0.35 × TDA + 2.88 | |
| | | | 0 (L) | <32 | HZO.RC.L | 0.55 × TDA + 6.88 | |
| | | Vertical closed transparent (VCT) | 38 (M) | ≥32 | VCT.RC.M | 0.15 × TDA + 1.95 | |
| | | | 0 (L) | <32 | VCT.RC.L | 0.49 × TDA + 2.61 | |
| | | Horizontal closed transparent (HCT) | 38 (M) | ≥32 | HCT.RC.M | 0.16 × TDA + 0.13 | |
| | | | 0 (L) | <32 | HCT.RC.L | 0.34 × TDA + 0.26 | |
| | | Vertical closed solid (VCS) | 38 (M) | ≥32 | VCS.RC.M | 0.10 × V + 0.26 | |
| | | | 0 (L) | <32 | VCS.RC.L | 0.21 × V + 0.54 | |
| | | Horizontal closed solid (HCS) | 38 (M) | ≥32 | HCS.RC.M | 0.10 × V + 0.26 | |
| | | | 0 (L) | <32 | HCS.RC.L | 0.21 × V + 0.54 | |
| | | Service over counter (SOC) | 38 (M) | ≥32 | SOC.RC.M | 0.44 × TDA + 0.11 | |
| | | | 0 (L) | <32 | SOC.RC.L | 0.93 × TDA + 0.22 | |
| Self-contained commercial refrigerators and commercial freezers with and without doors | Self-contained (SC) | Vertical open (VOP) | 38 (M) | ≥32 | VOP.RC.M | 1.69 × TDA + 4.71 | AHRI 1200 |
| | | | 0 (L) | <32 | VOP.RC.L | 4.25 × TDA + 11.82 | |
| | | Semivertical open (SVO) | 38 (M) | ≥32 | SVO.RC.M | 1.70 × TDA + 4.59 | |
| | | | 0 (L) | <32 | SVO.RC.L | 4.26 × TDA + 11.51 | |
| | | Horizontal open (HZO) | 38 (M) | ≥32 | HZO.RC.M | 0.72 × TDA + 5.55 | |
| | | | 0 (L) | <32 | HZO.RC.L | 1.90 × TDA + 7.08 | |
| | | Vertical closed transparent (VCT) | 38 (M) | ≥32 | VCT.RC.M | 0.10 × V + 0.86 | |
| | | | 0 (L) | <32 | VCT.RC.L | 0.29 × V + 2.95 | |
| | | Vertical closed solid (VCS) | 38 (M) | ≥32 | VCS.RC.M | 0.05 × V + 1.36 | |
| | | | 0 (L) | <32 | VCS.RC.L | 0.22 × V + 1.38 | |
| Self-contained commercial refrigerators | Self-contained (SC) | Horizontal closed transparent (HCT) | 38 (M) | ≥32 | HCT.RC.M | 0.06 × V + 0.37 | AHRI 1200 |
| | | | 0 (L) | <32 | HCT.RC.L | 0.08 × V + 1.23 | |

| Equipment Category | Condensing Unit Configuration | Equipment Family | Rating Temp. °F | Operating Temp. °F | Equipment Classification[c] | Maximum Daily Energy Consumption kWh/day[d,e] | Test Standard |
|---|---|---|---|---|---|---|---|
| and commercial freezers with and without doors | | Horizontal closed solid (HCS) | 38 (M) | ≥32 | HCS.RC.M | 0.05 × V + 0.91 | |
| | | | 0 (L) | <32 | HCS.RC.L | 0.06 × V + 1.12 | |
| | | Service over counter (SOC) | 38 (M) | ≥32 | SOC.RC.M | 0.52 × TDA + 1.00 | |
| | | | 0 (L) | <32 | SOC.RC.L | 1.10 × TDA + 2.10 | |
| Self-contained commercial refrigerators with transparent doors for pull-down temperature applications | Self-contained (SC) | Pull-down | 38(M) | ≥32 | PD.SC.M | 0.11 × V + 0.81 | AHRI 1200 |
| Commercial ice cream freezers | Remote (RC) | Vertical open (VOP) | -15 (I) | ≤-5[b] | VOP.RC.I | 2.79 × TDA + 8.70 | AHRI 1200 |
| | | Semivertical open (SVO) | | | SVO.RC.I | 2.79 × TDA + 8.70 | |
| | | Horizontal open (HZO) | | | HZO.RC.I | 0.70 × TDA + 8.74 | |
| | | Vertical closed transparent (VCT) | | | VCT.RC.I | 0.58 × TDA + 3.05 | |
| | | Horizontal closed transparent (HCT) | | | HCT.RC.I | 0.40 × TDA + 0.31 | |
| | | Vertical closed solid (VCS) | | | VCS.RC.I | 0.25 × V + 0.63 | |
| | | Horizontal closed solid (HCS) | | | HCS.RC.I | 0.25 × V + 0.63 | |
| | | Service over counter (SOC) | | | SOC.RC.I | 1.09 × TDA + 0.26 | |
| | Self-contained (SC) | Vertical open (VOP) | -15 (I) | ≤-5[b] | VOP.SC.I | × TDA + | AHRI 1200 |
| | | Semivertical open (SVO) | | | SVO.SC.I | × TDA + | |
| | | Horizontal open (HZO) | | | HZO.SC.I | × TDA + | |
| | | Vertical closed transparent (VCT) | | | VCT.SC.I | × TDA + | |
| | | Horizontal closed transparent (HCT) | | | HCT.SC.I | × TDA + | |
| | | Vertical closed solid (VCS) | | | VCS.SC.I | × V + | |
| | | Horizontal closed solid (HCS) | | | HCS.SC.I | × V + | |
| | | Service over counter (SOC) | | | SOC.SC.I | × TDA + | |

For SI: 1 square foot = 0.0929 $m^2$, 1 cubic foot = 0.02832 $m^3$, °C = (°F – 32)/1.8.

*-Continued-*

**Footnotes for Table C410.2:**

a The meaning of the letters in this column is indicated in the columns to the left.

b Ice cream freezer is defined in DOE 10 C.F.R. Part 431.62 as a commercial freezer that is designed to operate at or below -5°F and that the manufacturer designs, markets or intends for the storing, displaying, or dispensing of ice cream.

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 = Semi-vertical 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.

d V is the volume of the case ($ft^3$) as measured in AHRI 1200, Appendix C.

e TDA is the total display area of the case ($ft^2$) as measured in AHRI 1200, Appendix D.

**C410.2.1 Refrigerated display cases.** Refrigerated display cases shall comply with the following:

1. Lighting 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.

**C410.3 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers.** Site-assembled and site-constructed *walk-in coolers* and *walk-in freezers* and *refrigerated warehouse coolers* and *refrigerated warehouse 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:** 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 be provided with 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 be provided with wall, ceiling, and door insulation of not less than R-25 or have wall, ceiling and door assembly *U*-factors no greater than *U*-0.039. *Walk-in freezers* and *refrigerated warehouse freezers* shall be provided with wall, ceiling and door insulation of not less than R-32 or have wall, ceiling and door assembly *U*-factors no greater than *U*-0.030.

**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 coolers* shall be provided with floor insulation of not less than R-25 or have a floor assembly *U*-factor no greater than *U*-0.40. The floor of *walk-in freezers* shall be provided with floor insulation of not less than R-28 or have a floor assembly *U*-factor no greater than *U*-0.035.
   **Exception:** Insulation is not required in the floor of a *walk-in cooler* that is mounted directly on a slab on grade.
5. Transparent fixed window and reach-in doors for *walk-in freezers* and windows in *walk-in freezer* doors shall be provided with triple-pane glass, with the interstitial spaces filled with inert gas or be provided with heat-reflective treated glass.
6. Transparent fixed window and reach-in doors for *walk-in coolers* and windows for *walk-in coolers* doors shall be provided with double-pane or triple-pane glass, with interstitial space filled with inert gas, or be provided with heat-reflective treated glass.
7. Evaporator fan motors that are less than 1 hp (0.746 kW) and less than 460 volts shall be provided with 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. Antisweat heaters that are not provided with antisweat heater controls shall have a total door rail, glass and frame heater power draw of 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. Where antisweat heater controls are provided, they 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. Lights in *walk-in coolers*, *walk-in freezers*, *refrigerated warehouse coolers* and *refrigerated warehouse freezers* shall either be provided with light sources with an efficacy of not less than 40 lumens per watt, including 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* space is not occupied.

**C410.3.1 Performance standards.** Site-assembled and site-constructed *walk-in coolers* and *walk-in freezers* shall meet the requirements of Tables C410.3.1(1), C410.3.1(2), and C410.2.1(3).

**TABLE C410.3.1(1)**
**WALK-IN COOLER AND FREEZER DISPLAY DOORS EFFICIENCY REQUIREMENTS**

| Class Descriptor | Class | Maximum Energy Consumption (kWh/day)[a] | Test Procedure |
|---|---|---|---|
| Display door, medium temperature | DD, M | 0.04 × $A_{dd}$ + 0.41 | 10 CFR 431 |
| Display door, low temperature | DD, L | 0.15 × $A_{dd}$ + 0.29 | 10 CFR 431 |

a. $A_{dd}$ is the surface area of the display door.

**TABLE C410.3.1(2)**
**WALK-IN COOLER AND FREEZER NONDISPLAY DOORS EFFICIENCY REQUIREMENTS**

| Class Descriptor | Class | Maximum Energy Consumption (kWh/day)[a] | Test Procedure |
|---|---|---|---|
| Passage door, medium temperature | PD, M | 0.05 × $A_{nd}$ + 1.7 | 10 CFR 431 |
| Passage door, low temperature | PD, L | 0.14 × $A_{nd}$ + 4.8 | 10 CFR 431 |
| Freight door, medium temperature | FD, M | 0.04 × $A_{nd}$ + 1.9 | 10 CFR 431 |
| Freight door, low temperature | FD, L | 0.12 × $A_{nd}$ + 5.6 | 10 CFR 431 |

a. $A_{nd}$ is the surface area of the nondisplay door.

**TABLE C410.3.1(3)**
**WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEMS EFFICIENCY REQUIREMENTS**

| Class Descriptor | Class | Minimum Annual Walk-in Energy Factor AWEF (Btu/hW-h)[a] | Test Procedure |
|---|---|---|---|
| Dedicated condensing, medium temperature, indoor system | DC.M.I | 5.61 | AHRI 1250 |
| Dedicated condensing, medium temperature, outdoor system | DC.M.O | 7.60 | |
| Dedicated condensing, low temperature, indoor system, net capacity ($q_{net}$) < 6,500 Btu/h | DC.L.I, < 6,500 | $9.091 \times 10^{-5} \times q_{net} + 1.81$ | |
| Dedicated condensing, low temperature, indoor system, net capacity ($q_{net}$) ≥ 6,500 Btu/h | DC.L.I, ≥ 6,500 | 2.40 | |
| Dedicated condensing, low temperature, outdoor system, net capacity ($q_{net}$) < 6,500 Btu/h | DC.L.O, < 6,500 | $6.522 \times 10^{-5} \times q_{net} + 2.73$ | |
| Dedicated condensing, low temperature, outdoor system, net capacity ($q_{net}$) ≥ 6,500 Btu/h | DC.L.O, ≥ 6,500 | 3.15 | |
| Unit cooler, medium | UC.M | 9.00 | |
| Unit cooler, low temperature, net capacity ($q_{net}$) < 15,500 Btu/h | UC.L, < 15,500 | $1.575 \times 10^{-5} \times q_{net} + 3.91$ | |
| Unit cooler, low temperature, net capacity ($q_{net}$) ≥ 15,500 Btu/h | UC.L, ≥ 15,500 | 4.15 | |

a. $q_{net}$ is net capacity (Btu/h) as determined in accordance with AHRI 1250.

**C410.4 Refrigerated case and walk-in display doors.** Lighting in glass doors in all *walk-in coolers* and *walk-in freezers* and all *refrigerated warehouse coolers* and *refrigerated warehouse freezers* shall comply with the following:

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.
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.

**C410.5 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 *condensing unit*, shall comply with Sections C410.5.1, C410.5.2, and C403.9.2.3.

**Exception**: Systems where the working fluid in the refrigeration cycle goes through both subcritical and supercritical states (transcritical) or that use ammonia refrigerant are exempt.

**C410.5.1 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-*temperature refrigeration systems*, and the design dry-bulb temperature plus 15°F (8°C) for *medium temperature 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, evaporatively cooled condensers, air- or water-cooled fluid coolers or cooling towers shall reduce fan motor demand to not more than 30 percent of design wattage at 50 percent of design air volume, and incorporate 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 condensing 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).

**C410.5.2 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 subcooled 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 compressor 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 ~~C403.2.10~~C403.10.3(1) or C403.10.3(2).
3. Compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

**C410.6 Commissioning.** Refrigeration systems shall be commissioned in accordance with Section C408.

**Exception**: Self-contained units.

## SECTION C411
## RENEWABLE ENERGY

**C411.1 On-site renewable energy systems.** ~~Each new building or addition larger than 10,000 square feet of gross *conditioned floor area* shall include a renewable energy generation system consisting of not less than 0.5 W/ft² or 1.7 Btu/ft² multiplied by the sum of the gross *conditioned floor area*~~ *Buildings* shall be provided with on-site renewable electricity generation systems with a direct current (DC) nameplate power rating of not less than 0.75 watts per square foot (8.1 W/m²) multiplied by the sum of the gross *conditioned floor area* of all floors, not to exceed the combined gross *conditioned floor area* of the three largest floors.

**Exceptions**: The following *buildings* or building sites shall comply with **Section C405.15.2**:

1. ~~Any building where more than 50 percent of the roof area is shaded from direct beam sunlight by natural objects or by structures that are not part of the building for more than 2500 annual hours between 8:00 a.m. and 4:00 p.m.~~A *building site* located where an unshaded flat plate collector oriented toward the equator and tilted at an angle from horizontal equal to the latitude receives an annual daily average incident solar radiation less than 1.1 kBtu/ft² per day (3.5 kWh/m²/day).
2. ~~Any~~ A building where more than 80 percent of the roof area is covered by any combination of permanent obstructions such as, but not limited to, mechanical equipment ~~other than for on-site renewable energy systems, planters~~, vegetated space, ~~skylights or occupied roof deck~~access pathways or occupied roof terrace.
3. Buildings which can document they do not have adequate roof area to install the required on-site solar and that comply with Section C411.1.1 may install a lesser amount of on-site renewables but not zero.

~~3.~~4. A *building* with gross *conditioned floor area* less than 5,000 square feet (465 m²).

**C411.1.1 Additional efficiency credits.** Buildings which qualify for one of the exceptions in Section C411.1 to omit installation of on-site renewable energy must achieve an additional 18 efficiency package credits from

Table C406.2(1). The additional 18 credits can be reduced based on a prorated fraction of renewable capacity that is installed on-site.

On-site renewable energy installations of lower than required capacity can be counted proportionally toward achievement of required or additional efficiency credits in Section C411.1.1 based on the capacity of renewable energy installed compared to the requirements of Section C411.1.

**C411.2 On-site and off-site renewable energy accounting.** Qualifying on-site and off-site renewable energy delivered or credited to the building project to comply with this code shall meet the requirements of this section. Renewable energy certificates for an on-site or off-site renewable energy system shall be retired on behalf of the building owner for a period of not less than 15 years and tracked in accordance with Section C411.2.3 and submitted to the code official as part of the permit application.

**Commented [BK(102]:** The IECC language is inserted in blue under C411.2. The two methods for off site accounting would need to be consolidated.

**C411.2.1 Qualifying types of off-site renewable energy systems.** The following are considered qualifying off-site renewable energy systems:

1. Self-generation (an off-site renewable energy system owned by the building project owner) systems complying with Section C411.2.2.
2. Community renewable energy facility systems complying with Section C411.2.2.
3. Purchase contracts complying with Section C411.2.3.
4. Each source of renewable energy delivered to or credited to the building project shall be connected to the Western Interconnection and energy or capacity multiplied by the factors in Table C411.2.1.

**TABLE C411.2.1**
**MULTIPLIERS FOR RENEWABLE ENERGY PROCUREMENT METHODS**

| Location | Renewable Energy Source | Renewable Energy Factor | | |
|---|---|---|---|---|
| | | In the State of Washington | Western Interconnection | In the States of Oregon or Idaho |
| On-site | On-site renewable energy system | 1 | NA | NA |
| Off-site | Directly owned off-site renewable energy system that begins operation after submission of the initial permit application | 0.95 | 0.75 | 0.85 |
| Off-site | Community renewable energy facility that begins operation after submission of the initial permit application | 0.95 | 0.75 | 0.85 |
| Off-site | Directly owned off-site renewable energy system that begins operation before submission of the initial permit application | 0.75 | 0.55 | 0.65 |
| Off-site | Community renewable energy facility that begins operation before submission of the initial permit application | 0.75 | 0.55 | 0.65 |
| Off-site | Renewable Power Purchase Agreement (PPA) | 0.75 | 0.55 | 0.65 |

**C411.2.2 Documentation requirements for off-site renewable energy systems.** Off-site renewable energy delivered or credited to the building project to comply with Section C407.3 item 2.2 shall be subject to a legally binding contract to procure qualifying off-site renewable energy. Qualifying off-site renewable energy shall meet the following requirements:

1. Documentation of off-site renewable energy procurement shall be submitted to the *code official*.
2. The purchase contract shall have a duration of not less than 15 years. The contract shall be structured to survive a partial or full transfer of ownership of the building property.
3. Records on renewable power purchased by the building owner from the off-site renewable energy generator that specifically assign the RECs to the building owner shall be retained or retired by the building owner on behalf of the entity demonstrating financial or operational control over the building seeking compliance to this standard and made available for inspection by the *code official* upon request.

4. Where multiple buildings in a building project are allocated energy procured by a contract subject to this section, the owner shall allocate for not less than 15 years the energy procured by the contract to the buildings in the building project. A plan on operation shall be developed which shall indicate how renewable energy produced from on-site or off-site systems that is not allocated before issuance of the certificate of occupancy will be allocated to new or existing buildings included in the building project.

**C411.2.3 Renewable energy certificate (REC) tracking.** For multitenant buildings where RECs are transferred to tenants, the plan for operation shall include procedures for tracking the quantity and vintage of RECs that are required to be retained and retired. The plan shall include provisions to transfer the RECs to building tenants, or to retire RECs on their behalf, in proportion to the gross conditioned and semi-heated floor area leased or rented. The plan shall include provisions to use a REC tracking system that meets the requirements of Section V.B of the Green-e Framework for Renewable Energy Certification. The plan shall describe how the building owner will procure alternative qualifying renewable energy in the case that the renewable energy producer ceases.

---

**C405.15.2 Off-site renewable energy.** *Buildings* that qualify for one or more of the exceptions to **Section C405.15.1** or do not meet the requirements of **Section C405.15.1** with an on-site renewable energy system shall procure off-site renewable electrical energy, in accordance with **Sections C405.15.2.1** and **C405.15.2.2**, that shall be not less than the total off-site renewable electrical energy determined in accordance with **Equation 4-X**.

$$TRE_{off} = (REN_{off} \times 0.75\ W/ft2 \times FLRA - IRE_{on}) \times 15 \qquad \textbf{Equation 4-X}$$

where:

$TRE_{off}$ = Total off-site renewable electrical energy in kilowatt-hours (kWh) to be procured in accordance with **Table C405.15.2**.

$REN_{off}$ = Annual off-site renewable electrical energy from **Table C405.15.2**, in units of kilowatt hours per watt of array capacity.

FLRA = The sum of the gross conditioned floor area of all floors not to exceed the combined floor area of the three largest floors.

$IRE_{on}$ = Annual on-site renewable electrical energy generation of a new on-site renewable energy system, to be installed as part of the building project, whose rated capacity is less than the rated capacity required in **Section C405.15.1**.

**TABLE C405.15.2**
**ANNUAL OFF-SITE RENEWABLE ENERGY REQUIREMENTS**

| Climate Zone | Annual Off-Site Renewable Electrical Energy (kWh/W) |
|---|---|
| 4C | 1.35 |
| 5B | 1.75 |

**C405.15.2.1 Off-site procurement.** The building *owner,* as defined in the ***International Building Code***, shall procure and be credited for the total amount of off-site renewable electrical energy, not less than required in accordance with **Equation 4-X**, with one or more of the following:

1. *Physical renewable energy power purchase agreement*.
2. *Financial renewable energy power purchase agreement*.
3. *Community renewable energy facility.*
4. Off-site renewable energy system owned by the building property *owner.*
5. *Renewable energy investment fund.*
6. *Green retail tariff.*

The generation source shall be located where the energy can be delivered to the *building site* by any of the following:

1. Direct connection to the off-site renewable energy facility.
2. The local utility or distribution entity.
3. An interconnected electrical network where energy delivery capacity between the generator and the *building site* is available.

**C405.15.2.2 Off-site contract.** The renewable energy shall be delivered or credited to the *building site* under an energy contract with a duration of not less than 10 years. The contract shall be structured to survive a partial or full transfer of ownership of the building property.

**C405.15.3 Renewable energy certificate (REC) documentation.** The property *owner* or owner's authorized agent shall demonstrate that where renewable energy certificates (RECs) or energy attribute certificates (EACs) are associated with on-site and off-site renewable energy production required by **Sections C405.15.1** and **C405.15.2**, all of the following criteria for RECs and EACs shall be met:

1. The RECs and EACs are retained and retired by or on behalf of the property owner or tenant for a period of not less than 15 years or the duration of the contract in **Section C405.15.2.2**, whichever is less.
2. The RECs and EACs are created within a 12-month period of the use of the REC.
3. The RECs and EACs are from a generating asset placed in service not more than 5 years before the issuance of the certificate of occupancy.

**C405.15.4 Renewable energy certificate purchase.** A *building* that qualifies for one or more of the exceptions to **Section C405.15.1**, and where it can be demonstrated to the *code official* that the requirements of **Section C405.15.2** cannot be met, the building owner shall contract the purchase of renewable electricity products before the certificate of occupancy is issued. The purchase of renewable electricity products shall comply with the **Green-e Energy National Standard** for renewable electricity products equivalent to five times the amount of total off-site renewable energy calculated in accordance with **Equation 4-X**.

---

**C411.3 Solar readiness**. A solar zone shall be provided on buildings that are 20 stories or less in height above grade plane. The solar zone shall be located on the roof of the building or on another structure elsewhere on the site. The solar zone shall be in accordance with this section and the *International Fire Code.*

**Exception.** A solar zone is not required under the following conditions:

1. Where the solar exposure of the building's roof area is less than 75 percent of that of an unshaded area, as defined in Section C411.3.4, in the same location, as measured by one of the following:
   1.1. Incident solar radiation expressed in kWh/ft$^2$-yr using typical meteorological year (TMY) data;
   1.2. Annual sunlight exposure expressed in cumulative hours per year using TMY data;
   1.3. Shadow studies indicating that the roof area is more than 25 percent in shadow, on September 21 at 10am, 11am, 12pm, 1pm, and 2pm solar time.
2. Buildings, building additions, changes in space conditioning or occupancy where the total floor area is equal to or less than 500 square feet.

**C411.3.1 Minimum area**. The minimum area of the solar zone shall be determined by one of the following methods, whichever results in the smaller area:

1. 40 percent of roof area. The roof area shall be calculated as the horizontally-projected gross roof area less the area covered by skylights, occupied roof decks, mechanical equipment, mechanical equipment service clearances, and planted areas.
2. 20 percent of electrical service size. The electrical service size is the rated capacity of the total of all electrical services to the building, and the required solar zone size shall be based upon 10 peak watts of photovoltaic per square foot.

**Exception.** Subject to the approval of the *code official*, buildings with extensive rooftop equipment that would make full compliance with this section impractical shall be permitted to reduce the size of the solar zone required by Section C411.3 to the maximum practicable area.

**C411.3.2 Contiguous area.** The solar zone is permitted to be comprised of separated sub-zones. Each sub-zone shall be at least 5 feet wide in the narrowest dimension.

**C411.3.3 Obstructions.** The solar zone shall be free of pipes, vents, ducts, HVAC equipment, skylights and

other obstructions, except those serving photovoltaic systems within the solar zone. The solar zone is permitted to be located above any such obstructions, provided that the racking for support of the future system is installed at the time of construction, the elevated solar zone does not shade other portions of the solar zone, and its height is permitted by the *International Building Code*. Photovoltaic or solar water heating systems are permitted to be installed within the solar zone.

**C411.3.4 Shading.** The solar zone shall be set back from any existing or new object on the building or site that is located south, east, or west of the solar zone a distance at least two times the object's height above the nearest point on the roof surface. Such objects include but are not limited to taller portions of the building itself, parapets, chimneys, antennas, signage, rooftop equipment, trees and roof plantings. No portion of the solar zone shall be located on a roof slope greater than 2:12 that faces within 45 degrees of true north.

**C411.3.5 Access**. Areas contiguous to the solar zone shall provide access pathways and provisions for emergency smoke ventilation as required by the *International Fire Code*.

**C411.3.6 Structural integrity**. The as-designed dead load and live load for the solar zone shall be clearly marked on the record drawings and shall accommodate future photovoltaic system arrays at an assumed dead load of 4 pounds per square foot in addition to other required live and dead loads. A location for future inverters shall be designated either within or adjacent to the solar zone, with a minimum area of 2 square feet for each 1000 square feet of solar zone area, and shall accommodate an assumed dead load of 175 pounds per square foot. Where photovoltaic systems are installed in the solar zone, structural analysis shall be based upon calculated loads, not upon these assumed loads.

**C411.3.7 Photovoltaic interconnection.** Interconnection of the future photovoltaic system shall be provided for at the main service panel, either ahead of the service disconnecting means or at the end of the bus opposite the service disconnecting means, in one of the following forms:

1. A space for the mounting of a future overcurrent device, sized to accommodate the largest standard rated overcurrent device that is less than 20 percent of the bus rating.
2. Lugs sized to accommodate conductors with an ampacity of at least 20 percent of the bus rating, to enable the mounting of an external overcurrent device for interconnection.

The electrical construction documents shall indicate the following:

1. Solar zone boundaries and access pathways;
2. Location for future inverters and metering equipment; and
3. Route for future wiring between the photovoltaic panels and the inverter, and between the inverter and the main service panel.

## SECTION C412
## COMPRESSED AIR SYSTEMS

**C412.1 General.** All new *compressed air systems*, and all additions or alterations of *compressed air systems* where the total combined horsepower (hp) of the compressor(s) is 25 hp or more, shall meet the requirements of this section. These requirements apply to the compressors, related piping systems, and related controls that provide compressed air and do not apply to any equipment or controls that use or process the compressed air.

**Exception**: Medical gas compressed air systems in health care facilities.

**C412.2 Trim compressor and storage.** The compressed air system shall be equipped with an appropriately sized trim compressor and primary storage to provide acceptable performance across the range of the system and to avoid control gaps. The compressed air system shall comply with 1 or 2 below:

1. The *compressed air system* shall include one or more variable speed drive (VSD) compressors. For systems with more than one compressor, the total combined capacity of the VSD compressor(s) acting as trim compressors must be at least 1.25 times the *largest net capacity increment* between combinations of compressors. The *compressed air system*s hall include *primary storage* of at least one gallon per actual cubic feet per minute (acfm) of the largest trim compressor; or
2. The *compressed air system* shall include a compressor or set of compressors with total effective trim capacity at least the size of the *largest net capacity increment* between combinations of compressors, or the size of the smallest compressor, whichever is larger. The total effective trim capacity of single compressor systems shall cover at least the range from 70 percent to 100 percent of rated capacity. The effective trim capacity of a compressor is the size of the continuous operational range where the specific power of the compressor (kW/100 acfm) is within 15 percent of the specific power at its most efficient

operating point. The total effective trim capacity of the system is the sum of the effective trim capacity of the trim compressors. The system shall include *primary storage* of at least 2 gallons per acfm of the largest trim compressor.

**Exceptions**:

1. Alterations where the total combined added or replaced compressor horsepower is less than the average per-compressor horsepower of all compressors in the system.
2. Alterations where all added or replaced compressors are variable speed drive (VSD) compressors and *compressed air systems* includes *primary storage* of at least one gallon per acfm of the largest trim compressor.
3. *Compressed air systems* that have been pre*approved* as having demonstrated that the system serves loads for which typical air demand fluctuates less than 10 percent.
4. Alterations of existing *compressed air systems* that include one or more centrifugal compressors.

**C412.3 Controls.** *Compressed air systems* with three or more compressors and a combined horsepower rating of more than 100 hp, shall operate with controls that are able to choose the most energy efficient combination and loading of compressors within the system based on the current compressed air demand.

**C412.4 Monitoring.** *Compressed air systems* having a combined horsepower rating equal to or greater than 100 hp shall have an energy and air demand monitoring system with the following minimum requirements:

1. Measurement of system pressure.
2. Measurement of amps or power of each compressor.
3. Measurement or determination of total airflow from compressors in cfm.
4. Data logging of pressure, power in kW, airflow in cfm, and *compressed air system* specific efficiency in kW/100 cfm at intervals of five minutes or less.
5. Maintained data storage of at least the most recent 24 months.
6. Visual trending display of each recorded point, load and specific efficiency.

**C412.5 Leak testing of compressed air piping.** *Compressed air system* piping greater than 50 adjoining feet in length shall be pressure tested after being isolated from the compressed air supply and end-uses. The piping shall be pressurized to the design pressure and test pressures shall be held for a length of time at the discretion of the local jurisdiction, but in no case for less than 30 minutes, with no perceptible drop in pressure.

If dial gauges are used for conducting this test, for pressure tests less than or equal to 100 psi (689 kPa) gauges shall be incremented in units of 1 psi (7 kPa) less, for pressure tests greater than 100 psi (689 kPa) gauges shall be incremented in units less than 2 percent of the test pressure. Test gauges shall have a pressure range not exceeding twice the test pressure.

Piping less than or equal to 50 adjoining feet in length shall be pressurized and inspected. Connections shall be tested with a noncorrosive leak-detecting fluid or other leak-detecting methods as pre*approved* by the local jurisdiction.

**C412.6 Pipe sizing.** Compressed air piping greater than 50 adjoining feet in length shall be designed and installed to minimize frictional losses in the distribution network. These piping installations shall meet the requirements of Section C412.6.1 and either Section C412.6.2 or C412.6.3.

**C412.6.1 Service line piping.** Service line piping shall have inner diameters greater than or equal to 3/4 inch. Service line piping are pipes that deliver compressed air from distribution piping to end uses.

**C412.6.2 Piping section average velocity.** Compressor room interconnection and main header piping shall be sized so that at coincident peak flow conditions, the average velocity in the segment of pipe is no greater than 20 ft/sec. Compressor room interconnection and main header piping are the pipes that deliver compressed air from the compressor outlets to the inlet to the distribution piping. Each segment of distribution and service piping shall be sized so that at coincident peak flow conditions, the average velocity in the segment of pipe is no greater than 30 ft/sec. Distribution piping are pipes that deliver compressed air from the compressor room interconnection piping or main header piping to the service line piping.

**C412.6.3 Piping total pressure drop.** Piping shall be designed such that piping frictional pressure loss at coincident peak loads are less than 5 percent of operating pressure between the compressor and end use or end use regulator.

**C412.7 Compressed air system acceptance.** Before an occupancy permit is granted for a *compressed air system*, a certificate of acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the requirements of this code.

# CHAPTER 5
# EXISTING BUILDINGS

## SECTION C501
## GENERAL

**C501.1 Scope.** The provisions of this chapter shall control the *alteration*, *repair*, *addition* and change of occupancy of existing buildings and structures.

**C501.1.1 Existing buildings.** Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing building or building system lawfully in existence at the time of adoption of this code. Unaltered portions of existing buildings used for residential purposes that received a certificate of occupancy at least three years prior to a permit application for residential uses shall not be required to comply with this code.

**C501.2 Compliance.** *Additions*, *alterations*, *repairs*, changes in space conditioning and changes of occupancy to, or relocation of, existing buildings and structures shall comply with Section C502, C503, C504, or C505 of this code, and with all applicable provisions in the *International Building Code*, *International Existing Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *Uniform Plumbing Code*, and NFPA 70.

**C501.2.1 *U*-factor requirements for additions and alterations.** For existing building projects where an *addition* or *building thermal envelope alteration* area is combined with existing-to-remain building areas to demonstrate compliance with this code as a whole building, the *U*-factors applied to existing-to-remain envelope assemblies shall be in accordance with record documents.

**Exception:** If accurate record documents are not available, *U*-factors for the existing envelope assemblies may be in accordance with the edition of the Washington State Energy Code that was in effect at the time the building was permitted, or as approved by the *code official*.

**C501.2.2 Calculations of mechanical heating and cooling loads for alterations.** For the installation of new or replacement mechanical equipment that serves existing building areas, design loads associated with heating, cooling and ventilation of the existing building areas served shall be determined in accordance with Section C403.1.2.

*R*-values and *U*-factors used to determine existing thermal envelope performance for the purpose of calculating design loads shall be in accordance with record documents or existing conditions.

**Exception:** If accurate record documents are not available, *R*-values and *U*-factors used to determine existing building thermal envelope performance may be in accordance with the edition of the Washington State Energy Code that was in effect at the time the building was permitted, or as *approved* by the *code official*.

**C501.3 Maintenance.** Buildings and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems which are required by this code shall be maintained in conformance with 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 protection and safety systems and devices in existing structures.

**C501.4 New and replacement materials.** Except as otherwise required or permitted by this code, materials permitted by the applicable code for new construction shall be used. Like materials shall be permitted for *repairs*, provided no hazard to life, health or property is created. Hazardous materials shall not be used where the code for new construction would not permit their use in buildings of similar occupancy, purpose and location.

**C501.5 Historic buildings.** Provisions of this code relating to the construction, *repair*, *alteration*, restoration and movement of structures, and *change of occupancy* shall not be mandatory for historic buildings provided that a report has been submitted to the *code official* 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 provision would threaten, degrade or destroy the historic form, fabric or function of the *building*.

**C501.6 Commissioning**. Existing building systems shall be commissioned in accordance with Section C408. For the purposes of meeting the commissioning thresholds in Section C408.1, only the new and altered system capacities are considered when determining whether the project is exempt from some portion of the commissioning process.

## SECTION C502
## ADDITIONS

**C502.1 General.** *Additions* to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion 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 building. This allowance applies to prescriptive compliance in accordance with Section C502.2 or Total Building Performance in accordance with Section C407.

**C502.1.1 Additional energy efficiency credits.** Additions shall comply with Section C406.1. The addition shall be deemed to comply with this section if the addition alone complies or if the addition area is combined with existing building areas to demonstrate compliance with an additional efficiency credit.

**C502.1.2 Renewable energy.** Additions shall comply with Section C411. The addition shall be deemed to comply with this section if the addition alone complies or if the addition area is combined with existing building areas to demonstrate compliance with the requirements for on-site renewable energy or solar readiness, as applicable.

**C502.2 Prescriptive compliance.** *Additions* shall comply with Sections C502.2.1 through C502.2.6.2.

**C502.2.1 Building mechanical systems.** New mechanical systems and equipment serving the building heating, cooling or ventilation needs, that are installed as a part of the *addition*, shall comply with Sections C403, C408.2, C501.6, and C506.1.

**C502.2.2 Service water heating systems.** New service water-heating systems and equipment that are installed as a part of the addition shall comply with Section C404, C408.3, C501.6, and C506.1.

**C502.2.3 Pools and permanent spas.** Systems and equipment serving new pools and permanent spas that are installed as a part of the *addition* shall comply with Sections C404.11, C408.3, C501.6, and C506.1.

**C502.2.4 Electrical power and lighting systems and motors.** New electrical power and lighting systems and motors that are installed as a part of the *addition* shall comply with Sections C405, C408.4, C501.6, and C506.1.

**C502.2.4.1 Interior lighting power.** The total interior lighting power for the addition shall comply with Section C405.4.2 for the addition alone, or the existing building and the addition shall comply as a single building.

**C502.2.4.2 Exterior lighting power.** The total exterior lighting power for the addition shall comply with Section C405.5.2 for the addition alone, or the existing building and the addition shall comply as a single building.

**C502.2.5 Refrigeration systems.** New refrigerated spaces and refrigeration systems and equipment that are installed as a part of the addition shall comply with Sections C408.7, C410, C501.6, and C506.1.

**C502.2.6 Building thermal envelope.** Additions shall comply with Sections C402.1 through C402.5, C502.3.1, and C502.3.2.

**C502.2.6.1 Vertical fenestration.** Additions with *vertical fenestration* shall comply with the following:

1. Where an *addition* with *vertical fenestration* area results in a total building *vertical fenestration* area less than or equal to the maximum allowed by Section C402.4.1, the addition shall comply with Section C402.4.

2. Where an *addition* with *vertical fenestration* area results in a total building vertical fenestration area greater than the maximum allowed by Section C402.4.1 (regardless of the ratio prior to the *addition*), the *addition* shall comply with one of the following:
    2.1. Component performance alternative with target area adjustment per Section C402.1.5 for the addition area of the building only.
    2.2. Existing building and addition area are combined to demonstrate compliance with the component performance alternative for the whole building. *U*-factors applied to existing envelope assemblies in the UA calculation shall comply with Section C501.2.1.
    2.3. Total building performance in accordance with Section C407 for the addition area of the building only.
    2.4. Total building performance for the whole building.

**C502.2.6.2 Skylights.** *Additions* with *skylights* shall comply with the following:

1. Where an *addition* with skylight area results in a total building skylight area less than or equal to the maximum allowed by Section C402.4.1, the *addition* shall comply with Section C402.4.
2. Where an *addition* with skylight area results in a total building skylight area greater than the maximum allowed by Section C402.4.1 (regardless of the ratio prior to the *addition*), the *addition* shall comply with one of the following:
    2.1. Component performance alternative with target area adjustment per Section C402.1.5 for the addition area of the building only.
    2.2. Existing building and addition area are combined to demonstrate compliance with the component performance alternative for the whole building. *U*-factors applied to existing envelope assemblies in the UA calculation shall comply with Section C501.2.1.
    2.3. Total building performance in accordance with Section C407 for the addition area of the building only.
    2.4. Total building performance for the whole building.

## SECTION C503
## ALTERATIONS

**C503.1 General.** Alterations to any building or structure shall comply with the requirements of Section C503 and the code for new construction. Alterations to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portions of the existing building or building system to comply with this code. 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. The additional energy efficiency credit requirement in Section C406.1 and the renewable energy requirements in Section C411 do not apply to alterations.

**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 to reduce solar heat gain provided the code does not require the glazing fenestration to be replaced.
3. ~~Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are insulated to full depth with insulation having a minimum nominal value of R-3.0 per inch installed per Section C402.~~
4. ~~Construction where the existing roof, wall or floor cavity is not exposed.~~
3. *Roof recover*.
5.4. *Roof replacement* where roof assembly insulation is integral to or located below the structural roof deck.
5. *Air barriers* shall not be required for roof recover and roof replacement where the alterations or renovations to the building do not include alterations, renovations or repairs to the remainder of the *building thermal envelope*.

6. Replacement of existing doors that separate conditioned space from the exterior shall not require the installation of a vestibule or revolving door, provided however that an existing vestibule that separates a conditioned space from the exterior shall not be removed.

6.7. An existing building undergoing *alterations* that complies with Section C407.

**C503.2 Reserved.**

**C503.3 Building thermal envelope.** *New building envelope assemblies that are part of the alteration shall comply with Sections C402.1 through C402.5 and Sections C503.3.1 through C503.3.3.*Alterations of existing *building thermal envelope* assemblies shall comply with this section. New *building thermal envelope* assemblies that are part of the *alteration* shall comply with Section C402. An area-weighted average *U-factor* for new and altered portions of the *building thermal envelope* shall be permitted to satisfy the *U-factor* requirements in Table C402.1.4. The existing *R-value* of insulation shall not be reduced for the *U-factor* of a *building thermal envelope* assembly be increased as part of a *building thermal envelope alteration* except where comply with Section C407.

**Exception**: Air leakage testing is not required for alterations and repairs, unless the project includes a change in space conditioning according to Section C503.2 or a change of occupancy or use according to Section C505.1.

**C503.3.1 Roof, replacementceiling and attic alterations.** *Roof replacements* shall comply with Table C402.1.3 or C402.1.4 where the existing roof assembly is part of the *building thermal envelope* and contains no insulation or the insulation is located entirely above the roof deck. In no case shall the *R*-value of he roof insulation be reduced or the *U*-factor of the roof assembly be increased as a part of the *roof replacement*. Insulation complying with Sections C402.1 and C402.2.1, or an *approved* design that minimizes deviation from the insulation requirements, shall be provided for the following *alterations*:

1. An *alteration* of roof/ceiling construction other than *reroofing* where existing insulation located below the roof deck or on an attic floor above *conditioned space* does not comply with Table C402.1.2.
2. Roof replacement or a roof *alteration* that includes removing and replacing the roof covering, where the roof assembly includes insulation entirely above the roof deck.

**Exceptions:** Where compliance with Section C402.1 cannot be met due to limiting conditions on an existing roof, an *approved* design shall be submitted with the following:

1. *Construction documents* that include a report by a *registered design professional* or an *approved source* documenting details of the limiting conditions affecting compliance with the insulation requirements.
2. *Construction documents* that include a roof design by a *registered design professional* or an *approved source* that minimizes deviation from the insulation requirements.
3. Conversion of unconditioned attic space into *conditioned space*.
4. Replacement of ceiling finishes exposing cavities or surfaces of the roof/ceiling construction.

**C503.3.2 Vertical fenestration.** Alterations that include the addition of new vertical fenestration area shall comply with the following:

1. Where the addition of new *vertical fenestration* area results in a total building vertical fenestration area less than or equal to the maximum allowed by Section C402.4.1, the alteration shall comply with Section C402.4.
2. Where the addition of new vertical fenestration area results in a total building vertical fenestration area greater than the maximum allowed by Section C402.4.1 (regardless of the ratio prior to the addition), the alteration shall comply with one of the following:
   - 2.1. Vertical fenestration alternate in accordance with Section C402.4.1.1 for the new vertical fenestration added.
   - 2.2. Vertical fenestration alternate in accordance with Section C402.4.1.1 for the area adjacent to the new vertical fenestration added.
   - 2.3. Existing building and alternation area are combined to demonstrate compliance with the component performance alternative with target area adjustment in accordance with Section C402.1.5 for the whole building. U-factors applied to existing envelope assemblies in the UA calculation shall comply with Section C501.2.1. The Proposed Total UA is allowed to be up to 110 percent of the Allowed Total UA.

2.4. Total building performance in accordance with Section C407 for the whole building. The total annual site energy use of the proposed design is allowed to be up to 110 percent of the annual site energy use allowed in accordance with Section C407.3.

**Exception:** Where *approved* by the *code official*, additional *fenestration* is permitted where sufficient envelope upgrades beyond those required by other sections of this code are included in the project so that the addition of new *vertical fenestration* does not cause an increase in the overall energy use of the building.

**C503.3.2.1 Replacement fenestration products.** 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 C402.4.

**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 C402.4 shall be permitted to satisfy the *U*-factor requirements for each fenestration product category listed in Table C402.4. Individual fenestration products from different product categories listed in Table C402.4 shall not be combined in calculating the area-weighted average *U*-factor.

**C503.3.3 Skylights.** Alterations that include the addition of new skylight area shall comply with the following:

1. Where the addition of new *skylight* area results in a total building skylight area less than or equal to the maximum allowed by Section C402.4.1, the alteration shall comply with Section C402.4.
2. Where the addition of new *skylight* area results in a total building skylight area greater than the maximum allowed by Section C402.4.1 (regardless of the ratio prior to the addition), the alteration shall comply with one of the following:
   2.1. Existing building and alteration area are combined to demonstrate compliance with the component performance alternative with target area adjustment in accordance with Section C402.1.5 for the whole building. *U*-factors applied to existing envelope assemblies in the UA calculation shall comply with Section C501.2.1. The Proposed Total UA is allowed to be up to 110 percent of the Allowed Total UA.
   2.2. Total building performance in accordance with Section C407 for the whole building. The total annual site energy use of the proposed design is allowed to be up to 110 percent of the annual site energy use allowed in accordance with Section C407.3.

**Exception**: Additional envelope upgrades are included in the project so the addition of new skylights does not cause a reduction in overall building energy efficiency, as approved by the *code official*.

**C503.3.4 Above-grade wall alterations.** *Above-grade wall alterations* shall comply with the following:

1. Where wall cavities are exposed, the cavity shall be filled with *cavity insulation* complying with Section C303.1.4. New cavities created shall be insulated in accordance with Section C402.1 or an *approved* design that minimizes deviation from the insulation requirements.
2. Where exterior wall coverings and *fenestration* are added or replaced for the full extent of any exterior wall assembly on one or more elevations of the *building*, insulation shall be provided where required in accordance with one of the following:
   2.1. An *R-value* of *continuous insulation* not less than that designated in Table C402.1.3 for the applicable *above-grade wall* type and existing cavity insulation *R-value*, if any;
   2.2. An *R-value* of not less than that required to bring the *above-grade wall* into compliance with Table C402.1.2; or,
   2.3. An *approved* design that minimizes deviation from the insulation requirements of Section C402.1.
3. Where Items 1 and 2 apply, the insulation shall be provided in accordance with Section C402.1.

Where any of the above requirements are applicable, the *above-grade wall alteration* shall comply with Sections 1402.2 and 1404.3 of the *International Building Code*.

**C503.3.5 Floor alterations.** Where an *alteration* to a floor or floor overhang exposes cavities or surfaces to which insulation can be applied, and the floor or floor overhang is part of the *building thermal envelope*, the floor or floor overhang shall be brought into compliance with Section C402.1 or an *approved* design that minimizes deviation from the insulation requirements. This requirement applies to floor *alterations* where the floor cavities or surfaces are exposed and unobstructed prior to construction.

**C503.3.6 Below-grade wall alterations.** Where unconditioned below-grade space is changed to *conditioned space*, walls enclosing such *conditioned space* shall be insulated where required in accordance with Section C402.1. Where the below-grade space is *conditioned space* and where walls enclosing such space are altered, they shall be insulated where required in accordance with Section C402.1.

**C503.3.7 Air barrier.** Altered *building thermal envelope* assemblies shall be provided with an *air barrier* in accordance with Section C402.6.1. Such *air barrier* need not be continuous with unaltered portions of the *building thermal envelope*. Testing requirements of Section C402.6.1.2 shall not be required.

**C503.4 Building mechanical systems.** Components of existing mechanical systems that are altered or replaced shall comply with Section C403 or Section C407, unless specifically exempted in Section C503.4, and Sections C408.2, C501.2.2, C501.6, C503.4.2 through C503.4.6, and C506.1. Additions or alterations shall not be made to an existing mechanical system that will cause the existing system to become out of compliance.

**Exceptions**:

1. Existing mechanical systems which are not required to be modified to comply with Section C403.3 where mechanical cooling capacity is not added to a system that did not have cooling capacity prior to the alteration.
2. Compliance with Section C403.1.4 is not required where the alteration does not include replacement of a heating appliance.
3. Alternate mechanical system designs that are not in full compliance with this code may be approved when the *code official* determines that existing building constraints including, but not limited to, available mechanical space, limitations of the existing structure, or proximity to adjacent air intakes or exhausts make full compliance impractical. Alternate designs shall include additional energy saving strategies not prescriptively required by this code for the scope of the project including, but not limited to, demand control ventilation, energy recovery, or increased mechanical cooling or heating equipment efficiency above that required by Tables C403.3.2(1) through C403.3.2(16).
4. Only those components of existing HVAC systems that are altered or replaced shall be required to comply with Section C403.8.1. Section C403.8.1 does not require the removal and replacement of existing system ductwork. Additional fan power allowances are available when determining the fan power budget (Fan $kW_{budget}$) as specified in Table C503.4. These values can be added to the fan power allowance values in Tables C403.8.1.1(1) and C403.8.1.1(2) when calculating a new Fan $kW_{budget}$ for the fan system being altered. The additional fan power allowance is not applicable to alterations that add or change passive components which do not increase the fan system static pressure.

**TABLE C503.4**
**ADDITIONAL FAN POWER ALLOWANCES (W/CFM)**

| Airflow | Multi-Zone VAV Systems[a] ≤5,000 cfm | Multi-Zone VAV Systems[a] >5,000 and ≤10,000 cfm | Multi-Zone VAV Systems[a] >10,000 cfm | All Other Fan Systems ≤5,000 cfm | All Other Fan Systems >5,000 and ≤10,000 cfm | All Other Fan Systems >10,000 cfm |
|---|---|---|---|---|---|---|
| Supply *Fan System* additional allowance | 0.135 | 0.114 | 0.105 | 0.139 | 0.120 | 0.107 |
| Supply *Fan System* additional allowance in unit with adapter curb | 0.033 | 0.033 | 0.043 | 0.000 | 0.000 | 0.000 |
| Exhaust/ Relief/ Return/ Transfer *Fan System* additional allowance | 0.070 | 0.061 | 0.054 | 0.070 | 0.062 | 0.055 |
| Exhaust/ Relief/ Return/ Transfer *Fan System* additional allowance with adapter curb | 0.016 | 0.017 | 0.220 | 0.000 | 0.000 | 0.000 |

a. See definition of *FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV)*.

**C503.4.1 New building mechanical systems.** All new mechanical systems and equipment in existing buildings shall comply with Sections C403, C408.2, C501.6, and C506.1.

**Exceptions:**

1. Mechanical systems that are not required to comply with Section C403.3.5 are exempt from the requirements of Section C408.2 where the installed total mechanical equipment capacity is less than 180,000 Btu/h (15 tons) cooling capacity and less than 240,000 Btu/h (20 tons) heating capacity and energy recovery ventilation (ERV) equipment is less than 300 cfm capacity.
2. Systems included in Section C403.5 that serve individual *dwelling units* and *sleeping units* are exempt from the requirements of Section C408.2.

**C503.4.2 Replacement or added roof-mounted mechanical equipment.** For roofs with insulation entirely above the roof deck and where existing roof-mounted mechanical equipment is replaced or new equipment is added, and the existing roof does not comply with the insulation requirements for new construction in accordance with Sections C402.1 and C402.2.1, curbs for added or replaced equipment shall be of a height necessary to accommodate the future addition of above-deck roof insulation to be installed in accordance with Section C503.3.1, Item 2. Alternatively, the curb height shall be a minimum of 17 inches (43.2 cm), measured from the top of the curb to the top of the roof deck.

~~C503.4.2~~C503.4.3 **Addition of cooling capacity.** Where mechanical cooling is added to a space that was not previously cooled, the mechanical system shall comply with either Section C403.3.5 or C403.5.

**Exceptions**:

1. Qualifying small equipment: Economizers are not required for cooling units and split systems serving one *zone* with a total cooling capacity rated in accordance with Section C403.3.2 of less than 33,000 Btu/h (hereafter referred to as qualifying small systems) provided that these are high-efficiency cooling equipment with SEER and EER values more than 15 percent higher than minimum efficiencies listed in Tables C403.3.2(1), (2), (4), (8), (9), and (14) in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. The total capacity of all qualifying small equipment without economizers shall not exceed 72,000 Btu/h per building, or 5 percent of the building total air economizer capacity, whichever is greater.
   Notes and exclusions for Exception 1:
   1.1. The portion of the equipment serving Group R occupancies is not included in determining the total capacity of all units without economizers in a building.
   1.2. Redundant units are not counted in the capacity limitations.
   1.3. This exception shall not be used for the initial tenant improvement of a shell-and-core building or space, or for total building performance.in accordance with Section C407
   1.4. This exception shall not be used for unitary cooling equipment installed outdoors or in a mechanical room adjacent to the outdoors.
2. Chilled water terminal units connected to systems with chilled water generation equipment with IPLV values more than 25 percent higher than minimum part load equipment efficiencies listed in Table C403.3.2(3), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20 percent of the building total air economizer capacity, whichever is greater.
   Notes and exclusions for Exception 1:
   2.1. The portion of the equipment serving Group R occupancy is not included in determining the total capacity of all units without economizers in a building.
   2.2. This exception shall not be used for the initial tenant improvement of a shell-and-core building or space, or for total building performance in accordance with Section C407.

~~C503.4.3~~C503.4.4 **Alterations or replacement of existing cooling systems.** Alterations to, or replacement of, existing mechanical cooling systems shall not decrease the building total economizer capacity unless the system complies with either Section C403.3.5 or C403.5. System alterations or replacement shall comply with Table C503.4.3 when either the individual cooling unit capacity or the building total capacity of all cooling equipment without economizer does not comply with the exceptions in Section C403.5. Equipment replacements that include space heating shall also comply with Section C503.4.6.

**Commented [BK(103]:** The IECC now has this as the base section (C503.3), but has added new sections for commissioning, duct testing, controls and system sizing. Why they indicate all new systems must comply with C403 and then specify specific sections for compliance is very confusing to me. See below Table C503.4.7 for IECC language.

**Commented [BK(104]:** I moved language from the C408.1 exception since the scoping paragraph requires compliance with C408.2 without mention of C408.1. The second exception is from the 2024 IECC.

~~TABLE C503.4.3~~ C503.4.4

**ECONOMIZER COMPLIANCE OPTIONS FOR MECHANICAL ALTERATIONS**

| Unit Type | Option A | Option B (alternate to A) | Option C (alternate to A) | Option D (alternate to A) |
|---|---|---|---|---|
| | **Any alteration with new or replacement equipment** | **Replacement unit of the same type with the same or smaller output capacity** | **Replacement unit of the same type with a larger output capacity** | **New equipment added to existing system or replacement unit of a different type** |
| 1. Packaged Units | Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: min.[a]<br>Economizer: CC403.5[b] | Efficiency: min.[a]<br>Economizer: C403.5[b] |
| 2. Split Systems | Efficiency: min.[a]<br>Economizer: C403.5[b] | For units ≤ 60,000 Btuh, comply with two of two measures:<br>1. Efficiency: + 10%[e]<br>2. Economizer: shall not decrease existing economizer capability<br>For all other capacities:<br>Efficiency: min.[a]<br>Economizer: C403.5[b] | For units ≤ 60,000 Btuh replacing unit installed prior to 1991, comply with at least one of two measures:<br>1. Efficiency: + 10%[e]<br>2. Economizer: 50%[f]<br>For all other capacities:<br>Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: min.[a]<br>Economizer: C403.5[b] |
| 3. Water Source Heat Pump | Efficiency: min.[a]<br>Economizer: C403.5[b] | For units ≤72,000 Btuh, comply with at least two of three measures:<br>1. Efficiency: + 10%[e]<br>2. Flow control valve[g]<br>3. Economizer: 50%[f]<br>For all other capacities:<br>Efficiency: min.[a]<br>Economizer: C403.5[b] | For units ≤72,000 Btuh, comply with at least two of three measures:<br>1. Efficiency: + 10%[e]<br>2. Flow control valve[g]<br>3. Economizer: 50%[f] (except for certain pre-1991 systems[h])<br>For all other capacities:<br>Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: min.[a]<br>Economizer: C403.5[b] (except for certain pre-1991 systems[q]) |
| 4. Water Economizer using Air-Cooled Heat Rejection Equipment (Dry Cooler) | Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: +5%[d]<br>Economizer: shall not decrease existing economizer capacity | Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: min.[a]<br>Economizer: C403.5[b] |
| 5. Air-Handling Unit (including fan coil units) where the system has an air-cooled chiller | Efficiency: min.[a]<br>Economizer: C403.5[b] | Economizer: shall not decrease existing economizer capacity | Efficiency: min.[a]<br>Economizer: C403.5[b] (except for certain pre-1991 systems[q]) | Efficiency: min.[a]<br>Economizer: C403.5[b] (except for certain pre-1991 systems[q]) |
| 6. Air- Handling Unit (including fan coil units) and Water-cooled Process Equipment, where the system has a water-cooled chiller[j] | Efficiency: min.[a]<br>Economizer: C403.5[b] | Economizer: shall not decrease existing economizer capacity | Efficiency: min.[a]<br>Economizer: C403.5[b] (except for certain pre-1991 systems[h] and certain 1991-2016 systems[i].) | Efficiency: min.[a]<br>Economizer: C403.5[b] (except for certain pre-1991 systems[h] and certain 1991-2016 systems[i]) |
| 7. Cooling Tower | Efficiency: min.[a] | No requirements | Efficiency: min.[a] | Efficiency: min.[a] |

| Unit Type | Option A | Option B (alternate to A) | Option C (alternate to A) | Option D (alternate to A) |
|---|---|---|---|---|
| | Any alteration with new or replacement equipment | Replacement unit of the same type with the same or smaller output capacity | Replacement unit of the same type with a larger output capacity | New equipment added to existing system or replacement unit of a different type |
| | Economizer: C403.5[b] | | Economizer: C403.5[b] | Economizer: C403.5[b] |
| 8. Air-Cooled Chiller | Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: + 10%[k]<br>Economizer: shall not decrease existing economizer capacity | Efficiency: Comply with two of two measures:<br>1. + 10%[k,l]<br>2. Multistage<br>Economizer: shall not decrease existing economizer capacity | Efficiency: min.[a]<br>Economizer: C403.5[b] |
| 9. Water-Cooled Chiller | Efficiency: min.[a]<br>Economizer: C403.5[b] | Efficiency: Comply with at least one of two measures:<br>1. Part load IPLV + 15%[n]<br>2. Plate frame heat exchanger[o]<br>Economizer: shall not decrease existing economizer capacity | Efficiency: Comply with two of two measures:<br>1. Part load IPLV + 15%[n]<br>2. Plate frame heat exchanger[o]<br>Economizer: shall not decrease existing economizer capacity | Efficiency: min.[a]<br>Economizer: C403.5[b] |
| 10. Package Terminal Air Conditioner | Efficiency: min. [a]<br>Economizer: C403.5[b] | Efficiency: + 5%[a]<br>Economizer: shall not decrease existing economizer capacity | Efficiency: + 5%[a]<br>Economizer: shall not decrease existing economizer capacity | Efficiency: min. [a]<br>Economizer: C403.5[b] |
| 11. Package Terminal Heat Pump | Efficiency: min. [a]<br>Economizer: C403.5[b] | Cooling efficiency: + 5%[d]<br>Heating efficiency: + 10%[e]<br>Shall not decrease existing economizer capacity | Cooling efficiency: + 5%[d]<br>Heating efficiency: + 10%[e]<br>Shall not decrease existing economizer capacity | Efficiency: min. [a]<br>Economizer: C403.5[b] |

a. Minimum equipment efficiency shall comply with Section C403.3.2 and the tables in Section C403.3.2.

b. All separate new equipment and replacement equipment shall have air economizer complying with Section C403.5 including both the individual unit size limits and the total building capacity limits on units without economizer. It is acceptable to comply using one of the exceptions to Section C403.5.

c. Reserved.

d. Equipment shall have a capacity-weighted average cooling system efficiency that is 5 percent better than the requirements in the tables in Section C403.3.2 (1.05 x values in the tables).

e. Equipment shall have a capacity-weighted average cooling system efficiency that is 10 percent better than the requirements in the tables in Section C403.3.2 (1.10 x values in the tables).

f. Minimum of 50 percent air economizer that is ducted in a fully enclosed path directly to every heat pump unit in each *zone*, except that ducts may terminate within 12 inches of the intake to an HVAC unit provided that they are physically fastened so that the outside air duct is directed into the unit intake. If this is an increase in the amount of outside air supplied to this unit, the outside air supply system shall be configured to provide this additional outside air and be equipped with economizer control.

g. Water-source heat pump systems shall have a flow control valve to eliminate flow through the heat pumps that are not in operation and variable speed pumping control complying with Section C403.4.3 for that heat pump.

- When the total capacity of all units with flow control valves exceeds 15 percent of the total system capacity, a variable frequency drive shall be installed on the main loop pump.
- As an alternate to this requirement, the capacity-weighted average cooling system efficiency shall be 5 percent better than the requirements in footnote e for water-source heat pumps (i.e. a minimum of 15 percent better than the requirements in Table C403.3.2(14) (1.15 x values in the table).

h. Water economizer equipment shall have a capacity-weighted average cooling system efficiency that is 10 percent better than the requirements in Tables C403.3.2(10) and C403.3.2(16) (1.10 x values in Tables C403.3.2(10) and C403.3.2(16)).

i. Air economizer is not required for systems installed with water economizer plate and frame heat exchanger complying with previous codes between 1991 and June 2016, provided that the total fan coil load does not exceed the existing or added capacity of the heat exchangers.

j. For water-cooled process equipment where the manufacturers specifications require colder temperatures than available with water-side economizer, that portion of the load is exempt from the economizer requirements.

k. The air-cooled chiller shall have an IPLV efficiency that is a minimum of 10 percent greater than the IPLV requirements in EER in Table C403.3.2(3)(1.10 x IPLV values in EER in Table C403.3.2(3)).

l. The air-cooled chiller shall be multistage with a minimum of two compressors.

m. The water-cooled chiller shall have full load and part load IPLV efficiency that is a minimum of 5 percent greater than the IPLV requirements in Table C403.3.2(3) (1.05 x IPLV values in Table C403.3.2(3)).

n. The water-cooled chiller shall have an IPLV value that is a minimum of 15 percent lower than the IPLV requirements in Table C403.3.2(3), (0.85 x IPLV values in Table C403.3.2(3)). Water-cooled centrifugal chillers designed for non-standard conditions shall have an NPLV value that is at least 15 percent lower than the adjusted maximum NPLV rating in kW per ton defined in Section C403.3.2.3 (0.85 x NPLV).

o. Economizer cooling shall be provided by adding a plate-frame heat exchanger on the water-side with a capacity that is a minimum of 20% of the chiller capacity at standard AHRI rating conditions.

p. Reserved.

q. Systems installed prior to 1991 without fully utilized capacity are allowed to comply with Option B, provided that the individual unit cooling capacity does not exceed 90,000 Btuh.

~~C503.4.4~~C503.4.5 **Controls for cooling equipment replacement.** When space cooling equipment is replaced, controls shall comply with all requirements under Section C403.3.5 and related subsections, and Section C403.5.1 for integrated economizer control.

~~C503.4.5~~C503.4.6 **Mechanical equipment relocation.** Existing equipment currently in use may be relocated within the same floor or same tenant space if removed and reinstalled within the same permit.

~~C503.4.6~~C503.4.7 **Addition or replacement of heating appliances.** Where a mechanical heating appliance is added or replaced, the added or replaced appliance shall comply with Section C401.3, Section C403.1.4, or with an alternate compliance option in Table ~~C503.4.6~~C503.4.7. Where use of heat pump equipment for space heating is required by this section, it is permissible to utilize the Fossil Fuel Compliance Path in Section C401.3 to attain the credits required for building additions shown in Table C401.3.3.

**Exceptions**:

1. Terminal unit equipment including, but not limited to, hydronic VAV boxes, electric resistance VAV boxes, electric duct heaters, water source heat pumps, fan coils, or VRF indoor units that are served by an unaltered central system.
2. Air handling equipment with hydronic coils.
3. Air handling equipment designed for 100 percent outdoor air that is not subject to the requirements in Section C403.3.5 or that qualifies for an exception to Section C403.3.5.
4. Replacement of existing oil-fired boilers.
5. Replacement of existing steam boilers with steam distribution to terminal units and the associated boiler feed equipment.
6. Where compliance with Section C403.1.4 would trigger an unplanned utility electrical service upgrade based on the NEC 220.87 method for determining existing loads.
7. Replacement of heating equipment with equipment that is the same type as where the rated capacity of the new equipment does not exceed the rated capacity of the existing equipment.

~~C503.4.6.1~~C503.4.7.1 **Hydronic system alteration supply water temperature.** Hydronic heating coils and appliances subject to Section ~~C503.4.5~~C503.4.6 or Section ~~C503.4.6~~C503.4.7 shall comply with Section C403.3.8.2.

**TABLE ~~C503.4.6~~C503.4.7**
**COMPLIANCE OPTIONS FOR MECHANICAL HEATING EQUIPMENT ALTERATIONS**

| | Proposed Heating Equipment Type[a] | Heating Efficiency Table Reference | Alternate Compliance Options to Section C403.1.4 |
|---|---|---|---|
| 1 | Air-Cooled Unitary Heat Pumps | Table C403.3.2(2) | 1. Compliance with C403.1.4, except heat pump rated capacity in accordance with Section C403.1.4 exception 5d is permitted to be sized equal to the supplemental internal resistance heating capacity in Climate Zone 4 or 5[c]<br>2. Compliance with C403.1.4, except electric resistance mixed air preheat is permissible[c] |
| 2 | Packaged terminal, single-package vertical, and room air-conditioner heat pumps | Table C403.3.2(4) | 1. Compliance with C403.1.4, except heat pump rated capacity in accordance with Section C403.1.4 Exception 5d is permitted to be sized equal to the supplemental internal resistance heating capacity in Climate Zone 4 or 5 |
| 3 | Furnaces, duct furnaces, and unit heaters | Table C403.3.2(5) | 1. Efficiency: +5%[b] |
| 4 | Gas-fired hot water boilers with fewer than 80% of served coils replaced | Table C403.3.2(6) | 1. Efficiency: +5%[b] |
| 5 | Variable refrigerant flow air-to-air and applied heat pumps | Table C403.3.2(9) | No alternate compliance option |
| 6 | DX-DOAS equipment | Table C403.3.2(12) and Table C403.3.2(13) | 1. DX-DOAS is provided with heat recovery if not required by C403.3.5.1. |
| 7 | Water-source heat pumps | Table C403.3.2(14) | No alternate compliance option |

a. Includes replacement of equipment with a unit that is the same type or higher efficiency and the same or lower capacity, or a replacement of one equipment type with a different equipment type.
b. Equipment shall have a capacity-weighted average heating system efficiency that is five percent better than that shown in the reference table (1.05 x values in reference table).
c. Option 1 and Option 2 can be combined.

***Here is the Section C503.4 (actually numbered as C503.3 in the IECC) from the 2024 IECC for comparison:***

**C503.3 Heating and cooling systems.** New heating, cooling and *duct systems* that are part of the *alteration* shall comply with **Section C403**. and C408.

**C503.3.1 Economizers.** New cooling systems that are part of *alteration* shall comply with **Section C403.5**.

**Commented [DJ105]:** Seems dramatically less stringent than the WSEC

**C503.3.2 Mechanical system acceptance testing.** Where an *alteration* requires compliance with **Section C403** or any of its subsections, mechanical systems that serve the *alteration* shall comply with **Sections C408.2.2**, **C408.2.3** and **C408.2.5**.

**Exceptions:**

1. *Buildings* with less than 10,000 square feet (929 m2) and a combined heating, cooling and service water-heating capacity of less than 960,000 Btu/h (281 kW).
2. Systems included in **Section C403.5** that serve individual *dwelling units* and *sleeping units*.

**C503.3.3 Duct testing.** *Ducts* and plenums designed to operate at static pressures not less than 3 inches water gauge (747 Pa) that serve an *alteration* shall be tested in accordance with this section where the *alteration* includes any of the following:

1. Twenty-five percent or more of the total length of the *ducts* in the system are relocated.
2. The total length of all *ducts* in the system is increased by 25 percent or more.

*Ducts* and plenums shall be leak tested in accordance with the SMACNA ***HVAC Air Duct Leakage Test Manual*** and shown to have a rate of *air leakage* (CL) less than or equal to 12.0 as determined in accordance with **Equation 4-7** of Section C403.13.2.3. Documentation shall be available demonstrating that representative sections totaling not less than 25 percent of the *duct* area have been tested and that all tested sections comply with the requirements of this section.

**C503.3.4 Controls.** New heating and cooling equipment that is part of the *alteration* shall be provided with controls that comply with the control requirements in **Sections C403.4** and **C403.5** other than the requirements of **Sections C403.4.3.3** and **C403.4.4**.

**Exceptions:**

1. Systems with *direct digital control* of individual *zones* reporting to a central control panel.
2. The replacement of individual components of multiple-zone VAV systems.

**C503.3.5 System sizing.** New heating and cooling equipment that is part of an *alteration* shall be sized in accordance with **Section C403.3.1** based on the existing building features as modified by the *alteration*.

**Exceptions:**

1. Where it has been demonstrated to the *code official* that compliance with this section would result in heating or cooling equipment that is incompatible with the rest of the heating or cooling system.
2. Where it has been demonstrated to the *code official* that the additional capacity will be needed in the future.

**C503.3.6 Replacement or added roof-mounted mechanical equipment. *(As noted above in the WSEC ID)***

---

**C503.5 Service water heating equipment.** All new service water heating systems, equipment, and components of existing systems that are altered or replaced shall comply with Section C407 or Sections C404, C408.3, C501.6, and C506.1. Additions or alterations shall not be made to an existing service water heating system that will cause the existing system to become out of compliance. Where use of heat pump equipment for service water heating is required by this section, it is permissible to utilize the Fossil Fuel Compliance Path in Section C401.3 to attain the credits required for building additions shown in Table C401.3.3.

**Exceptions:**

1. 1.The following equipment is not required to comply with Section C401.3 or Section C404.2.1, as applicable:
   - 1.1. Replacement of service water heating appliances with equipment that is the same type and has the same or higher efficiency and the same or lower capacity, provided there are no other alterations made to the existing service water heating system size or configuration.
   - 1.2. Replacement of any of the following water heater appliances:
     - 1.2.1. Electric water heaters with an input of 12 kW or less.
     - 1.2.2. Gas storage water heaters with an input of 75,000 Btu/h or less.
     - 1.2.3. Gas instantaneous water heaters with an input of 200,000 Btu/h or less and 2 gallons or less of storage.
   - 1.3. Where it has been determined by the code official that existing building constraints including, but not limited to, available floor space or ceiling height, limitations of the existing structure, or electrical service capacity, make compliance technically infeasible.
2. Service water heating systems are exempt from the commissioning requirements of Section C408.3 in buildings where the largest service water heating system capacity is less than 200,000 Btu/h and meet the following:
   - 2.1. No pools or permanent spas.
   - 2.2. No solar thermal water heating.
   - 2.3. No recirculation pumps.
   - 2.4. No heat pump water heaters, except fully-packaged for individual residential dwelling unit use.
3. ~~2.~~3. Systems included in Section C403.5 that serve individual *dwelling units* and *sleeping units*

**C503.6 Pools and permanent spas.** All new systems and equipment serving pools and permanent spas and components of existing systems that are altered or replaced, shall comply with Sections C404.11, C408.3, C501.6, and C506.1. Additions or alterations shall not be made to an existing system serving a pool or spa that will cause the existing system to become out of compliance.

**C503.7 Electrical power and lighting systems and motors.** Alterations or the addition of lighting, receptacles and motors shall comply with Sections C503.7.1 through C503.7.7. Additions or alterations shall not be made to an existing lighting or electrical system that will cause the existing system to become out of compliance.

~~**C503.7.1 New lighting systems and controls.** All new interior and exterior lighting systems within an existing building site shall be provided with lighting controls in accordance with Section C405.2 and shall comply with C408.4, C501.6, and C506.1.~~

**C503.7.1 Interior lighting and controls.** *Alterations* to interior spaces, lighting or controls shall comply with the following:

1. All new lighting systems within an existing building shall be provided with lighting controls in accordance with Section C405.2 and shall comply with Section C408.4, C501.6 and C506.1.

**Commented [DJ106]:** Don't we have a separate commissioning section for SWH in alterations. This placement seems awkward.

**Commented [BK(107]:** This seems to say the same thing as the struck WSEC section with a lot more words. There are portions that conflict or overlap somewhat with later WSEC sections. A decision needs to be made on whether to go with the IECC 400 watt limitation or the WSEC 20 percent, or combine them in some way.

**Commented [DJ108R107]:** I like the 20% rule better, to keep the requirement proportionate to the size of the job

2. Where an *alteration* of an interior space includes the addition or relocation of full height partitions, the space shall comply with Sections C405.2, C405.3 and C408.4.
3. Where the lighting within interior spaces is altered, those spaces shall comply with Sections C405.2, C405.3 and C408.4.
4. Where the lighting controls within interior spaces are altered, those spaces shall comply with Sections C405.2 and C408.4.

**Exception:** Compliance with Section C405.2.8 is not required for *alterations*.

**C503.7.2 Exterior lighting and controls.** *Alterations* to exterior lighting and controls shall comply with the following:

1. Where the connected exterior lighting power is increased by more than 400 watts, all exterior lighting, including lighting that is not proposed to be altered, shall comply with Sections C405.5, C501.6 and C506.1.
2. Where the combined power of added and replacement luminaires is more than 400 watts, all lighting that is added or altered shall be controlled in accordance with Sections C405.2, C408.4, C501.6 and C506.1.

   **Exception:** Individual luminaires less than 50 watts provided they pass functional tests verifying *automatic* shut off where daylight is present.
3. Where portions of exterior lighting controls are added or altered, those portions shall comply with Sections C405.2, C408.4, C501.6 and C506.1.

~~C503.7.2~~C503.7.3 **Luminaire additions and alterations.** Alterations that add or replace 20 percent or more of the luminaires in a space enclosed by walls or ceiling-height partitions, replace 20 percent or more of parking garage luminaires, or replace 20 percent or more of the total installed wattage of exterior luminaires shall comply with Sections C405.4 and C405.5. Exterior power allowance shall be determined using the specific area allowances for the areas altered and shall not include the base site allowance. Where less than 20 percent of the fixtures in an interior space enclosed by walls or ceiling-height partitions or in a parking garage are added or replaced, or less than 20 percent of the installed exterior wattage is replaced, the installed lighting wattage shall be maintained or reduced.

~~C503.7.3~~C503.7.4 **Rewiring and recircuiting.** Where new wiring is being installed to serve added fixtures and/or fixtures are being relocated to a new circuit, lighting controls shall comply with all applicable requirements in accordance with Sections C405.2.1, C405.2.3, C405.2.4, C405.2.5, and C405.2.6, C405.2.7, C405.2.8, C408.4, and C501.6.

~~C503.7.4~~C503.7.5 **New or moved lighting panel.** Where a new lighting panel (or a moved lighting panel) with all new raceway and conductor wiring from the panel to the fixtures is being installed, lighting controls shall also comply with, in addition to the requirements of Section C503.7.3, all requirements in Sections C405.2, C408.4, and C501.6.

~~**C503.7.5 Newly-created rooms.** Where new walls or ceiling-height partitions are added to an existing space and create a new enclosed space, but the lighting fixtures are not being changed, other than being relocated, the new enclosed space shall have lighting controls that comply with all applicable requirements in accordance with Sections C405.2.1, C 405.2.2, C405.2.3, C405.2.4, C405.2.5, C405.2.6, C408.4, and C501.6.~~

**C503.7.6 Motors.** Motors that are altered or replaced shall comply with Section C405.8.

**C503.7.7 Controlled receptacles.** Where electric receptacles are added or replaced, controlled receptacles shall be provided in accordance with Section C405.10 and shall comply with Sections C408.4 and C501.6.

**Exceptions:**

1. Where an alteration project impacts an area smaller than 5,000 square feet, controlled receptacles are not required.
2. Where existing systems furniture or partial-height relocatable office cubicle partitions are reconfigured or relocated within the same area, controlled receptacles are not required in the existing systems furniture or office cubicle partitions.
3. Where new or altered receptacles meet exception 1 to Section C405.10.1, they are not required to be controlled receptacles or be located within 12 inches of non-controlled receptacles.

**Commented [DJ109]:** I like our "newly-created rooms" verbiage better

**Commented [BK(110]:** This is covered under the new C503.7.1 item 1.

**Commented [DJ111R110]:** I like this better

**C503.8 Refrigeration systems.** Components of existing refrigeration systems that are altered or replaced shall comply with Sections C408.7, C410 and C501.6. Additions or alterations shall not be made to an existing refrigeration system that will cause the existing system to become out of compliance. All new refrigerated spaces and refrigeration systems and equipment in existing buildings, including new refrigerated display cases, shall comply with Sections C408.7, C410, C501.6, and C506.1.

**C503.9 Additional energy efficiency credit requirements for alterations.** *Alterations* that are *substantial improvements* shall comply with measures from Sections C406.2 and C406.3 to earn the number of required credits specified in Table C406.1 for new buildings. Where a project contains multiple occupancies, credits specified in Table C406.1 for each building occupancy shall be weighted by the gross *conditioned floor area* to determine the weighted average credits required. Accessory occupancies, other than Group F or H, shall be included with the primary occupancy group for the purposes of this section.

**Exceptions:**

1. *Alterations* that do not contain *conditioned space*.
2. Portions of *buildings* devoted to manufacturing or industrial use.
3. *Alterations* to *buildings* where the *building* after the *alteration* complies with Section C407.
4. *Alterations* that are permitted with an *addition* complying with Section C502.3.7.

**Commented [DJ112]:** Don't think this is a defined term in WSEC

**Commented [BK(113R112]:** New definition in Chapter 2

## SECTION C504
## REPAIRS

**C504.1 General.** Buildings and structures, and parts thereof, shall be repaired in compliance with Section C501.3 and this section. Work on nondamaged components that is necessary for the required *repair* of damaged components shall be considered part of the *repair* and shall not be subject to the requirements for *alterations* in this chapter. Routine maintenance required by Section C501.3, 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.

**C504.2 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 thermal 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 however that an existing vestibule that separates a *conditioned space* from the exterior shall not be removed.
5. *Repairs* where only the bulb and/or ballast within the existing luminaires in a space are replaced provided that the replacement does not increase the installed interior lighting power.

## SECTION C505
## CHANGE OF SPACE CONDITIONING, OCCUPANCY OR USE

**C505.1 General.** Buildings or spaces undergoing a change in space conditioning alteration shall comply with Sections C505.2 and C505.4. Buildings or spaces undergoing a change in occupancy alteration shall comply with Sections C505.3 and C505.4. Spaces changing from one use type to another shall comply with Section C505.5.

Buildings or spaces undergoing a change in space conditioning, change in occupancy or use shall conform to the provisions of this code without requiring the unaltered portion of the existing building to comply with this code. 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.

A change in space conditioning alteration shall be deemed to comply with this code if the alteration area alone complies or if the alteration area is combined with all other spaces within the existing building that are of the same space conditioning category according to Section C505.2 to demonstrate compliance. A change in occupancy alteration shall be deemed to comply with this code if the alteration area alone complies or if the existing building and the alteration area are combined to demonstrate compliance for the whole building. This

allowance applies to prescriptive compliance in accordance with Section C505.4 or ~~total~~ simulated building performance in accordance with Section C407.

Buildings or spaces that were permitted prior to the 2009 Washington state energy code, or were originally permitted as unconditioned, may comply with this section as follows:

1. Where the component performance alternative in Section C402.1.5 is used to demonstrate compliance with this section, the Proposed Total UA is allowed to be up to 110 percent of the Allowable Total UA. This exception may be applied to the project area alone, or to the existing building and project area combined as a whole building.
2. Where total building performance in accordance with Section C407 is used to demonstrate compliance with this section, the total annual site energy use of the proposed design is allowed to be up to 110 percent of the annual site energy use allowed by Section C407.3. This exception may be applied to the project area alone, or to the existing building and project area combined as a whole building.

**C505.1.1 Additional energy efficiency credits.** Buildings or spaces that are required to comply with Sections C505.2 or C505.3 shall also comply with Section C502.1.1 in the same manner as an addition.

**C505.1.2 Renewable energy.** Buildings or spaces that are required to comply with Section C505.2 or C505.3 shall also comply with Section C502.1.2 in the same manner as an addition.

**C505.2 Change in space conditioning.** Spaces undergoing a change in space conditioning alteration shall be brought up to full compliance with this code for all disciplines in the following cases:

1. Any nonconditioned or low-energy space in accordance with Section C402.1.1.1 that is altered to become *conditioned space* or *semi-heated* space shall be brought into full compliance with this code.
2. Any semi-heated space in accordance with Section C402.1.1.2 that is altered to no longer qualify as semi-heated space shall be brought into full compliance with this code.

For buildings with more than one space conditioning category, the interior partition walls, ceilings, floors and fenestration that separate space conditioning areas shall comply with the thermal envelope requirements per the area with the highest level of space conditioning.

**C505.3 Change in occupancy.** Spaces undergoing a change in occupancy alteration shall be brought up to full compliance with this code for all disciplines in the following cases:

1. Any space that is converted from a Group F, S or U occupancy to an occupancy other than Group F, S or U.
2. Any space that is converted to a Group R dwelling unit or portion thereof, from another use or occupancy.
3. Any Group R dwelling unit or portion thereof permitted prior to July 1, 2002, that is converted to a commercial use or occupancy.

***Here is the Section C505.3 from the 2024 IECC for comparison:***

**C505.3 Change in occupancy**. Spaces undergoing a change in occupancy from Group F, H, S or U occupancy classification shall comply with Section C503. Buildings or portions of buildings undergoing a change of occupancy without alterations shall comply with Section C505.X.

**Exception**: Where the simulated building performance option in Section C407 is used to comply with this section, the annual energy use of the proposed design shall be not greater than 110 percent of the annual energy use otherwise permitted by Section C407.3.

**C505.3.1 Alterations and change of occupancy.** Alterations made concurrently with any change of occupancy shall be in accordance with Section C503.

**C505.3.2 Portions of buildings**. Where changes in occupancy and use are made to portions of an existing building, only those portions of the building shall be required to comply with Section C505.4.

**C505.X Energy use intensities**. Building thermal envelope, space heating, cooling, ventilation, lighting and service water heating shall comply with Sections C505.X.1 through C505.X.4.

**Commented [DJ114]:** This is an interesting concept, worthy of another working group

Exceptions:

1. Where it is demonstrated by analysis approved by the code official that the change will not increase energy use intensity.
2. Where the occupancy or use change is less than 5,000 square feet (465 m2) in area.

**C505.X.1 Building thermal envelope.** Where a change of occupancy or use is made to a whole building that results in a fenestration area greater than the maximum fenestration area allowed by Section C402.5.1, the building shall comply with Section C402.1.4, with a proposed UA that shall be not greater than 110 percent of the target UA.

**Exception:** Where the change of occupancy or use is made to a portion of the building, the new occupancy is exempt from Section C402.5.1, provided that there is not an increase in fenestration area.

**C505.X.2 Building mechanical systems**. Where a change of occupancy or use results in the same or increased energy use intensity rank as specified in Table C505.X.2, the systems serving the building or space undergoing the change shall comply with Section C403.

**TABLE C505.X.2**
**BUILDING MECHANICAL SYSTEMS**

| ENERGY USE INTENSITY RANK | *INTERNATIONAL BUILDING CODE* OCCUPANCY CLASSIFICATION AND USE |
|---|---|
| High | A-2, B (laboratories), I-2 |
| Medium | A-1, A-3,[a] A-4, A-5, B,[b] E, I-1, I-3, I-4, M, R-4 |
| Low | A-3 (places of religious worship), R-1, R-2, R-3,[c] S-1, S-2 |

a. Excluding places of religious worship.
b. Excluding laboratories.
c. Buildings three stories or less in height above grade plane shall comply with Section R505.

**C505.X.3 Service water heating.** Where a *change of occupancy* or use results in the same or increased *energy use intensity* rank as specified in Table C505.X.3, the *service water heating* systems serving the *building* or space undergoing the change shall comply with Section C404.

**TABLE C505.2.3**
**SERVICE WATER HEATING**

| ENERGY USE INTENSITY RANK | *INTERNATIONAL BUILDING CODE* OCCUPANCY CLASSIFICATION AND USE |
|---|---|
| High | A-2, I-1, I-2, R-1 |
| Low | All other occupancies and uses |

**C505.X.4 Lighting.** Where a *change of occupancy* or use results in the same or increased *energy use intensity* rank as specified in Table C505.X.4, the lighting systems serving the *building* or space undergoing the change shall comply with Section C405 except for Sections C405.2.6 and C405.4.

**TABLE C505.X.4**
**LIGHTING**

| ENERGY USE INTENSITY RANK | *INTERNATIONAL BUILDING CODE* OCCUPANCY CLASSIFICATION AND USE |
|---|---|
| High | B (laboratories), B (outpatient healthcare), I-2, M |
| Medium | A-2, A-3 (courtrooms), B,[a] I-1, I-3, I-4, R-1, R-2, R-3,[b] R-4, S-1, S-2 |
| Low | A-1, A-3,[c] A-4, E |

a. Excluding laboratories and outpatient healthcare.
b. Buildings three stories or less in height above grade plane shall comply with **Section R505**.
c. Excluding courtrooms.

**C505.4 Prescriptive compliance.** Change in space conditioning and change in occupancy alterations shall comply with Sections C505.4.1 through C505.4.7.

**C505.4.1 Vertical fenestration.** A change in space conditioning alteration with vertical fenestration shall comply with the following:

1. Where the vertical fenestration area of the alteration combined with the vertical fenestration area of all equivalent space conditioning areas in the existing building results in a total vertical fenestration area that is less than or equal to the maximum allowed by Section C402.4.1, the alteration shall comply with Section C402.4.

2. Where the vertical fenestration area of the alteration combined with the vertical fenestration area of all equivalent space conditioning areas in the existing building results in a total vertical fenestration area that is greater than the maximum allowed by Section C402.4.1, the alteration shall comply with one of the following:
    2.1. Component performance alternative with target area adjustment in accordance with Section C402.1.5 for the alteration area of the building only.
    2.2. Alteration area is combined with all equivalent space conditioning areas to demonstrate compliance with the component performance alternative.
    2.3. Total building performance in accordance with Section C407 for the alteration area of the building only.
    2.4. Alteration area is combined with all equivalent space conditioning areas to demonstrate total building performance compliance.

**C505.4.2 Skylights.** A change in space conditioning alteration with skylights shall comply with the following:

1. Where the skylight area of the alteration combined with the skylight area of all equivalent space conditioning areas in the existing building results in a total skylight area that is less than or equal to the maximum allowed by Section C402.4.1, the alteration shall comply with Section C402.4.
2. Where the skylight area of the alteration combined with the skylight area of all equivalent space conditioning areas in the existing building results in a total skylight area that is greater than the maximum allowed by Section C402.4.1, the alteration shall comply with one of the following:
    2.1. Component performance alternative with target area adjustment in accordance with Section C402.1.5 for the alteration area of the building only.
    2.2. Alteration area is combined with all equivalent space conditioning areas to demonstrate compliance with the component performance alternative.
    2.3. Total building performance in accordance with Section C407 for the alteration area of the building only.
    2.4. Alteration area is combined with all equivalent space conditioning areas to demonstrate total building performance compliance.

**C505.4.3 Building mechanical systems.** All new and existing mechanical systems and equipment that serve the new building heating, cooling and ventilation needs of the alteration area shall comply with Sections C403, C408.2, C501.6, and C506.1.

**C505.4.4 Service water-heating systems.** All new and existing service water-heating systems and equipment that serve the new service water-heating needs of the alteration area shall comply with Sections C404, C408.3, C501.6, and C506.1.

**C505.4.5 Pools and permanent spas.** All new and existing systems and equipment serving pools and permanent spas that are included in the alteration shall comply with Sections C404.11, C408.3, C501.6, and C506.1.

**C505.4.6 Electrical power and lighting systems and motors.** All new and existing electrical power and lighting systems and motors that are included in the alteration shall comply with Sections C405, C408.4, C501.6, and C506.1.

**C505.4.7 Refrigeration systems.** All new and existing refrigerated spaces and refrigeration systems and equipment that serve the new refrigeration needs of the alteration area shall comply with Sections C410, C408.7, C501.6, and C506.1.

**C505.5 Change of use.** Where the use in a space changes from one use in Table C405.4.2 (1) or (2) to another use in Table C405.4.2 (1) or (2), the installed lighting wattage in the space shall comply with Section C405.4 and the ventilation air flow provided to the space shall be in accordance with Chapter 4 of the *International Mechanical Code.*

## SECTION C506
## METERING FOR EXISTING BUILDINGS

**C506.1 Metering in existing buildings.** Where new or replacement systems or equipment are installed in an

existing building that was constructed subject to the requirements of this section, metering shall be provided for such new or replacement systems or equipment so that their energy use is included in the corresponding end-use category defined in Section C409.2. This includes systems or equipment added in conjunction with additions or alterations to existing buildings.

**C506.1.1 Small existing buildings.** Metering and data acquisition systems shall be provided for additions over 25,000 square feet to buildings that were constructed subject to the requirements of this section, in accordance with the requirements of Sections C409.2 and C409.3.

## 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 106.

## ~~AAMA~~FGIA

~~American Architectural Manufacturers Association~~Fenestration & Glazing Industry Alliance
~~1827 Walden Office Square~~1900 E Golf Road
Suite ~~550~~1250
Schaumburg, IL 60173-4268

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| AAMA/WDMA/CSA 101/I.S.2/A440—~~17~~ 2022 | North American Fenestration Standard/ Specifications for Windows, Doors and Unit Skylights | Table C402.4, C402.4.1.1.2 |

## 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~~ 2020 | Room Air Conditioners | Table C403.3.2(4) |
| ~~AHAM HRF-1—2017~~ | ~~Household Refrigerators, Refrigerator-Freezers and Freezers~~ | ~~Table C410.1(1)(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 |
|---|---|---|
| ISO/AHRI/ASHRAE 5801-2017 | Fans—Performance Testing Using Standardized Airways | C403.8.1.1 |
| ISO/AHRI/ASHRAE 13256-1—1998 (~~2017~~R2012) | ~~Water-source Heat Pumps—Testing and Rating for Performance—Part 1:~~ Water-to-air and Brine-to-air Heat Pumps—Testing and Rating for Performance | Table C403.3.2(14) |
| ISO/AHRI/ASHRAE 13256-2 –1998 (R2012) | Water-to-Water and Brine-to-Water Heat Pumps—Testing and Rating for Performance | Table C403.3.2(14) |
| ~~ISO/AHRI/ASHRAE 13256-2 (2017)~~ | ~~Water-source Heat Pumps—Testing and Rating for Performance—Part 2: Water-to-water and Brine-to-water Heat Pumps~~ | ~~Table C403.3.2(14)~~ |
| 210/240—~~2017 and~~ 2023 (2020) | Performance Rating of Unitary Air Conditioning and Air-Source Heat Pump Equipment | Table C403.3.2(1), Table C403.3.2(2) |
| 310/380—2017 | Standard for Packaged Terminal Air Conditioners and Heat Pumps | Table C403.3.2(4) |
| 340/360—~~2018~~2022 | Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment | Table C403.3.2(1), Table C403.3.2(2) |
| 365 (I-P)—2009 | Commercial and Industrial Unitary Air-conditioning Condensing Units | Table C403.3.2(1) |

| | |
|---|---|
| 390 (I-P)—20112003 | Performance Rating of Single Package Vertical Air Conditioners and Heat Pumps ..... Table C403.3.2(4) |
| 400 (I-P)—012015 | Liquid to Liquid Heat Exchangers with Addendum 2 ..... C403.3.2 |
| 430—2022 | Performance Rating of Central Station Air-Handling Unit Supply Fans ..... C403.8.1.1 |
| 440—2019 | Room Fan Coil ..... C403.8.1.1, C403.10.3 |
| 460—2005 | Performance Rating Remote Mechanical Draft Air-cooled Refrigerant Condensers ..... Table C403.3.2(7) |
| 550/590—20182022 | Water Chilling Packages Using the Vapor Compression Cycle—with Addenda ..... Table C403.3.2(3), Table C403.3.2(15) |
| 560—20182000 | Absorption Water Chilling and Water-heating Packages ..... Table C403.3.2(3) |
| 840 (I-P)—1998 | Performance Rating of Unit Ventilators ..... C403.13.3 |
| 910 (I-P)—2014 | Performance Rating of Indoor Pool Dehumidifiers ..... Table C403.3.2(11) |
| 920 (I-P)—152020 | Performance Rating of DX-Dedicated Outdoor Air System Units ..... Table C403.3.2(12), Table C403.3.2(13) |
| 1160—2014 | Performance Rating of Heat Pump Pool Heaters ..... Table C404.2, C404.11.1 |
| 1200 (I-P)—20142022 | Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets ..... C410.1.1, Table C410.1.1(1) Table C410.1.1(2) |
| 1230—2014 2021 | Performance Ration of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment (with Addendum 1) ..... Table C403.3.2(9) |
| 1250 (I-P)—2014 2020 | Standard for Performance Rating in Walk-in Coolers and Freezers ..... Table C410.2.1(3) |

## AISI

American Iron and Steel Institute
25 Massachusetts Avenue NW
Suite 800
Washington DC 20001

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| AISI S250—22 | North American Standard for Thermal Transmittance of Building Envelopes with Cold-Formed Steel Framing, with Supplement 1, dated 2022 | C403.8.1.1 |

## 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 |
|---|---|---|
| 205-12 | Energy Efficiency Classification for Fans | C403.8.3, C406.2.3 |
| 208—2018 | Calculation of the Fan Energy Index | C403.8.1.1, C403.8.3 |
| 210—2016 | Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating | C403.8.1.1 |
| ANSI/AMCA 220—2019 21 | Laboratory Methods of Testing Air Curtain Units | C402.5.7 |
| ANSI/AMCA 230—15 22 | Laboratory Methos of Testing Air Circulating Fans for Rating and Certification | C403.9 |
| 500D—18 | Laboratory Methods for Testing Dampers for Rating | C403.7.8.3 |

## ANSI

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| ANSI/AMCA 208—2018 | Calculation of the Fan Energy Index | C403.8.1.1 |
| ANSI/AMCA 210-16/ASHRAE 51-16 | Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating | C403.8.1.1 |
| ANSI/AMCA 500-D—18 | Laboratory Methods for Testing Dampers for Ratings | C403.7.7 |

| | | |
|---|---|---|
| ANSI/ASME A17.1—2010 | Safety Code for Elevators and Escalators | C405.12.1 |
| ANSI/CTA 2045-A—2018 | Modular Communications Interface for Energy Management | C404.14 |
| ANSI/CTA 2045-B—2021 | Modular Communications Interface for Energy Management | C404.14 |
| ANSI/NEMA WD 6—2016 | Wiring Devices—Dimensional Specifications | C405.9.2 |
| ~~Z21.10.3/CSA 4.3—11~~ | ~~Gas Water Heaters, Volume III—Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous~~ | ~~Table C404.2~~ |
| Z21.47/CSA 2.3—~~12~~2021 | Gas-fired Central Furnaces | Table C403.3.2(5) |
| Z83.8/CSA 2.6—~~09~~2016 | Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-fired Duct Furnaces | Table C403.3.2(5) |

# APSP

The Association of Pool and Spa Professionals
2111 Eisenhower Avenue
Alexandria, VA 22314

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| 14-2019 | American National Standard for Portable Electric Spa Efficiency | C404.8 |

# ASABE

The American Society of Agricultural and Biological Engineers
2950 Niles Road
St. Joseph, MI 49085

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| S640—July 2017 (R2022) | Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms) | C405.3 |

# 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 |
|---|---|---|
| ANSI/ASHRAE/ACCA Standard 127-~~2007~~2020 | Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners | C403.5 |
| Standard 183—~~RA2017~~2007 (RA2020) | Peak Cooling and Heating Load Calculations in Buildings, Except Low-rise Residential Buildings | C403.1.2 |
| Standard 51—16 | Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating | Table C403.8.5 |
| ASHRAE—2020 | ASHRAE HVAC Systems and Equipment Handbook—2020 | C403.1.2 |
| ISO/AHRI/ASHRAE 13256-1 (2012) | Water-source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-air and Brine-to-air Heat Pumps | Table C403.3.2(14) |
| ISO/AHRI/ASHRAE 13256-2 (2012) | Water-source Heat Pumps—Testing and Rating for Performance—Part 2: Water-to-water and Brine-to-water Heat Pumps | Table C403.3.2(14) |
| 62.1—2019 | Ventilation for Acceptable Indoor Air Quality | C403.6.1 |
| 90.1—~~2019~~2022 | Energy Standard for Buildings Except Low-rise Residential Buildings (with addendum af) | Table C402.1.3, Table C402.1.4, C406.2 |
| 90.4—~~2019~~2022 | Energy Standard for Data Centers (with addenda a, b, d, e) | C403.1.3 |
| ~~146—2011~~ | ~~Testing and Rating Pool Heaters~~ | ~~Table C404.2~~ |

**Commented [BK(115]:** The 2024 IMC cites the 2022 edition

# ASME

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| ASME A17.1/ CSA B44—~~2019~~2022 | Safety Code for Elevators and Escalators | C405.9.2 |
| BPVC Section IV—~~2021~~ 2023 | Boiler and Pressure Vessel Code, Section IV—Rules for Construction of Heating Boilers | C404.14 |

| | | |
|---|---|---|
| BPVC Section X—~~2021~~ 2023 | Boiler and Pressure Vessel Code, Section X—Fiber Reinforced Plastic Pressure Vessels | C404.14 |

# ASTM

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| C 90—~~2016A~~21 | Specification for Load-bearing Concrete Masonry Units | Table C402.1.3 |
| C 518—17 | Standard Test Method for Steady-State Thermal Transmission Properties By Means of the Heat Flow Meter Apparatus | Table C403.10.1.1 |
| C835—06(2020) | Standard Test Method for Total Hemispherical Emittance of Surfaces up to 1400°C | C402.3 |
| C 1363—~~11~~ 19 | Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus | C303.1.4.4, Table C402.1.4, C402.2.7 |
| C 1371—15 | Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers | C303.1.4.1, Table C402.1.4 |
| C 1549—09 | Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer | Table C402.4 |
| D 1003—~~13~~21 | Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics | C402.4.2.2 |
| E 283/283M—~~04(2012)~~19 | Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen | C402.5.8, |
| E 408—13(2019) | Test Method for Total Normal Emittance of Surface Using Inspection-meter Techniques | Table C402.3 |
| E 779—~~18~~19 | Standard Test Method for Determining Air Leakage Rate by Fan Pressurization | C402.5.1.2, C406.11.1 |
| E 903—~~12~~ 20 | Standard Test Method Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres ~~(Withdrawn 2005)~~ | Table C402.4 |
| E 1677—~~11~~ 19 | Standard Specification for an Air-retarder (AR) Material or ~~System~~ Assemblies for Low-rise Framed Building Walls | C402.5.1.2.2 |
| E 1827-~~2011(2017)~~22 | Standard Test Methods for Determining Airtightness of Building Using an Orifice Blower Door | C402.5.2, C402.5.3 |
| E 1918—~~06(2015)~~21 | Standard Test Method for Measuring Solar Reflectance of Horizontal or Low-sloped Surfaces in the Field | Table C402.4 |
| E 1980—11(2019) | Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-sloped Opaque Surfaces | Table C402.2.1.1 |
| E 2178—~~13~~ 21a | Standard Test Method for Determining Air Leakage Rate and Calculation of Air Permanence of Building Materials | C402.4 |
| E 2357—~~11~~ 23 | Standard Test Method for Determining Air Leakage of Air Barrier Assemblies | C402.5.1.2.2 |
| E 3158—18 | Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building | C402.6.2.1 |
| F 1281—~~20~~17(2021) | Standard Specification for Cross-linked Polyethylene/Aluminum/Cross-linked Polyethylene (PEX-AL-PEX) Pressure Pipe | Table C404.5.2.1 |

# CSA

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| AAMA/WDMA/CSA 101/I.S.2/A440—17 | North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights | Table C402.4, C402.4.1.1.2 |
| CSA B55.1—2012 | Test Method for Measuring Efficiency and Pressure Loss of DWHR Units | C404.10 |
| CSA B55.2—2012 | Drain Water Heat Recovery Units | C404.10 |

## CTA

Consumer Technology Association
1919 S Eads Street
Arlington, VA 22202

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| ANSI/CTA 2045-A—2018 | Modular Communications Interface for Energy Management | C404.14 |
| ANSI/CTA 2045-B—2021 | Modular Communications Interface for Energy Management | C404.14 |

## CTI

Cooling Technology Institute
2611 FM 1960 West, Suite A-101
Houston, TX 77068

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| ATC 105—2019 | Acceptance Test Code for Water Cooling Tower | Table C403.3.2(7) |
| ATC 105DS—2018 | Acceptance Test Code for Dry Fluid Coolers | Table C403.3.2(7) |
| ATC 105S—2011 | Acceptance Test Code for Closed Circuit Cooling Towers | Table C403.3.2(7) |
| ATC 106—2011 | Acceptance Test for Mechanical Draft Evaporative Vapor Condensers | Table C403.3.2(7) |
| STD 201—17 | Standard for Certification of Water Cooling Towers Thermal Performances | Table C403.3.2(7) |

## DASMA

Door and Access Systems Manufacturers Association
1300 Sumner Avenue
Cleveland, OH 44115-2851

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| 105—17 | Test Method for Thermal Transmittance and Air Infiltration of Garage Doors | Table C402.4.2 |

## 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—2015 | Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirement for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule | Table C403.3.2(1), Table C403.3.2(2), Table C403.3.2(5), Table C403.3.2(6), Table C403.3.2(14), Table C404.2 |
| 10 CFR, Part 431—2015 | Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards; Final Rules | Table C403.3.2(6), C403.8.4, C403.11, Table C403.11, C403.11.2, C405.7, Table C405.7, C405.8, Table C405.8(1), Table C405.8(2), Table C405.8(3) |

## HVI

Hove Ventilating Institute
1740 Dell Range Blvd., Sut. H, PMB 450
Cheyenne, WY 82009

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| 920—2020 | Product Performance Certification Procedure Including Verification and Challenge | C403.3.5.1, C403.3.6 |

## IAPMO

International Association of Plumbing and Mechanical Officials
4755 E. Philadelphia Street
Ontario, CA 91761

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| UPC—2021 | Uniform Plumbing Code | C201.3, C501.2 |

## ICC

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| IBC—21 | International Building Code | C201.3, C303.2, C402.4.3, C501.2 |
| ICC 500—2020 | Standard for the Design and Construction of Storm Shelters | C402.4.2 |
| IEBC—21 | International Existing Building Code | C201.3, 501.2 |
| IFC—21 | International Fire Code | C201.3, C411.1, C411.6, C501.2 |
| IFGC—21 | International Fuel Gas Code | C201.3, C501.2 |
| IMC—21 | International Mechanical Code | C106.3, C201.3, C402.5.3, C403.2.2.1, C403.2.2.2 C403.3.5, C403.3.5.1, C403.6.1, C403.6.5, C403.6.10, C403.7.1, C403.7.2, C403.7.5, C403.7.5.1, C403.7.6, C403.7.7.3, C403.7.8, C403.7.8.4, C403.8.4, C403.8.5.1, C403.9.2.4.2, C403.10.1.1, Table C403.10.1.1, C403.10.1.2, Table C403.10.1.2, C403.10.2, C403.10.2.1, C403.10.2.2, C403.12, C406.6, C408.2.2.1, C501.2 |

## IEEE

The Institute of Electrical and Electronic Engineers
Three Park Avenue
New York, NY 10016

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| IEEE 515.1—2012 | Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Trace Heating for Commercial Applications | C404.6.2 |

## IES

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| ANSI/ASHRAE/IESNA 90.1—2019 | Energy Standard for Buildings Except Low-rise Residential Buildings | Table C402.1.3, Table C402.1.4, Table C407.5.1 |

## ISO

International Organization for Standardization
1, rue de Varembe, Case postale 56, CH-1211
Geneva, Switzerland

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| ISO/AHRI/ASHRAE 13256-1 (2017) | Water-source Heat Pumps—Testing and Rating for Performance— Part 1: Water-to-air and Brine-to-air Heat Pumps | Table C403.3.2(14) |
| ISO/AHRI/ASHRAE 13256-2 (2017) | Water-Source Heat Pumps—Testing and Rating for Performance— Part 2: Water-to-water and Brine-to-water Heat Pumps | Table C403.3.2(14) |
| 25745-2:2015 | Energy Performance of Lifts, Escalators and Moving Walks—Part 2: Energy Calculation and Classification for Lifts (Elevators) | C406.2.14 |

## NEEA

Northwest Energy Efficiency Alliance
421 SW 6th Ave, Suite 600
Portland, OR 97204

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| AWHS Vers. 8.0—2022 | Advanced Water Heating Specification | C404.2.1 |

## NEMA

National Electric Manufacturer's Association
1300 North 17th Street
Suite 1753
Rosslyn, VA 22209

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| ANSI/NEMA WD 6-2016 | Wiring devices—Dimensional Specifications | C405.12 |
| MG1—2014 | Motors and Generators | C202 |
| TP-1—2002 | Guide for Determining Energy Efficiency for Distribution Transformers | C405.9 |

## NFRC

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| 100—2020 | Procedure for Determining Fenestration Products U-factors—Second Edition | C303.1.2, C402.2.1 |
| 200—2020 | Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence—Second Edition | C303.1.3, C402.3.1.1 |
| 202—2017 | Procedure for Determining Fenestration Product Visible Transmittance at Normal Incidence | C202 |
| 203—2017 | Procedure for Determining Visible Transmittance of Tubular Daylighting Devices | C202, C402.4.2 |
| 400—2017 | Procedure for Determining Fenestration Product Air Leakage | Table C402.4.2 |

## 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—2012 | HVAC Air Duct Leakage Test Manual | C403.10.2.3 |

## UL

Underwriters Laboratories
333 Pfingsten Road
Northbrook, IL 60062-2096

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| 710—12 | Exhaust Hoods for Commercial Cooking Equipment | C403.7.7.1.2, C403.7.7.1.3 |
| 727—18 | Oil-fired Central Furnaces—with Revisions through April 2010 | Table C403.3.2(4), Table C403.3.2(5) |
| 731—18 | Oil-fired Unit Heaters—with Revisions through April 2010 | Table C403.3.2(5) |

## US-FTC

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| CFR Title 16 (2015) | R-value Rule | C303.1.4 |

## WDMA

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

| Standard reference number | Title | Referenced in code section number |
|---|---|---|
| AAMA/WDMA/CSA 101/I.S.2/A440—~~17~~22 | North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights | Table C402.4.2 |