

CITY COUNCIL AGENDA ITEM

CITY OF SHORELINE, WASHINGTON

AGENDA TITLE:	Discussion of Prohibition of Fossil Fuels in New Construction
DEPARTMENT:	Planning and Community Development Recreation, Cultural and Community Services
PRESENTED BY:	Ray Allshouse, Building Official Autumn Salamack, Environmental Services Coordinator
ACTION:	<input type="checkbox"/> Ordinance <input type="checkbox"/> Resolution <input type="checkbox"/> Motion <input checked="" type="checkbox"/> Discussion <input type="checkbox"/> Public Hearing

PROBLEM/ISSUE STATEMENT:

The City's 2019 communitywide greenhouse gas emissions inventory showed a 1.3% increase in emissions compared to 2009. This trend is not on track to meet the City's goals to reduce emissions by 25% by 2020, 50% by 2030, and 80% by 2050, as compared to 2009. Fossil fuels used in the built environment were responsible for approximately 30% of communitywide emissions in 2019, with 28% from natural gas and 2% from heating oil.

Increasing concerns about the environmental and public health impacts of fossil fuels used in buildings have led some municipalities to ban fossil fuel hookups in new construction. The City Council discussed this topic at their 2021 Strategic Planning Workshop in March 2021 and indicated general support for a natural gas ban on space/water heating for new residential construction (referring to both single-family and multi-family construction), with an allowance for gas for cooking only.

Staff has since evaluated options to ban fossil fuels in various types of new construction and the current policy in Washington State prohibits local governments from passing electrification ordinances for new residential construction. Given this prohibition, the City can only evaluate limitations on the use of fossil fuels for commercial construction and multi-family projects over three stories in height.

To this end, the City could incorporate the same language used in the City of Seattle's 2018 Energy Code Update regarding the ban of the use of fossil fuels in new commercial and large multi-family construction projects for space heating and most water heating. The code envisioned to ban the use of fossil fuels for space and water heating in new commercial construction would be included under Shoreline Municipal Code (SMC) Title 15 – local amendments to the State Construction Codes, specifically amending the State Energy Code Commercial Provisions.

Tonight, staff is interested in hearing from Council on their interest in staff bringing back a proposed ordinance for Council consideration that would ban the use of fossil fuels in new commercial and large multi-family construction for space heating and most water heating. Staff is also interested in receiving any additional feedback from Council on other regulatory options that Council would like staff to explore.

RESOURCE/FINANCIAL IMPACT:

City staff time would be required to codify and implement changes to SMC Title 15 and provide outreach to local builders.

RECOMMENDATION

This is a discussion item only; no action is required tonight. Based on feedback from the 2021 Council Strategic Planning Workshop, staff recommends that the Council discuss the Regional Code Collaboration Suggested Commercial Energy Code Amendments and provide staff feedback on whether Council would like staff to develop an ordinance for Council consideration that aligns with these amendments.

Approved By: City Manager ***DT*** City Attorney ***MK***

BACKGROUND

The City of Shoreline's 2019 communitywide greenhouse gas emissions inventory showed a 1.3% increase in emissions compared to 2009. This trend is not on track to meet the City's goals to reduce emissions by 25% by 2020, 50% by 2030, and 80% by 2050, as compared to 2009. Working to reduce emissions is critical to preventing the most catastrophic impacts of climate change for the community. The more quickly emissions are reduced, the more quickly climate change impacts are mitigated.

The Puget Sound region is already experiencing the impacts of a changing climate and is likely to see more extreme weather due to climate change, including extreme heat, wildfires, rising sea levels, and more-frequent flooding, all of which can harm public health. Direct effects, such as breathing problems from long exposure to wildfire smoke and heat-related illness from lasting heat waves, are already being seen. The communities in Shoreline that are most likely to be harmed by climate change include people of color, immigrants, and/or refugees; people with low incomes; and those who are experiencing homelessness. These communities are also the least likely to have resources to respond to climate change.

In Shoreline, buildings are largely heated by three fuel sources: electricity from Seattle City Light, natural gas from Puget Sound Energy, and heating oil from private companies. Electricity from Seattle City Light is considered carbon neutral and thus is the preferred energy source from both a carbon emissions reduction and public health perspective.

The City's 2019 communitywide greenhouse gas emissions inventory (Figure 1) reported that the largest sources of emissions were transportation (67%) and the built environment (32%), primarily from natural gas usage in the residential and commercial sectors. As shown in Figure 2, natural gas consumption was responsible for 87% of emissions from the built environment. The residential sector was the largest consumer of natural gas (11,681 customers, ~9.4 million therms), followed by the commercial sector (563 customers, ~4.8 million therms).

Figure 1. Sources of communitywide greenhouse gas emissions for Shoreline in 2019 (328,790 metric tons of carbon dioxide equivalent, MTCO₂e).

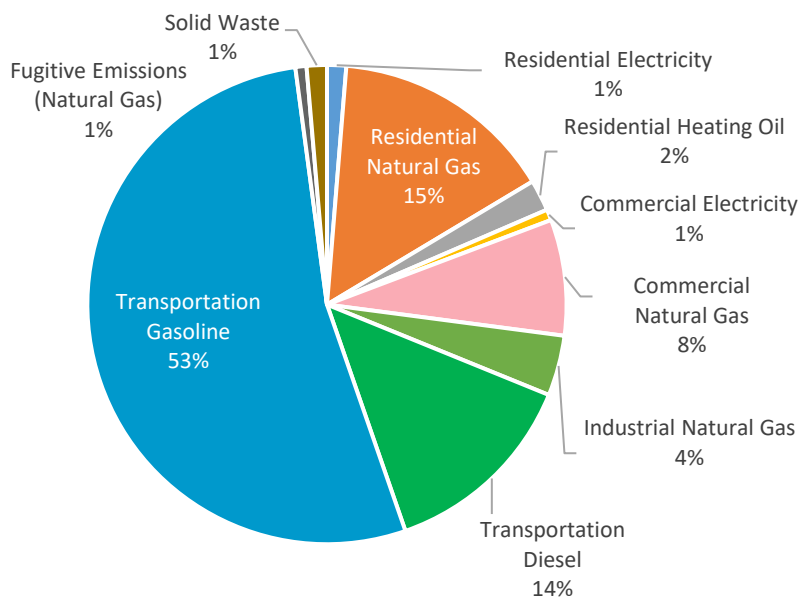
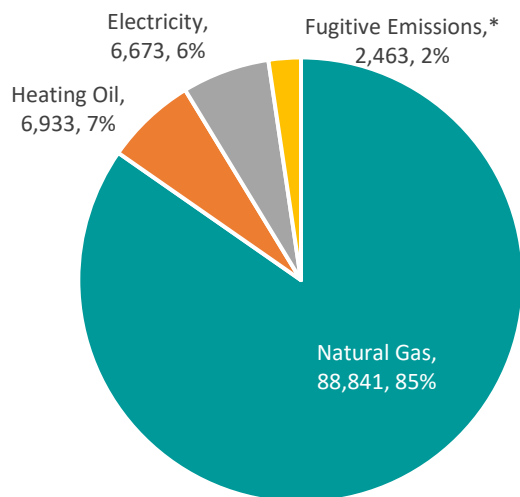


Figure 2. 2019 greenhouse gas emissions from the building energy use (104,910 MTCO₂e).



*Fugitive emissions refers to leakage in the local natural gas distribution system based on the total quantity of natural gas consumed (14,194,696 therms) and assumed leakage rate (default value = 0.3%).

Reducing the number of buildings that rely on fossil fuels for heating spaces and water is an important way to both reduce greenhouse gas emissions and protect public health. Per an April 2020 “Building Code Amendments – Energy Focus” document from King County, “Even large-scale changes in how we make electricity cannot make up for the

carbon we release by using natural gas. Also, natural gas stoves and ovens are bad for indoor air quality. They can increase a child's chance of developing asthma by 42%."

Various tools have been used to either encourage all-electric buildings or ban fossil fuels, such as natural gas, for specific uses in new construction. Building codes are one such tool that can have a powerful influence on the type of energy used in buildings and resulting emissions.

City of Seattle Fossil Fuel Ban

In December 2020, the City of Seattle announced that they would ban the use of fossil fuels in new commercial and large multi-family construction for space heating and most water heating. The Seattle Energy Code update includes the following key changes for commercial and large multifamily buildings:

- eliminates all gas and most electric resistance space heating systems;
- eliminates gas water heating in large multifamily buildings and hotels;
- improves building exteriors to improve energy efficiency and comfort;
- creates more opportunities for solar power; and
- requires electrical infrastructure necessary for future conversion of any gas appliances in multifamily buildings.

2018 State Energy Code

The 2018 Washington State Energy Code, which went into effect on February 1, 2021, includes elements that continue to work towards a 70% reduction in net annual energy consumption in newly constructed residential and nonresidential buildings by 2031, compared to the 2006 Washington State Energy Code. The 2018 Code includes a few elements that support increased electrification of building energy systems, including the following:

- new energy modeling protocol based on source carbon emissions savings instead of site energy savings for the proposed building in comparison to the baseline building (commercial code);
- carbon emissions factors for each fuel source (commercial code);
- new requirement for a minimum efficiency standard for fireplaces (residential code);
- new general section to prohibit continuously burning pilot lights (residential code); and
- revised additional required energy credits to discourage the use of gas furnaces (residential code).

Incident to the energy credits, the Code provides "Fuel Normalization Credits" that establish a negative 1 credit for solely electric resistance systems as well as all heating energy sources other than heat pumps. This penalty must be compensated by other energy credit options. It is important to note that gas is not totally ruled out because installation of a high efficiency gas furnace earns 1 credit back. However, it makes no headway towards satisfying the bottom-line additional requirement.

Inquiries to local Shoreline builders indicate that it is too early to conclude the impact of these new provisions since most new ongoing construction projects were vested under the prior Energy Code. Heat pump systems are common, but high efficiency gas furnaces already represent a significant percentage of new installations as an exercised option under prior Energy Code compliance, so the true impact of the 2018 Energy Code remains to be seen.

Limits to Local Options

While local jurisdictions have free reign to modify the State commercial Energy Code, state law restricts local jurisdictions from making the residential Energy Code anything other than equivalent to the State Code. The term “Mini-Maxi” is used to reflect this limitation depicting this code as both a minimum as well as a maximum requirement. The only flexibility is in the form of additional energy credit options that must be selected beyond baseline requirements based on the new dwelling size in square feet. The minimum additional credits required are 3, 6, and 7 for small, medium, and large dwelling units respectively. The 2018 Energy Code also addresses apartment building units and additions separately.

DISCUSSION

The City Council discussed this topic at their 2021 Strategic Planning Workshop in March 2021 and indicated general support for a natural gas ban on space/water heating for new residential construction (referring to both single-family and multi-family construction), with an allowance for gas for cooking only.

Staff has since evaluated options to ban fossil fuels in various types of new construction. The current policy in Washington State ([RCW 19.27A.020](#)) prohibits local governments from passing electrification ordinances for new residential construction, defined as single family homes, townhouses, and multi-family dwelling unit buildings that are three stories and less. Given the State’s Mini-Maxi restrictions for the residential Energy Code, the City can thus only evaluate limitations on the use of fossil fuels for commercial construction and multi-family projects over three stories in height.

The City of Seattle has successfully enacted their 2018 Energy Code Update regarding the ban on the use of fossil fuels in new commercial and large multi-family construction for space heating and most water heating. The City of Seattle Commercial Energy Code aims to exceed the State baseline savings by 20%. The City of Seattle’s amendments have been outlined in a modified format for consideration by other jurisdictions in the Regional Code Collaboration Suggested 2018 Energy Code Amendment Package (Attachment A). Other local jurisdictions, namely unincorporated King County and Bellingham, are currently pursuing adoption of Seattle’s amendments, in large part, as early as this calendar year. The City of Shoreline could also incorporate the City of Seattle’s code update language. A King County presentation regarding the Regional Code Collaboration Proposed Energy Code Amendments is attached to this staff report as Attachment B.

A Shoreline Municipal Code envisioned ban for the use of fossil fuels for space/water heating in new commercial construction, including multi-family dwelling unit buildings that are four stories or more, would be included under SMC Title 15 – local amendments to the State Construction Codes, specifically amending the State Energy Code Commercial Provisions. This approach would provide consistency for builders operating in Seattle, Shoreline and King County and yield regional emission reduction benefits. Staff would share information and seek comment from local developers and utility companies, including Puget Sound Energy, on proposed amendments to Title 15.

Tonight's Council Discussion

Given the State preclusion of a natural gas ban on space/water heating for new residential construction, tonight, staff is interested in hearing from Council on their interest in staff bringing back a proposed ordinance for Council consideration that would ban the use of fossil fuels in new commercial and large multi-family construction for space heating and most water heating, in alignment with the Regional Code Collaboration Suggested 2018 Energy Code Amendment Package. Staff is also interested in receiving any additional feedback from Council on other regulatory options that Council would like staff to explore.

Given the State's Mini-Maxi restrictions for the residential Energy Code, and the fact that the Regional Code Collaboration Suggested 2018 Energy Code Amendment Package has already been implemented in other jurisdictions, staff recommends that Council move forward with a similar ordinance for Shoreline.

RESOURCE/FINANCIAL IMPACT

City staff time would be required to codify and implement changes to SMC Title 15 and provide outreach to local builders.

RECOMMENDATION

This is a discussion item only; no action is required tonight. Based on feedback from the 2021 Council Strategic Planning Workshop, staff recommends that the Council discuss the Regional Code Collaboration Suggested Commercial Energy Code Amendments and provide staff feedback on whether Council would like staff to develop an ordinance for Council consideration that aligns with these amendments.

ATTACHMENT

- Attachment A: Regional Code Collaboration Suggested 2018 Energy Code Amendment Package
- Attachment B: Regional Code Collaboration Proposed Energy Code Amendments Presentation



RCC SUGGESTED 2018 ENERGY CODE AMENDMENT PACKAGE

King County is currently evaluating the possibility to adopt this package in its entirety – it will be transmitted to Council in July 9, 2021

This package includes:

- *RCC suggested amendments to the 2018 WA State Energy Code which are based on Seattle's 2018 Energy Code amendments - slightly modified to better reflect other jurisdictions. Amendments have been written in standard underline and strikeout format. This document is not the entire 2018 code, only the amended sections.*
- *It is suggested that jurisdictions adopt this package in its near entirety; However, if the focus is only on decarbonization, the text in green reflects the text associated with decarbonization (The "Highlights" matrix below provides a brief overview of these sections).*
- *Seattle's code has "Informative Notes" which provide clarification for the design professional. These have been left in; Delete if unnecessary.*
- *Seattle's code had some delayed enforcement dates in order to allow time for the industry to acclimate. These have been left in.*
- *WA State's IRC Appendix T, Solar-ready provisions for detached single family, duplex, townhouse structures*

2018 Amendment Package Highlights Include:

Heat Pump Space Heating: New Sections: C403.1.4, C403.4.1.1, 503.4.6	No gas space heating permitted, and no electric resistance space heating. A long list of exceptions allowing electric resistance for certain small loads and for supplemental heat used during very cold weather. (Delayed implementation to June 1, 2021 permit application date)
Heat Pump Water Heater: * New Section C404.2.3 * New definitions for "multi-pass", "single-pass", and "temperature maintenance"	Require heat pump water heaters for R-1 & R-2 buildings with central hot water (Seattle delays implementation to Jan 1, 2022)
Section 406 Energy Efficiency Credits: * Alter Sections C406.1, C406.5 - C406.9, Table C406.1 * Delete Section C406.12 & Table C406.5	Increase C406 credit requirement to 8 (from 6) credits. Add & alter credits to say that credits cannot be applied toward gas-sourced equipment or electric baseboard
Electrical Outlets at Gas Appliances: New Section C405.7.1	Provide receptacles at dwelling unit gas-fired appliances for future electric appliances
Solar Readiness: * Alter Section C411.1 * New definition "solar zone" * AND Adopt IRC Appendix T	Require solar readiness for multifamily and commercial buildings
Renewable Energy Requirement: * Alter C407.3, Table C407.2, Table C407.3(1) * New Section 412 * New definition for "affordable housing"	Require on-site PV, 0.25 watts per sf of conditioned space, or get evidence that they donated their solar to affordable housing
Reduced Fenestration U-Values + Increased Allowable Window Area: * Alter Sections: C402.4.1, C402.4.1.1, C402.1.1.2, & Table C402.4	Reduces allowable fenestration U-values + increases allowable area for glazing from 30% up to 35% of wall area
Thermal Bridging: Control for Concrete Balconies: * New Sections C402.2.9 * Alter Table C402.1.4, footnote h * New definition "Thermal Bridging"	Thermal bridging control for concrete balconies. Specifies that cantilevered concrete balconies either have to use an R-10 thermal break assembly (such as Schoeck Isokorb or similar product) or calculate the additional heat loss in UxA calculation
Thermal Bridging: Control for Window Frames: * New Section C402.2.10 * Alter Section C402.2 * New definition "Thermal Bridging"	Thermal bridging control for window frames. Requires that the plane of the glass line up with the wall insulation layer (or within 2 inches of it) and that any space between the outside face of the fenestration frame and the outside face of framing get R-3 insulation
Total System Performance Ratio (TSPR): * Alter Sections: C403.1.1 If adopting Appendix D: * Alter Sections: D101, D601.2.1, D601.4.1, D601.4.2, D601.6, D601.7 & Tables: D601.11.2, D602.11	Increase the scope of WA State's TSPP requirement to include R-2 MF, medical office, and exempt other service areas. Just check to be sure they ran the online test and passed
Service Hot Water Efficiency Improvements: Alter Section C404.7.3.1	Insulation and efficiency improvements to hot water circulation systems. (Typically for reviewer of potable water systems)
Lighting Control Systems: Alter C405.2 + subsections	Provide LLC (luminaire-level lighting controls) or networked lighting control system for large (>5,000 sf) open office areas
Lighting Power Allowance: Alter Tables C405.4.2(1) and C405.4.2(2)	Reduce interior LPAs (lighting power allowances) 10% below state code
Indoor Horticultural Lighting: Alter Section C405.4.1	Require efficacy for "indoor horticultural lighting" of 1.6 micromoles per joule (for cannabis grow facilities)
Eliminate Sub-Standard Envelopes: * Alter Sections: C407.3, C407.3.1, Table C407.2	For energy modeling, prohibit envelope heat loss more than 10% worse than prescriptive code (state code permits 20% worse)
Total Building Performance (BPF): * Alter Table C407.3(2)	Require BPF (building performance factor) 10% below WA Appendix G modeling values, to stay equivalent to prescriptive code
Heat Recovery: New Table C403.3.2(13)	Add new table from ASHRAE 90.1 – 2019 for heat-recovery chiller efficiency
DCV (demand control ventilation) and Energy Recovery: Alter Sections: C403.3.5.1, C403.7.1	Require both DCV (demand control ventilation) and energy recovery for high occupancy spaces larger than 650 sf and more than 15 occ per 1000 sf. (This adds retail and large conference rooms to list of spaces requiring DCV & energy recovery.)
Energy Recovery Ventilation Alter Sections: C403.3.5.1, C403.7.6	Increases energy recovery ventilation effectiveness to 60%
Altered Cooling System: Alter Section C503.4.3	Clarifies that cooling system alterations must comply with the economizer compliance table, both at the individual equipment level and the total system level
Envelope Exemption for Commercial Kitchens/Laundries: Alter Sections: C505.1, C503.1	Exempt change of use projects with high process loads (commercial kitchen, laundry, etc.) from envelope improvement requirements, if use Energy star Equipment and no use of natural gas
Metering for Existing Buildings: New Section C506 (relocated from C409.5)	Requires individual meters in existing buildings where applicable

CHAPTER 1 [CE]

SCOPE AND ADMINISTRATION

SECTION C101

SCOPE AND GENERAL REQUIREMENTS

C101.1 Title. This code, consisting of Chapter 1 [CE] through Chapter ((5)) 6 [CE] and Appendices A through D, shall be known as the *Washington State Energy Code*, and shall be cited as such. It is referred to herein as "this code."

C101.3 Intent. This code shall regulate the design and construction of buildings for the use and conservation of energy and the reduction of carbon emissions 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.

SECTION C102

ALTERNATIVE MATERIALS, DESIGN AND METHODS
OF CONSTRUCTION AND EQUIPMENT

C102.1 General. The provisions of this code ((are not intended to)) do not prevent the installation of any material, or to prohibit any design or method of construction prohibited by this code or not specifically ((prescribed)) allowed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the code official finds 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 and safety. Where the alternative material, design or method of construction is not approved, the code official shall respond in writing, stating the reasons why the alternative was not approved.

The code official may require that sufficient evidence or proof be submitted to reasonably substantiate any claims regarding the use or suitability of the alternate. The code official may, but is not required to, record the approval of modifications and any relevant information in the files of the building official or on the approved permit plans.

C102.2 Modifications. The code official may modify the requirements of this code for individual cases provided the code official finds: (1) there are practical difficulties involved in carrying out the provisions of this code; (2) the modification is in conformity with the intent and purpose of this code; (3) the modification will provide a reasonable level of fire protection and structural integrity when considered together with other safety features of the building or other relevant circumstances, and (4) the modification maintains or improves the energy efficiency of the building. The code official may, but is not required to, record the approval of modifications and any relevant information in the files of the code official or on the approved permit plans.

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CHAPTER 2 [CE]

DEFINITIONS

SECTION C202

GENERAL DEFINITIONS

AFFORDABLE HOUSING. Affordable housing for the purposes of this code shall include buildings which;
a) receive or have received public funding or an allocation of federal low-income housing tax credits;
and b) are subject to a regulatory agreement, covenant, or other legal instrument recorded on the
property title, and enforceable by [the Jurisdiction], Washington State Housing Finance Commission,
State of Washington, King County, U.S. Department of Housing and Urban Development, or other
similar entity as approved by the Seattle Director of Housing, that either:

1) Restricts at least 40 percent of the units to occupancy by households earning no greater than 60
percent of median income, and controls the rents that may be charged, for a minimum period of 40
years; or

2) Restricts initial and subsequent sales of at least 40 percent of the residential units to households
with incomes no greater than 80 percent of median income, for a minimum period of 50 years. The
sale price for sales subsequent to the initial sale shall be calculated to allow modest growth in
homeowner equity while maintaining long-term affordability for future buyers.

ATTIC AND OTHER ROOFS. ~~((All 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. ~~((but excluding roofs with insulation entirely above
deck and metal building roofs.))~~

AUTOMATIC CONTROL DEVICE. A device capable of automatically turning loads off and on without
manual intervention.

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 and leave,
this also includes any doors ordinarily used to leave the building.

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 load less than or equal to 20 watts per square foot of conditioned floor area (215 watts/m²)
or a design *ITE* equipment load less than or equal to 10 kW. See also data center.

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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 transferred at a rate exceeding three air changes per hour are considered *conditioned spaces* for the purposes of the *building thermal envelope* requirements.

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 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.

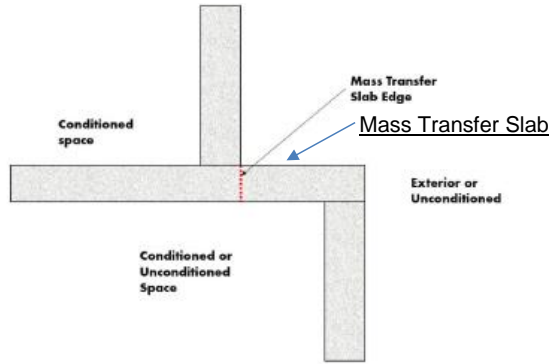
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CONTROLLED RECEPTACLE. An electrical receptacle that is controlled by an *automatic control device*.

IT (INFORMATION TECHNOLOGY) ENERGY. Electrical energy consumed by UPS (uninterruptible power supply) units, servers, and associated electronic data storage and data processing equipment, but not by lighting or HVAC equipment.

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 local or central wireless networking capabilities to detect and share information with other *luminaires* to adjust to occupancy and/or daylight in the space.

MASS TRANSFER DECK SLAB ((EDGE)). ~~That portion of the above-grade wall made up of the concrete slab where it extends past the footprint of the floor above.)~~ 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 ((perimeter)) 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.



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

SINGLE-PASS. 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 through the heat exchanger with variable incoming water temperatures.

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

SPACE CONDITIONING CATEGORY. Categories are based on the allowed peak space conditioning output capacity per square foot of *conditioned floor area*, or the design set point 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.

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

CHAPTER 3 [CE]

GENERAL REQUIREMENTS

SECTION C302

DESIGN CONDITIONS

C302.2 Exterior design conditions. The heating or cooling outdoor design temperatures shall be ((selected from Appendix C)) 24°F for heating and 86°F dry bulb and 67°F wet bulb for cooling.

CHAPTER 4 [CE]

COMMERCIAL ENERGY EFFICIENCY

SECTION C401

GENERAL

C401.2 Application. *Commercial buildings* shall comply with one of the following:

1. **Prescriptive Path.** The requirements of ~~((Sections C402, C403, C404, C405, C406, C408, C409, C410 and C411))~~ all of Chapter 4, other than Section C407.
2. **Total Building Performance Path.** The requirements of Section C407.
3. **Appendix F is not adopted by [the Jurisdiction].** ~~((When adopted by the local jurisdiction, the requirements of Appendix F, Outcome-Based Energy Budget, Sections C408, C409, C410, C411 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-))~~

SECTION C402

BUILDING 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, the U-, C- and F-factor based method of Section C402.1.4, or the component performance alternative of Section C402.1.5.
2. Fenestration in the building envelope assemblies shall comply with Section C402.4, or the component performance alternative of Section C402.1.5.
3. Air leakage of building envelope assemblies shall comply with Section C402.5.

[Jurisdiction] Informative Note: For the application of the building envelope requirements to elevator shafts and stair enclosures, see the definition of *conditioned space* in Chapter 2 and the exception to Section C402.1.3.

C402.1.1.2 Semi-heated buildings and spaces. The building 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, except as modified by this section. Building envelope assemblies separating *conditioned space* from semi-heated space shall comply with the exterior envelope insulation requirements.

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Semi-heated spaces heated by mechanical systems that do not include electric resistance heating equipment 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 ~~((Standard Reference))~~ Baseline Building Design for Total Building Performance compliance per ASHRAE 90.1, Appendix G. 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: Building or space may comply as *semi-heated* when served by ~~((one or more of))~~ the following system ~~((alternatives))~~ alternative:

1. Electric infrared heating equipment for localized heating applications, but not for general area heating, insulated in compliance with Section C402.2.8 and controlled by occupant sensing devices in compliance with Section C403.11.1.

~~((2. Heat pumps with cooling capacity permanently disabled, as pre-approved by the jurisdiction.))~~

[Jurisdiction] Informative Note: There is no separate "freeze protection" space conditioning category for unoccupied utility buildings. Spaces with no cooling and less than 3.4 BTU/h-ft² heating capacity are not required to be insulated. The opaque walls of spaces that meet the definition of "semiheated" in Chapter 2 are not required to be insulated, but otherwise the thermal envelope of semiheated spaces must meet all requirements for *conditioned space*. Spaces with any mechanical cooling or with more than 8 BTU/h-ft² heating capacity must meet all the *building thermal envelope* requirements for *conditioned space*.

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 insulation shall not be less than that specified in Table C402.1.3. *Commercial 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.

Exception: For stair and elevator shafts that do not comply with Section C402.1.2.1 and that are located within enclosed garages or other enclosed non-conditioned spaces and without conditioned supply air or cooling or heating appliances rated higher than 2 kW in any shaft, walls enclosing the shafts are permitted to be:

1. Concrete or masonry with minimum R-5 *continuous insulation*;
2. Metal studs with R-15 *cavity insulation* and without *continuous insulation*; or
3. Other assemblies with a maximum U-value of 0.120.

Slab floors, intermediate mass floor edges and elevator pits within shafts using this exception are excluded from envelope insulation requirements. Shaft surfaces using this exception shall not

be included in the gross exterior wall area for purposes of maximum fenestration area calculations in Section C402.4.1 component performance calculations in Section C402.1.5, or for the total building performance calculation of Section C407.

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT
MINIMUM REQUIREMENTS, R-VALUE METHOD^{a, j}

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-14)) <u>R-22 LS</u>	R-25 .+ ((R-14)) <u>R-22 LS</u>
Attic and other	R-49	R-49
Walls, Above Gradeⁱ		
Mass ^h	((R-9.5 ^{c, ei})) <u>Exterior: R-16 c.i.</u> <u>Interior:</u> <u>R-13 + R-6 ci wood stud, or</u> <u>R-13 + R-10 ci metal stud</u>	((R-13.3 ^{ei})) <u>Exterior: R-16 c.i.</u> <u>Interior:</u> <u>R-13 + R-6 ci wood stud, or</u> <u>R-13 + R-10 ci metal stud</u>
Mass transfer deck slab edge	((R-5)) <u>N/R</u>	((R-5)) <u>N/R</u>
Metal building	R-19ci or R-13+13ci	R-19ci or R-13+13ci
Steel framed	R-13 .+ R-10ci	R-19 .+ R-8.5ci
Wood framed and other	((R-24 int or R-15+5ci std)) <u>R-13 + R-7.5 ci</u>	R-13+7.5ci std or R-20+3.8ci std or R-25 std
Walls, Below Grade		
<i>Below-grade wall^{d, h}</i>	((Same as above-grade)) <u>Exterior: R-10 ci</u> <u>Interior:</u> <u>R-19 wood stud, or</u> <u>R-13 + R-6 ci metal stud</u>	((Same as above-grade)) <u>Exterior: R-10 ci</u> <u>Interior:</u> <u>R-19 wood stud, or</u> <u>R-13 + R-6 ci metal stud</u>

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Floors		
Mass ^f	R-30ci	R-30ci
Joist/framing	((R-30 ^e)) <u>Steel frame:</u> <u>R-38 +R-10 ci</u> <u>Wood frame: R-38</u>	((R-30 ^e)) <u>Steel frame:</u> <u>R-38 +R-10 ci</u> <u>Wood frame: R-38</u>
Slab-on-Grade Floors		
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
Opaque Doors^g		
<u>Swinging</u>	<u>U-0.37</u>	<u>U-0.37</u>
<u>Nonswinging</u>	R-4.75	R-4.75

Keys for Table C402.1.3

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

Footnotes for Table C402.1.3

- 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. (Reserved) ((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.))
- d. Where heated slabs are below grade, they shall comply with the insulation requirements for heated slabs.
- e. (Reserved) ((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. Not applicable to *garage doors*. See Table C402.1.4.
- h. 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. 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 C402.1.4.2.

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

Table C402.1.3(j)
Continuous Insulation Equivalents

Column A Assemblies with continuous insulation (see definition)	Column B Alternate option for assemblies with metal penetrations, greater than 0.04% but less than 0.08%	Column C 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-19.0ci	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

Footnotes for Table C402.1.3(j)

((This)) These alternate nominal *R*-value compliance ((option-is)) options are allowed for projects complying with all of the following:

1. 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.
 - a. 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.

C402.1.4.1 Thermal resistance of cold-formed steel stud walls. *U*-factors of walls with cold-formed steel studs shall be permitted to be determined either by using the values in Table C402.1.4.1, or in accordance with Equation 4-1:

$$U = 1/[R_s + (ER)] \quad \text{(Equation 4-1)}$$

where:

R_s = 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.

C402.1.4.2 Thermal resistance of mechanical equipment penetrations. When the total area of penetrations from through-wall mechanical equipment or equipment listed in Table C403.3.2(3) 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.

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.

TABLE C402.1.4

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-0.034)) <u>U-0.027</u>	((U-0.034)) <u>U-0.027</u>
Attic and other	U-0.021	U-0.021
Joist or single rafter	U-0.027	U-0.027
Walls, Above Grade		
Mass ^{g,k}	((U-0.104 ^d)) <u>U-0.057</u>	((U-0.078)) <u>U-0.057</u>
Mass transfer deck slab edge ⁱ	U-0.20	U-0.20
<u>Slab penetrating thermal envelope wall^h</u>	<u>U-0.10</u>	<u>U-0.10</u>
Metal building ^k	U-0.052	U-0.052
Steel framed ^k	U-0.055	U-0.055
Wood framed and other ^k	((U-0.054)) <u>U-0.051</u>	U-0.051
Walls, Below Grade		

<i>Below-grade wall^{b,g}</i>	((Same-as-above-grade)) <u>U-0.070</u>	((Same-as-above-grade)) <u>U-0.070</u>
Floors		
Mass ^e	U-0.031	U-0.031
Joist/framing	((U-0.029)) <u>U-0.029 steel joist</u> <u>U-0.025 wood joist</u>	((U-0.029)) <u>U-0.029 steel joist</u> <u>U-0.025 wood joist</u>
Concrete column or concrete wall penetrating thermal envelope floor ⁱ	<u>U-0.55</u>	<u>U-0.55</u>
Concrete slab floor directly above an electrical utility vault	<u>N.R.</u>	<u>N.R.</u>
Slab-on-Grade Floors		
Unheated slabs	F-0.54	F-0.54
Heated slabs ^c	F-0.55	F-0.55
Opaque Doors		
Swinging door	U-0.37	U-0.37
Nonswinging door	U-0.34	U-0.34
Garage door <14% glazing	U-0.31	U-0.31

Footnotes for Table C402.1.4

- 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. (Reserved) ((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. (Reserved) ((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:
- 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 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.
- h. Intermediate concrete floor slabs penetrating the *building thermal envelope* shall comply with Section C402.2.9. The area of such penetrating concrete floor slabs shall be defined as the thickness of the slab multiplied by the length of the penetration. The "exposed concrete" row in Table A103.3.7.2 shall be used for typical default *U*-factors for the penetrating concrete slab.
- i. Value applies to concrete columns and concrete walls that interrupt mass floor insulation, but not to perimeter walls or columns separating interior *conditioned space* from exterior space.
- j. 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 the top line of Table A104.3.7.2 shall be used.
- k. Through-wall mechanical equipment subject to Section C402.1.4.2 shall be calculated at the *U*-factor defined in Section C402.1.4.2. The area-weighted *U*-factor of the wall, including through-wall mechanical equipment, shall not exceed the value in the table.

TABLE C402.1.4.1

EFFECTIVE *R*-VALUES FOR STEEL STUD WALL ASSEMBLIES

NOMINAL STUD DEPTH (inches)	SPACING OF FRAMING (inches)	CAVITY <i>R</i> -VALUE (insulation)	CORRECTION FACTOR (<i>F</i> _c)	EFFECTIVE <i>R</i> -VALUE (<i>E</i> _R) (Cavity <i>R</i> -Value \times <i>F</i> _c)
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

C402.1.5 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the *U*-factors and *F*-factors in Table C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1.

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-value x proposed area) for each distinct vertical fenestration type, up to code maximum area
UA-sky-prop	=	Sum of (proposed U-value x proposed area) for each distinct skylight type, up to the code maximum area
UA-opaque-prop	=	Sum of (proposed U-value x proposed area) for each distinct opaque thermal envelope type
FL-slab-prop	=	Sum of (proposed F-value x proposed length) for each distinct slab on grade perimeter assembly
UA-glaz-allow	=	Sum of (code maximum vertical fenestration U-value from Table C402.4, or Section C402.4.1.1.2 if applicable, x proposed area) for each distinct vertical fenestration type, not to exceed the code maximum area ¹
UA-glaz-excess	=	U-value for the proposed wall type from ((Table C402.4)) <u>Table C402.1.4</u> ² x vertical fenestration area in excess of the code maximum area
UA-sky-allow	=	Sum of (code maximum skylight U-value from Table C402.4 x proposed area) for each distinct skylight type proposed, not to exceed the code maximum area
UA-sky-excess	=	U-value for the proposed roof type from Table C402.4 ³ x skylight area in excess of the code maximum area
UA-opaque-allow	=	Code maximum opaque envelope U-value from Table C402.1.4 for each opaque door, wall, roof, and floor assembly x proposed area
FL-slab-allow	=	Code maximum F-value for each slab-on-grade perimeter assembly x proposed length

Notes

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

C402.1.5.1 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 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 and Table C402.1.4.1.

C402.2 Specific building thermal envelope insulation requirements. Insulation in *building thermal envelope* opaque assemblies shall comply with Sections C402.2.1 through ~~((C402.2.6))~~ C402.2.10 and Table C402.1.3.

Where this section refers to installing insulation levels as specified in Section C402.1.3, assemblies complying with Section ~~((C402.1.5))~~ C402.1.4 and buildings complying with Section C402.1.5 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. 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. *Continuous insulation* board shall be installed in not less than 2 layers and the edge joints between each layer of insulation shall be staggered. Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

Exceptions:

1. Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted *U*-factor is equivalent to the same assembly with the *R*-value specified in Table C402.1.3.
2. ~~(Reserved) ((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).))~~
3. 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.

C402.2.9 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 adjoining wall assemblies. Stainless steel (but not carbon steel) reinforcing 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 assigned the default U-factors from the "exposed concrete" row of Table A103.3.7.2.

Exception: Mass transfer deck slab edges.

C402.2.10 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.

C402.4 Fenestration. Fenestration shall comply with Sections C402.4 through C402.4.4 and Table C402.4. *Daylight responsive controls* shall comply with this section and Section ((C405.2.4.1)) C405.2.4.

Exception: For prescriptive envelope compliance, single-pane glazing is permitted for security purposes and for revolving doors, not to exceed 1 percent of the gross exterior wall area. Where Section C402.1.5, component performance alternative, is used, the single glazing shall be included in the percentage of the total glazing area, U-factor and SHGC requirements.

TABLE C402.4

BUILDING ENVELOPE FENESTRATION MAXIMUM U-FACTOR AND SHGC REQUIREMENTS

CLIMATE ZONES 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-0.38)) <u>U-0.34</u>	
Operable ^c U-factor	((U-0.40)) <u>U-0.36</u>	
Entrance doors ^d		
U-factor	U-0.60	
U-factor for all other vertical fenestration		
<u>Fixed</u> U-factor	((U-0.30)) <u>U-0.26</u>	
<u>Operable^c U-factor</u>	<u>U-0.28</u>	
SHGC for all vertical fenestration		
Orientation ^{e,f}	SEW	N
PF < 0.2	0.38	0.51
0.2 ≤ PF < 0.5	0.46	0.56
PF ≥ 0.5	0.61	0.61

Skylights	
U-factor	((U-0.50)) <u>U-0.45</u>
SHGC	((0.35)) <u>0.32</u>

Footnotes for Table C402.4

- U-factor and SHGC shall be rated in accordance with NFRC 100.
- "Fixed" includes *curtain wall*, storefront, picture windows, and other fixed windows.
- "Operable" includes openable fenestration products other than "entrance doors."
- "Entrance door" includes glazed *swinging* entrance doors and *automatic glazed sliding entrance doors*. Other doors which are not entrance doors, including *manually operated* sliding glass doors, are considered "operable."
- "N" indicates vertical fenestration oriented within 30 degrees of true north. "SEW" indicates orientations other than "N."
- 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.

[Jurisdiction] Informative Note: The category at the top of Table C402.4, labeled "*U-factor for Class AW windows rated in accordance with AAMA/CSA101/I.S.2/A440, vertical curtain walls and site-built fenestration products*," includes *curtain wall*, storefront, ribbon wall, window wall, and similar site-assembled systems, but does not include typical punched-opening manufactured windows except for "Class AW" windows. Class AW is the AAMA designation for windows typically used in mid-rise and high-rise buildings to resist high wind and water intrusion loads.

C402.4.1 Maximum area. The total building vertical fenestration area (not including opaque doors and opaque spandrel panels) shall not exceed ((30)) 35 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)) 35 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 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:

- Not less than 50 percent of the total *conditioned floor area* in the building is within a *daylight zone* that includes *daylight responsive controls* complying with Section C405.2.4.1.
- 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 maximum U-factors:
 - a. 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) = ~~((0.34))~~ 0.30
 - b. 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
 - c. Entrance doors = 0.60
 - d. U-factor for all other vertical fenestration, fixed = ~~((0.28))~~ 0.22
 - e. U-factor for all other vertical fenestration, operable = 0.24
2. The SHGC of the vertical fenestration shall be ~~((less than or equal to 0.35, adjusted for projection factor in compliance with C402.4.3))~~ no more than 0.90 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.

C402.4.2 Minimum skylight fenestration area. For buildings with single story *enclosed spaces* greater than 2,500 square feet (232 m²) in floor area that are 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; these single-story spaces shall be provided with *skylights* and *daylight responsive controls* in accordance with Section C405.2.4. Space types required to comply with this provision include 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 toplight zone area not less than 50 percent of the floor area and shall provide one of the following:

1. A minimum ratio of skylight area to toplight *daylight zone* area of not less than 3 percent where all skylights have a VT of at least 0.40 as determined in accordance with Section C303.1.3
2. A minimum skylight effective aperture of at least 1 percent determined in accordance with Equation 4-5.

$$\text{Skylight Effective Aperture} = \frac{(0.85 \times \text{Skylight Area} \times \text{Skylight VT} \times \text{WF})}{\text{Toplight zone}}$$

(Equation 4-5)

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. Reserved.
 - 1.2. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft² (5.4 W/m²) 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 zone area is less than 2,500 square feet (232 m²), and where the lighting in the *daylight zone* is controlled in accordance with Section ((C405.2.3.4)) C405.2.4.
2. The skylight effective aperture, calculated in accordance with Equation 4-5, 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* complying with Section ((C405.2.4.1)) C405.2.4 shall be provided to control all electric lights within toplit zones.

C402.5.1.1 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 the thermal envelope of the building and across the joints and assemblies.
2. *Air barrier* joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.
3. Penetrations of the *air barrier* shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. 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 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. Where similar objects are installed which penetrate the *air barrier*, provisions shall be made to maintain the integrity of the *air barrier*.
5. 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.

[Jurisdiction] Informative Note: The continuous air barrier is intended to control the air leakage into and out of the *conditioned space*. The definition of *conditioned space* includes semi-heated spaces, so these spaces are included when detailing the continuous air barrier and when determining the pressure boundary for conducting the air leakage test. However, unheated spaces are not included when determining the pressure boundary.

C402.5.1.2 Building test. The completed building shall be tested and the air leakage rate of the *building envelope* shall not exceed 0.25 cfm/ft² at a pressure differential of 0.3 inches water gauge (~~((2-9))~~ 1.27 L/s x m² at 75 Pa) at the upper 95 percent confidence interval in accordance with ASTM E 779 or an equivalent method *approved* by the *code official*. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the building owner and the *code official*. If the tested rate exceeds that defined here by up to 0.15 cfm/ft², a visual inspection of the *air barrier* shall be conducted and any leaks noted shall be sealed to the extent practicable. An additional report identifying the corrective actions taken to seal air leaks shall be submitted to the building owner and the *Code Official* and any further requirement to meet the leakage air rate will be waived. If the tested rate exceeds 0.40 cfm/ft², corrective actions must be made and the test completed again. A test above 0.40 cfm/ft² will not be accepted.

1. Test shall be accomplished using either (1) both pressurization and depressurization or (2) 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.
2. The test pressure range shall be from 25 Pa to 80 Pa per Section 8.10 of ASTM E779, but the upper limit shall not be less than 50 Pa, and the difference between the upper and lower limit shall not be less than 25 Pa.
3. If the pressure exponent *n* is less than 0.45 or greater than 0.85 per Section 9.6.4 of ASTM E779, the test shall be rerun with additional readings over a longer time interval.

C402.5.7 Vestibules. All *building entrances* shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. 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 m²) 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* with a velocity of not less than 6.56 feet per second (2 m/s) at the floor that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. *Manual* or *automatic* controls shall be provided that will operate the *air curtain* with the opening and closing of the door. *Air curtains* 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.

[Jurisdiction] Informative Note: *Building entrance* is defined as the means ordinarily used to gain access to the building. Doors other than *building entrances*, such as those leading to service areas, mechanical rooms, electrical equipment rooms, outdoor seating areas or exits from fire stairways, are not covered by this requirement. There is less traffic through these doors, and the vestibule may limit access for large equipment. Note that enclosed lobbies in parking garages also serve to reduce the flow of vehicle exhaust into the building.

SECTION C403

MECHANICAL SYSTEMS

C403.1.1 HVAC total system performance ratio (HVAC TSPR). For systems serving office, medical office, retail, library and education occupancies and buildings, and the dwelling units and residential common areas within R-2 multifamily buildings, which are subject to the requirements of Section C403.3.5 without exceptions, the *HVAC total system performance ratio (HVAC TSPR)* of the *proposed design* HVAC system shall be more 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 with *conditioned floor area* less than 5,000 square feet.
2. HVAC systems using district heating water, chilled water or steam.
3. HVAC systems not included in Table D601.11.1.

4. 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 with no more than 10 percent of the cooling capacity of the combination being supplied by air cooled chillers.
5. HVAC system served by heating water plants that include air to water or water to water heat pumps.
6. Underfloor air distribution HVAC systems.
7. Space conditioning systems that do not include *mechanical cooling*.
8. *Alterations* to existing buildings that do not substantially replace the entire HVAC system.
9. HVAC systems meeting all the requirements of the *standard reference design* HVAC system in Table D602.11, Standard Reference Design HVAC Systems.
10. HVAC systems serving laundry rooms, elevator rooms, mechanical rooms, electrical rooms, data centers, computer rooms, and kitchens.
11. 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.

C403.1.3 Data centers. *Data center systems* shall comply with Sections 6 and 8 of ASHRAE Standard 90.4 (2019). (~~(, with the following changes:~~

1. ~~Replace design MLC in ASHRAE Standard 90.4 Table 6.2.1.1 "Maximum Design Mechanical Load Component (Design MLC)" with the following per applicable climate zone:~~
~~Zone 4C Design MLC = 0.22 Zone 5B Design MLC = 0.24~~
2. ~~Replace annualized MLC values of Table 6.2.1.2 "Maximum Annualized Mechanical Load Component (Annualized MLC)" in ASHRAE Standard 90.4 with the following per applicable climate zone:~~
~~Zone 4C Annual MLC = 0.18 Zone 5B Annual MLC = 0.17))~~

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 IBC Chapter 12 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. For the purposes of this exception, overhead or wall-mounted radiant heating panels installed in an unheated or semi-heated space, insulated in compliance with Section C402.2.8 and controlled by occupant sensing devices in compliance with Section C403.11.1 need not be included as part of the HVAC heating energy calculation.

2. Dwelling and sleeping units. Dwelling or sleeping units having an installed HVAC heating capacity no greater than 750 watts in any separate habitable room with exterior fenestration are permitted to be heated using electric resistance appliances.

a. Corner rooms. A room within a dwelling or sleeping unit that has two primary walls facing different cardinal directions, each with exterior fenestration, is permitted to have an installed HVAC heating capacity no greater than 1000 watts. Bay windows and other minor offsets are not considered primary walls.

3. Small buildings. Buildings with less than 2,500 square feet of conditioned floor area are permitted to be heated using electric resistance appliances.

4. Defrost. Heat pumps are permitted to utilize electric resistance as the first stage of heating when a heat pump defrost cycle is required and is in operation.

5. Air-to-air heat pumps. Buildings are permitted to utilize internal electric resistance heaters to supplement heat pump heating for air-to-air heat pumps that meet all of the following conditions:

- a. Internal electric resistance heaters have controls that prevent supplemental heater operation when the heatingload can be met by the heat pump alone during both steady-state operation and setback recovery.
- b. 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 or lower.
- c. The heat pump complies with one of the following:
 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 set point or to warm up the space at a sufficient rate.
 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.
 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.
- d. The heat pump rated heating capacity is sized to meet the heating load at an outdoor air temperature of 32°F or lower and has a rated heating capacity at 47°F no less than 2 times greater than supplemental internal electric resistance heating capacity, or utilizes the smallest available factory-available internal electric resistance heater.

6. Air-to-water heat pumps, up to 2,000 MBH. Buildings are permitted to utilize electric resistance auxiliary heating to supplement heat pump heating for hydronic heating systems that have air-to-water heat pump heating capacity no greater than 2000 kBTU/hr at 47°F, and that meet all of the following conditions:

- a. Controls for the auxiliary electric resistance heating are configured to lock out the supplemental heat when the outside air temperature is above 32°F, unless the hot water supply temperature setpoint to the building heat coils cannot be maintained for 20 minutes.
- b. 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 or lower except during startup or defrost operation.

- c. The heat pump rated heating capacity at 47°F is no less than 2 times greater than supplemental electric resistance heating capacity.

7. Air-to-water heat pumps, up to 3,000 MBH. Buildings are permitted to utilize electric resistance auxiliary heating to supplement heat pump heating for hydronic heating systems that have air-to-water heat pump heating capacity greater than 2000 KBTU/hr and no greater than 3000 kBTU/hr at 47°F, and that meet all of the following conditions:

- a. Controls for the auxiliary electric resistance heating are configured to **lock out the supplemental heat when the outside air temperature is above 36°F**, unless the hot water supply temperature setpoint to the building heat coils cannot be maintained for 20 minutes.
- b. 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 or lower except during startup or defrost operation.
- c. The heat pump rated heating capacity at 47°F is no less than 1.75 times greater than supplemental electric resistance heating capacity.

8. Air-to-water heat pumps, over 3,000 MBH. Buildings are permitted to utilize electric resistance auxiliary heating to supplement heat pump heating for hydronic heating systems that have air-to-water heat pump heating capacity greater than 3000 kBTU/hr at 47°F and that meet all of the following conditions:

- a. Controls for the auxiliary resistance heating are configured to **lock out the supplemental heat when the outside air temperature is above 40°F** unless the hot water supply temperature setpoint to the building heat coils cannot be maintained for 20 minutes.
- b. 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 or lower except during startup or defrost operation.
- c. The heat pump rated heating capacity at 47°F is no less than 1.5 times greater than supplemental electric resistance heating capacity.

9. Ground source heat pumps. Buildings are permitted to utilize electric resistance auxiliary heating to supplement heat pump heating for hydronic heating systems with ground source heat pump equipment that meets all of the following conditions:

- a. Controls for the auxiliary resistance heating are configured to **lock out the supplemental heat when the outdoor air temperature is above 32°F**, unless the hot water supply temperature setpoint to the building heat coils cannot be maintained for 20 minutes.
- b. The heat pump controls are configured to use the compressor as the first stage of heating down to an outdoor temperature of 17°F or lower.
- c. The heat pump rated heating capacity at 32°F entering water conditions is no less than 2 times greater than supplemental electric resistance heating capacity.

10. 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*.

11. 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.

12. Kitchen exhaust. 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 using electric resistance appliances.

13. 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.

14. 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.

15. 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.

16. Emergency generators. Emergency generators are permitted to use fossil fuels.

17. 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 or lower during the pasteurization cycle.

C403.2.1 Zone isolation required. HVAC systems serving ((~~zones~~)) areas that are intended to operate or be occupied nonsimultaneously shall be divided into isolation areas. Zones may be grouped into a single isolation area provided it does not exceed 25,000 square feet (2323 m²) of conditioned floor area nor 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.

C403.2.3 Variable flow capacity. For fan and pump motors 5 (~~(7-5)~~) hp and greater including motors in or serving custom and packaged air handlers serving variable air volume fan systems, constant volume fans, parking garage ventilation 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 set point 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.).

C403.3.2 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables C403.3.2(1) through (~~(C403.3.2(12))~~) C403.3.2(13) when tested and rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of Table C403.3.2(10). 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.

Gas-fired and oil-fired 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.

Air-to-water heat pump manufacturers shall report the hourly heating output or heating efficiency with and without defrost operation at 32°F, in addition to meeting the efficiency requirements of Table C403.3.2(13) at the AHRI 550/590 applicable leaving water temperatures. The hourly heating output or heating efficiency with and without defrost operation shall be documented on the mechanical permit drawings.

Exception:

Heat recovery chillers and air-to-water heat pumps covered under Table C403.3.2(13), are not required to be listed in the AHRI certification program for AHRI 550/590. The equipment heating and cooling efficiency ratings shall be supported by data furnished by the manufacturer at AHRI 550/590 conditions. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements.

[Jurisdiction] Informative Note: Table C403.3.2.(13) is from ASHRAE 90.1-2019. At the time of the adoption of the 2018 SEC there were no air-to-water heat pumps or heat recovery chillers listed in the AHRI Certified Product Directory. <https://www.ahridirectory.org/> According to AHRI 550/590 Section 5.3, "Full and part-load application ratings shall include the range of Rating Conditions listed in Table 2 or be within the operating limits of the equipment."

C403.3.2.1 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. ~~((Where the air-to-water heat pumps are designed for a maximum supply leaving water temperature of less than 140°F, the efficiency rating will be calculated and reported at the maximum unit leaving water temperature for this test condition.))~~

TABLE C403.3.2(1)B

**MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED VARIABLE REFRIGERANT FLOW AIR CONDITIONERS**

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure
VRF Air Conditioners, Air Cooled	<65,000 Btu/h	All	VRF Multi-split System	13.0 SEER	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	11.2 EER 15.5 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	11.0 EER 14.9 IEER	
	≥240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	10.0 EER ((13.9 EER)) <u>13.9 IEER</u>	

TABLE C403.3.2(7)
MINIMUM EFFICIENCY REQUIREMENTS:
WATER CHILLING PACKAGES^{a, b}

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	PATH A		PATH B		TEST PROCEDURE ^c
			FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-cooled chillers	< 150 tons	EER	≥ 10.100	≥ 13.700	≥ 9.700	≥ 15.800	AHRI 550/590
	≥ 150 tons	EER	≥ 10.100	≥ 14.000	≥ 9.700	≥ 16.100	
Air cooled without condenser, electrical operated	All capacities	EER	Air-cooled chillers without condensers shall be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water 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 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	≤ 0.400	
	≥ 300 tons and < 400 tons	kW/ton	≤ 0.560	≤ 0.520	≤ 0.595	≤ 0.390	
	≥ 400 tons	kW/ton	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR	NA	NA	AHRI 560
Water cooled, absorption single effect	All capacities	COP	≥ 0.700	NR	NA	NA	
Absorption double effect, indirect fired	All capacities	COP	≥ 1.000	≥ 1.050	NA	NA	
Absorption double effect, direct fired	All capacities	COP	≥ 1.000	≥ 1.000	NA	NA	

Keys for Table C403.3.2(7)

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.

NA = Not applicable, not to be used for compliance; NR = No requirement.

Footnotes for Table C403.2.3(7)

- ~~((The centrifugal chiller equipment requirements, after adjustment in accordance with Section C403.2.2.2 or Section C403.2.3, do not apply to chillers used in low-temperature applications where the design leaving fluid temperature is less than 36°F. The requirements do not apply to positive displacement chillers with leaving fluid temperatures less than or equal to 32°F. The requirements do not apply to absorption chillers with design leaving fluid temperatures less than 40°F.)) The requirements for air-cooled, water-cooled positive displacement, and absorption chillers are at standard rating conditions defined in the reference test procedure. The requirements for centrifugal chillers shall be adjusted for nonstandard rating conditions per Section C403.2.3.1 and are only applicable for the range of conditions listed there.~~
- Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or B.
- Chapter 12 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

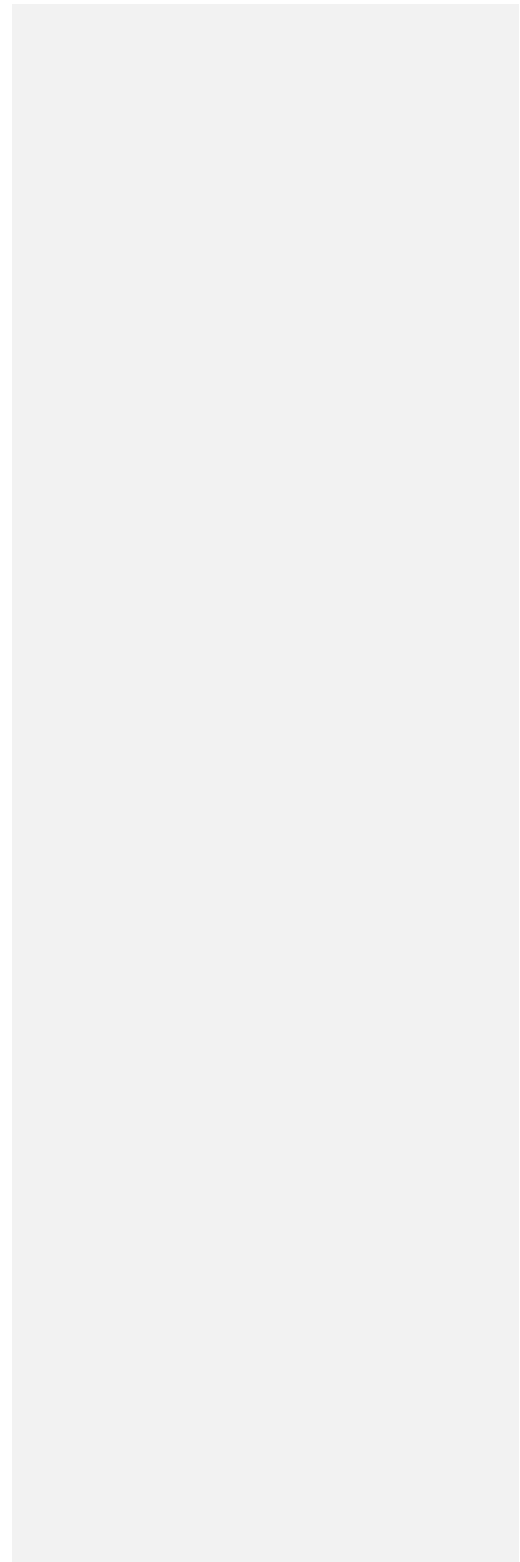


Table C403.3.2(13) f, g, h, i

HEAT PUMP AND HEAT RECOVERY CHILLER PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS

Commented [PK7]: Note to RCC: The amendment here is that the existing table has been replaced by this Table from ASHRAE 90.1

Equipment Type	Size Category (tons)	Cooling only Operation Cooling Efficiency ^a (Air EER FL/IPLV-Btu/W-h) Water Source Power Input per Capacity FL/IPLV (kW/ton)		Heating Operation								Test Procedure	
				Heating Source Conditions (Entering/leaving water) or OAT (db/wb) °F	Heat Pump Heating Full Load Efficiency (COP _{HP}) ^b (W/W)				Heat Recovery Chiller Full Load Efficiency Full Load Efficiency (COP _{HP}) ^{b,c} (W/W) Simultaneous Cooling and Heating Full Load Efficiency (COP _{SHC}) ^b (W/W)				
					Leaving Heating Water Temperature				Leaving Heating Water Temperature				
					Low	Medium	High	Boost	Low	Medium	High		Boost
					105°F	120°F	140°F	140°F	105°F	120°F	140°F		140°F
		Path A	Path B										
Air Source	All sizes	≥9.595 FL ≥13.02 IPLV.IP	≥9.215 FL ≥15.01 IPLV.IP	47 db 43 wb ^d	≥3.290	≥2.770	≥2.310	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 ^d	≥2.230	≥1.950	≥1.630	NA	NA	NA	NA		
Water Source electrically operated positive displacement	≤ 75	≤0.7885 FL	≤0.7875 FL	54/44°	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	AHRI 550/590
		≤0.6316 IPLV.IP	≤0.5145 IPLV.IP	75/65°	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥75 and <150	≤0.7579 FL	≤0.7140 FL	54/44°	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
		≤0.5895 IPLV.IP	≤0.4620 IPLV.IP	75/65°	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥150 and <300	≤0.6947 FL	≤0.7140 FL	54/44°	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
		≤0.5684 IPLV.IP	≤0.4620 IPLV.IP	75/65°	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥300 and <600	≤0.6421 FL	≤0.6563 FL	54/44°	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA	
		≤0.5474 IPLV.IP	≤0.4305 IPLV.IP	75/65°	NA	NA	NA	≥3.900	NA	NA	NA	6.850	
	≥600	≤0.5895 FL	≤0.6143 FL	54/44°	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA	
		≤0.5263 IPLV.IP	≤0.3990 IPLV.IP	75/65°	NA	NA	NA	≥3.900	NA	NA	NA	6.850	
Water source electrically operated centrifugal	≤ 75	≤0.6421 FL	≤0.7316 FL	54/44°	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	AHRI 550/590
		≤0.5789 IPLV.IP	≤0.4632 IPLV.IP	75/65°	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥75 and <150	≤0.5895 FL	≤0.6684 FL	54/44°	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
		≤0.5474 IPLV.IP	≤0.4211 IPLV.IP	75/65°	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥150 and <300	≤0.5895 FL	≤0.6263 FL	54/44°	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
		≤0.5263 IPLV.IP	≤0.4105 IPLV.IP	75/65°	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° 75/65°	≥4.930 NA	≥3.960 NA	≥2.970 NA	NA ≥3.900	≥8.900 NA	≥6.980 NA	≥5.000 NA	NA 6.850
	>600	≤0.5895 FL ≤0.5263 IPLV/IP	≤0.6158 FL ≤0.4000 IPLV/IP	54/44° 75/65°	≥4.930 NA	≥3.960 NA	≥2.970 NA	NA ≥3.900	≥8.900 NA	≥6.980 NA	≥5.000 NA	NA 6.850

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Footnotes:

- a. Cooling-only rating conditions are standard rating conditions defined in AHRI 550/590, Table 1.
b. Heating full-load rating conditions are at rating conditions defined in AHRI 550/590, Table 1.
c. For water-cooled heat recovery chillers 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% heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table 6.8.1-3.
d. Outdoor air entering dry-bulb (db) temperature and wet-bulb (wb) temperature.
e. Source-water entering and leaving water temperature.
f. AHRI ratings are not required for equipment sizes larger than those covered by the test standard.
g. 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.
h. Units that are both an air-to-water heat pump and an heat recovery chiller are required to comply with either the applicable air source efficiency requirements or the heat recovery chiller requirements but not both.
i. 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 is closest to the design leaving water temperature shall be utilized.

C403.3.2.2 Water-cooled centrifugal chilling package. Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44°F (7°C) leaving chilled-water temperature and 2.4 gpm/ton evaporator fluid flow and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 L/s × kW) condenser water flow shall have maximum full-load kW/ton (FL) and part-load ratings adjusted using Equations 4-7 and 4-8.

Exception: Centrifugal chillers designed to operate outside of these temperature ranges are not regulated by this section.

$$FL_{adj} = FL/K_{adj}$$

(Equation 4-7)

$$PLV_{adj} = IPLV/K_{adj}$$

(Equation 4-8)

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 = Values as specified in Table C403.3.2(7)

PLV_{adj} = Maximum NPLV rating, adjusted for nonstandard conditions.

$$A = 0.00000014592 \times (\text{LIFT})^4 - 0.0000346496 \times (\text{LIFT})^3 + 0.00314196 \times (\text{LIFT})^2 - 0.147199 \times \text{LIFT} + 3.9302$$

$$B = 0.0015 \times L_{vg}^{Evap} (°F) + 0.934$$

$$\text{LIFT} = L_{vg}^{Cond} - L_{vg}^{Evap}$$

L_{vg}^{Cond} = Full-load condenser leaving fluid temperature (°F)

L_{vg}^{Evap} = Full-load evaporator leaving temperature (°F)

The FL_{adj} and PLV_{adj} values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

1. Minimum evaporator leaving temperature: 36°F.
2. Maximum condenser leaving temperature: 115°F.
3. LIFT is not less than 20°F and not greater than 80°F.

C403.3.2.4 Packaged and split system electric heating and cooling equipment. Packaged and split system electric equipment providing both 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.

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

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.
3. Spaces that are within building types not subject to the requirements of Section C403.3.5, and that qualify as accessory occupancies according to Section 508.2 of the International Building Code, are not required to comply with this section.

C403.3.5.1 Energy recovery ventilation with DOAS. The DOAS shall include *energy recovery ventilation*. The energy recovery system shall have a ~~((60 percent minimum sensible recovery effectiveness or have 50))~~ 60 percent enthalpy recovery effectiveness in accordance with Section C403.7.6. For DOAS having a total fan system motor nameplate hp less than 5 hp, total combined fan power shall not exceed 1 W/cfm of outdoor air. For DOAS having a total fan system motor hp greater than or equal to 5 hp, refer to fan power limitations of Section C403.8.1. This fan power restriction applies to each dedicated outdoor air unit in the permitted project, but does not include the fan power associated with the zonal heating/cooling equipment. The airflow rate thresholds for energy recovery requirements in Tables C403.7.6.1(1) and C403.7.6.1(2) do not apply.

Exceptions:

1. Occupied spaces with all of the following characteristics:
 - a. ~~((complying))~~ Complying with Section C403.7.6~~((;))~~;
 - b. ~~((served))~~ Served by equipment less than 5000 cfm~~((;))~~;
 - c. ~~((with))~~ With an average occupant load ~~((greater than 25))~~ 15 people or greater per 1000 square feet (93 m²) of floor area (as established in Table 403.3.1.1 of the *International Mechanical Code*);
 - d. ~~((that))~~ That include *demand control ventilation* configured to reduce outdoor air by at least 50% below design minimum ventilation rates when the actual occupancy of the space served by the system is less than the design occupancy; and
 - e. Smaller than 650 square feet.
2. 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.
3. The energy recovery systems for R-1 and R-2 occupancies are permitted to provide 60 percent minimum sensible heat recovery effectiveness in lieu of 60 percent enthalpy recovery effectiveness. The return/exhaust air stream temperature for heat recovery device selection shall be 70°F or as determined by an *approved* calculation procedure.

C403.3.6 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 all habitable space. 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.

[Jurisdiction] Informative Note. When an H/ERV (heat recovery ventilator or energy recovery ventilator) that is rated and listed in accordance with HVI 920 is used to comply with the "sensible recovery effectiveness" requirement in Section C403.3.6 or C403.7.6 Exception 2, use the product's Adjusted Sensible Recovery Efficiency (ASRE) at 32°F, as listed in the HVI Section 3 H/ERV Directory. Select the ASRE for a flow rate that is no less than the design flow rate, or interpolate between two listed flow rates. HVI refers to the Home Ventilating Institute.

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 two-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.

[Jurisdiction] Informative Note. The flow rates listed here do not consider noise or erosion. Lower flow rates are often recommended for noise sensitive locations.

TABLE C403.3.7

PIPING SYSTEM DESIGN MAXIMUM FLOW RATE IN GPM¹

Pipe Size	<= 2000 hours/yr		>2000 and <= 4400 hours/year		> 4400 hours/year	
(in)	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

1. There are no requirements for pipe sizes smaller than the minimum size or larger than the maximum size shown in the table.

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 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. ~~((Any interior zone open to a perimeter zone shall have set points and dead bands coordinated so that cooling in the interior zone shall not operate while the perimeter zone is in heating until the interior zone temperature is 5°F (2.8°C) higher than the perimeter zone temperature, unless the interior and perimeter zones are separated by a partition whose permanent openings are smaller than 10 percent of the perimeter zone floor area.))~~ 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. ~~((Unitary air cooled heat pumps shall include microprocessor controls that minimize supplemental heat usage during start up, set up, and defrost conditions. These controls shall anticipate need for heat and use compression heating as the first stage of heat. Controls shall indicate when supplemental heating is being used through visual means (e.g., LED indicators). Heat pumps equipped with supplementary heaters shall be installed with controls that prevent supplemental heater operation above 40°F (4.4°C).))~~ 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 heater operation is permitted during outdoor coil defrost cycles. Heat pumps equipped with supplementary heaters shall comply with all conditions of Section C403.1.4.

Exception. ~~((Packaged terminal heat pumps (PTHPs) of less than 2 tons (24,000 Btu/hr) cooling capacity provided with controls that prevent supplementary heater operation above 40°F.))~~ 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.

C403.4.2 Off-hour controls. For all occupancies other than Group R and for *conditioned spaces* other than *dwelling units* within Group R occupancies, 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*.

C403.4.12 Pressure Independent Control Valves. Where design flow rate of heating water and chilled water coils is 10 GPM or higher, modulating pressure independent control valves shall be provided.

C403.5 Economizers. *Air economizers* shall be provided on all new cooling systems including those serving computer server rooms, electronic equipment, radio equipment, and telephone switchgear. Economizers shall comply with Sections C403.5.1 through C403.5.5.

Exception: Economizers are not required for the systems listed below:

1. Cooling systems not installed outdoors nor in a mechanical room adjacent to outdoors and 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.
2. Unitary or packaged systems serving one zone with dehumidification ~~((that affect other systems so as to))~~ where an economizer would 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(3).

**TABLE C403.5(3)
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.

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 units installed outdoors 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) through (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. 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) and (7).
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.
11. Equipment used to cool any dedicated server room, electronic equipment room, elevator machine room or telecom switch room provided the system complies with Option a, b, ~~((or))~~ c, d or e in ((the table)) Table C403.5(11) below. The total cooling capacity of all fan systems qualifying under this exception 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.

Table C403.5(11)
Server room, electronic equipment room or telecom room cooling equipment

	Equipment Type	Higher Equipment Efficiency	Part-Load Control	Economizer
Option a	Tables C403.3.2(1) and C403.3.2(2) ^a	+15% ^b	Required over 85,000 Btu/h ^c	None Required
Option b	Tables C403.3.2(1) and C403.3.2(2) ^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
<u>Option d</u>	<u>Table C403.3.2(7)^h</u>	<u>+ 25%ⁱ</u>	<u>Required for all chillers^j</u>	None Required
<u>Option e</u>	<u>Table C403.3.2(7)^h</u>	<u>+ 10/15%^k</u>	<u>Required over 85,000 Btu/h^c</u>	<u>Dedicated waterside Economizer^e</u>

((Notes for Exception 11)) Footnotes for Table C403.5(11):

- For a system where all of the cooling equipment is subject to the AHRI standards listed in Tables C403.3.2(1) and C403.3.2(2), the system shall comply with ~~((all of the following))~~ the higher equipment efficiency, part-load control and economizer requirements of the row in which this footnote is located, including the associated footnotes (note that if the system contains any cooling equipment that exceeds the capacity limits in Table C403.3.2(1) or C403.3.2(2), or if the system contains any cooling equipment that is not included in Table C403.3.2(1) or C403.3.2(2), then the system is not allowed to use this option).
- The cooling equipment shall have an SEER/EER value and an IEER/PLV value that ~~((is))~~ are each a minimum of 15 percent greater than the value listed in Tables C403.3.2(1) and C403.3.2(2).

- 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 SEER/EER value and an IEER/IPLV value that ~~((is))~~ are each a minimum of 5 percent greater than the value listed in Tables C403.3.2(1) and C403.3.2(2).
- 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, the system shall comply with the higher equipment efficiency, part-load control, and economizer requirements of the row in which this footnote is located, including the associated footnotes.
- g. The cooling equipment subject to ASHRAE Standard 127 shall have an ~~((EER value and an IPLV))~~ SCOP value that is ~~((equal-or))~~ a minimum of 10 percent greater than the value listed in Tables C403.3.2(1) and C403.3.2(2) ~~((1.10 x values in these tables))~~ 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.
- h. For a system with chillers subject to the AHRI standards listed in Table C403.3.2(7) (e.g., a chilled water system with fan coil units), the system shall comply with the higher equipment efficiency, part-load control and economizer requirements of the row in which this footnote is located, including the associated footnotes.
- i. The cooling equipment shall have a full-load EER value and an IPLV value that is a minimum of 25 percent greater than the value listed in Table C403.3.2(7) (1.25 x value in Table C403.3.2(7) or a full-load and IPLV kW/ton that is at least 25 percent lower than the value listed in Table C403.3.2(7) (0.75 x value in Table C403.3.2(7)). For all chillers, 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 and that result 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, or dual tandem scrolls, but hot gas bypass is not a qualifying compressor unloading system).
- j. For air-cooled chillers, 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 and that result 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, or dual tandem scrolls, but hot gas bypass is not a qualifying compressor unloading system).
- k. For air-cooled chillers, the cooling equipment shall have an IPLV EER value that is a minimum of 10 percent greater than the IPLV EER value listed in Table C403.3.2(7) (1.10 x values in Table C403.3.2(7)). For water-cooled chillers, the cooling equipment shall have an IPLV kW/ton that is at least 15 percent lower than the IPLV kW/ton value listed in Table C403.3.2(7) (0.85 x values in Table C403.3.2(7)).

12. Medical and laboratory equipment that is directly water-cooled and is not dependent upon space air temperature.

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 in addition to the applicable requirements of Sections C403.8.6 through C403.8.8. ~~((this))~~ This exception shall not be used as a substitution for a DOAS per Section C406.6 or C406.7((-)):

1. Each VAV system must serve a minimum of 3,000 square feet (278.7 m²) 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 m²) unless a single floor is greater than 50,000 square feet (4645 m²) 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 set point of 50 percent or greater of the maximum primary airflow set point 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. 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 set point shall be configured to exceed the value required to provide the required ventilation air.
10. 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.
11. 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 set point, based on the VAV air handling unit outdoor air vent fraction, to the minimum ventilation airflow required per *International Mechanical Code*.
12. Spaces that are larger than 150 square feet (14 m²) and with an occupant load greater than or equal to ((25)) 15 people per 1000 square feet (93 m²) 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:
 - 12.1. A dedicated VAV terminal unit capable of controlling the space temperature and minimum ventilation shall be provided.
 - 12.2. Demand control ventilation (DCV) shall be provided that utilizes a carbon dioxide sensor to reset the ventilation set point of the VAV terminal unit from the design minimum to design maximum ventilation rate as required by Chapter 4 of the *International Mechanical Code*.

12.3. Occupancy sensors shall be provided that are configured to reduce the minimum ventilation rate to zero and setback room temperature set points by a minimum of 5°F, for both cooling and heating, when the space is unoccupied.

13. Dedicated *data centers*, *computer rooms*, electronic equipment rooms, telecom rooms, or other similar spaces with cooling loads greater than 5 watts/ft² 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.

14. HVAC system central heating or cooling plant will include a minimum of one of the following options:
- 14.1. 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, η_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.
 - 14.2. Chilled water VAV air handling 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(7), 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.
15. The DDC system shall include a fault detection and diagnostics (FDD) system complying with the following:
- 15.1. The following temperature sensors shall be permanently installed to monitor system operation:
 - 15.1.1. Outside air.
 - 15.1.2. Supply air.
 - 15.1.3. Return air.
 - 15.2. Temperature sensors shall have an accuracy of $\pm 2^\circ\text{F}$ (1.1°C) over the range of 40°F to 80°F (4°C to 26.7°C).
 - 15.3. The VAV air handling unit controller shall be configured to provide system status by indicating the following:
 - 15.3.1. Free cooling available.
 - 15.3.2. Economizer enabled.
 - 15.3.3. Compressor enabled.
 - 15.3.4. Heating enabled.
 - 15.3.5. Mixed air low limit cycle active.
 - 15.3.6. The current value of each sensor.
 - 15.4. 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.
 - 15.5. 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.

- 15.6. 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:
- 15.6.1. Command VAV terminal unit primary air inlet valve closed and verify that primary airflow goes to zero or other approved means to verify that the VAV terminal unit damper actuator and flow ring are operating properly.
 - 15.6.2. Command VAV thermal unit primary air inlet valve to design airflow and verify that unit is controlling to within 10% of design airflow.
- 15.7. 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:
- 15.7.1. Supply air temperature set point reset to lowest supply air temperature set point for cooling operation.
 - 15.7.2. Supply air duct static pressure set point reset for the highest duct static pressure set point allowable.
- 15.8. The FDD system shall be configured to detect the following faults:
- 15.8.1. Air temperature sensor failure/fault.
 - 15.8.2. Not economizing when the unit should be economizing.
 - 15.8.3. Economizing when the unit should not be economizing.
 - 15.8.4. Outdoor air or return air damper not modulating.
 - 15.8.5. Excess outdoor air.
 - 15.8.6. VAV terminal unit primary air valve failure.

C403.7.1 Demand control ventilation. *Demand control ventilation* (DCV) shall be provided for spaces larger than 500 square feet (46 m²) and with an occupant load greater than or equal to ~~((25))~~ 15 people per 1000 square feet (93 m²) of floor area (as established in Table 403.3.1.1 of the *International Mechanical Code*) and served by systems with one or more of the following:

1. An air-side economizer.
2. *Automatic* modulating control of the outdoor air damper.
3. A design outdoor airflow greater than 3,000 cfm (1416 L/s).

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

1. Systems with energy recovery complying with Section C403.7.6.1 or Section C403.3.5.1. This exception is not available for space types located within the "inclusions" column of Groups A-1 and A-3 occupancy classifications of Table C403.3.5.
2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
3. System with a design outdoor airflow less than 750 cfm (354 L/s).
4. ~~((Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (566 L/s)))~~ 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.
5. Ventilation provided for process loads only.
6. Spaces with one of the following occupancy categories (as defined by the *International Mechanical Code*): Correctional cells, daycare sickrooms, science labs, barbers, beauty and nail salons, and bowling alley seating.

7. Dormitory sleeping areas.

C403.7.5 Enclosed loading dock, motor vehicle repair garage and parking garage exhaust ventilation system controls. Mechanical ventilation systems for enclosed 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 50 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.

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. ~~((Garage))~~ 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.

C403.7.5.1 System activation devices for enclosed loading docks. Ventilation systems for enclosed loading docks shall operate continuously during unoccupied hours at the minimum ventilation rate required by Section 404 of the *International Mechanical Code* 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 enclosed parking garages. Ventilation systems for enclosed parking garages shall be activated by gas sensors.

Exception: A parking garage ventilation system having a total design capacity under 8,000 cfm may use occupant sensors to activate the full required ventilation rate.

C403.7.6 Energy recovery ventilation systems. Any system 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 have the capability to provide a change in the enthalpy of the outdoor air supply of not less than ~~((50))~~ 60 percent of the difference between the outdoor air and return air enthalpies, 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.

[Jurisdiction] Informative Note: In Seattle, the energy recovery effectiveness is determined typically by the winter heat recovery condition. See example below for how the minimum supply air enthalpy leaving the energy recovery media is calculated for the winter condition:

1. In Seattle, the winter outdoor design air temperature is 24°F as specified in Appendix C. The registered design professional shall determine the coincident winter wet bulb temperature or percent relative humidity at the anticipated design conditions. Based on these conditions the outdoor design air enthalpy is determined from a psychrometric chart.

2. Determine the return/exhaust air stream enthalpy from a psychrometric chart based on the 70°F (21°C) at 30 percent relative humidity.

3. Calculate the 60% difference between the outside air and return air enthalpies at design winter conditions.

4. See example below:

a. OA Enthalpy at 24°F / 23°F (drybulb / wetbulb) = 8.2 BTU/LB

b. RA/EA Enthalpy at 70°F and 30% RH = 21.9 BTU/LB

c. SA Enthalpy Minimum Leaving Energy Recovery Media

= $(8.2 + (21.9 - 8.2) \times 60\%)$

= 16.42 BTU/LB

(Note that this example represents 60% enthalpy recovery. For an equivalent sensible-only recovery system, it would take 73.9% effectiveness (increasing from 24°F DB to 58°F DB) to achieve the same enthalpy recovery.)

Commented [PK8]: Note to RCC: Keep if this note is helpful and alter with your local content

Exceptions:

1. The energy recovery systems for occupancy type I-2 hospitals, medical office buildings, and buildings that primarily consist of technical laboratory spaces, are permitted to provide a change of enthalpy of the outdoor air and return air of not less than 50 percent of the difference between the outdoor air and return air enthalpies, at design conditions. These occupancies are also permitted to utilize exception #3.
2. The energy recovery systems for R-1 and R-2 occupancies shall have a 60 percent minimum sensible heat recovery effectiveness, in lieu of 60 percent enthalpy recovery effectiveness. 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.
3. An energy recovery ventilation system shall not be required in any of the following conditions:
 - 3.1. 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:
 - 3.1.1. Kitchen exhaust systems where they comply with Section C403.7.7.1.
 - 3.1.2. Laboratory fume hood systems where they comply with Exception 2 of Section C403.7.6.
 - 3.1.3. 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.

- 3.2. Laboratory fume hood systems that include at least one of the following features and also comply with Section C403.7.7.2:
- 3.2.1. 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.
 - 3.2.2. 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 set point, cooled to no cooler than 3°F (1.7°C) below room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
- 3.3. Systems serving spaces that are heated to less than 60°F (15.5°C) and are not cooled.
- 3.4. Where more than 60 percent of the outdoor air heating energy is provided from site-recovered energy.
- 3.5. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.
- 3.6. Cooling energy recovery in *Climate Zones* 3C, 4C, 5B, 5C, 6B, 7 and 8.
- 3.7. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
- 3.8. 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.
- 3.9. Equipment which meets the requirements of Section C403.9.2.4.
- 3.10. Systems serving Group R-1 and R-3 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.

C403.7.8.1 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))~~ 300 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 ~~((400))~~ 300 cfm (189 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.

C403.8.1 Allowable fan motor horsepower. Each HVAC system having a total fan system motor nameplate horsepower exceeding 5 hp (3.7kW) at fan system design conditions shall not exceed the allowable *fan system motor nameplate hp* (Option 1) or *fan system bhp* (Option 2) as shown in Table C403.8.1(1). This includes supply fans, exhaust fans, return/relief fans, and fan-powered VAV air terminal units associated with systems providing heating or cooling capability. Single zone variable-air-volume systems shall comply with the constant volume fan power limitation. Zone heating and/or cooling terminal units installed in conjunction with a dedicated outdoor air system (DOAS) shall be evaluated as separate HVAC systems for allowable fan motor horsepower.

Exceptions:

- 1. Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.
- 2. Individual exhaust fans with motor nameplate horsepower of 1 hp or less are exempt from the allowable fan motor horsepower requirements, but must meet the requirements of Section C405.8 for fractional hp fan motors.

C403.8.3 Fan efficiency. Fans shall have a fan efficiency grade (FEG) of 67 or higher based on manufacturers' certified data, as defined by AMCA 205. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

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

- 1. Individual fans with a motor nameplate horsepower of 5 hp (3.7 kW) or less that are not part of a group operated as the functional equivalent of a single fan.
- 2. Multiple fans in series or parallel that have a combined motor nameplate horsepower of 5 hp (3.7 kW) or less and are operated as the functional equivalent of a single fan.
- 3. Fans that are part of equipment covered under Section C403.3.2.
- 4. Fans included in an equipment package certified by an *approved* agency for air or energy performance.
- 5. Powered wall/roof ventilators.
- 6. Fans outside the scope of AMCA 205.
- 7. Fans that are intended to operate only during emergency conditions.
- 8. Fans and fan arrays having a fan energy index (FEI) of not less than 1.00, or 0.95 for VAV systems, 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.

C403.8.4 Group R occupancy ((exhaust)) ventilation fan efficacy. The Group R occupancies of the building shall be provided with ventilation that meets the requirements of the *International Mechanical Code*, as applicable, or with other *approved* means of ventilation. Mechanical ventilation system fans with 400 cfm or less in capacity shall meet the efficacy requirements of Table C403.8.4 at one or more rating points. Air flow shall be tested in accordance with Home Ventilating Standard (HVS) Standard 916 and listed. Fan 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 of not less than 0.2 inch w.c. Fan efficacy for other exhaust fans shall be determined at a static pressure of not less than 0.1 inch w.c.

Exceptions:

1. ~~((Group R heat recovery ventilator and energy recovery ventilator fans that are less than 400 cfm.~~
- 2.) Where whole house ventilation fans are integrated with forced-air systems that are tested and listed HVAC equipment, provided they are powered by an electronically commutated motor where required by Section C405.8
- ~~((3))~~2. Domestic clothes dryer booster fans, domestic range hood exhaust fans, and domestic range booster fans that operate intermittently.

TABLE C403.8.4
GROUP R EXHAUST FAN EFFICACY

Fan location	((Air Flow Rate- Minimum (cfm)))	Minimum Efficacy (cfm/watt)	Air Flow Rate ((Minimum)) (cfm)
Exhaust fan: Bathroom, utility room, whole house	((140))	2.8	< 90
Exhaust fan: Bathroom, utility room, whole house	((90))	3.5	((Any)) <u>≥ 90</u>
In-line (single-port and multi-port) fans	((Any))	3.8	Any
<u>ERV, HRV or balanced fan</u>		<u>1.2</u>	<u>Any</u>

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)A, C403.3.2(1)B, C403.3.2(1)C, C403.3.2(2), C403.3.2(3), C403.3.2(7) and C403.3.2(9).

Heat rejection equipment shall have a minimum efficiency performance not less than values specified in Table C403.3.2(8).

Cooling towers serving chilled water systems shall be selected to maintain a return condenser water temperature to the tower of 86°F (30°C) or less at peak design conditions.

EXCEPTION: In existing buildings where physical constraints preclude a change from the original design, replacement cooling towers of the same or smaller capacity are exempt from this requirement.

Single-pass water cooling systems that use domestic water only one time before dumping it to waste shall not be used for hydronic heat pump and other cooling and refrigeration equipment, including but not limited to icemakers and walk-in coolers.

EXCEPTIONS:

1. Replacement of existing icemakers is exempt from this requirement.
2. Use of single-pass cooling for medical and dental equipment during power outages and other emergencies is exempt from this requirement.

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 steam generated off-site with steam heating systems which do not have condensate water recovery shall have condensate (~~water~~) heat recovery.

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 ft² 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. The required heat recovery system shall have the capacity to provide the smaller of:

1. 60 percent of the peak heat rejection load at design conditions; or
2. 50 percent of the sum of the service water heating load plus space heating load.

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.

C403.10.2.2 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 and exterior duct systems. Ducts designed to operate at static pressures equal to or greater than 3 inches water gauge (w.g.) (750 Pa) and all supply and return

ductwork located outside the *building thermal envelope* that serves a *conditioned space* shall be insulated and sealed in accordance with Section ~~((C403.2.10.4))~~ 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, regardless of the Design Construction Pressure Class level, as determined in accordance with Equation 4-9. Ducts shall be tested using a pressure equal to the average operating pressure or the design Duct Construction Pressure Class level in accordance with the SMACNA HVAC Air Duct Leakage Test Manual.

$$CL = F/P^{0.65} \quad \text{(Equation 4-9)}$$

Where:

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

P = The static pressure of the test.

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

C403.10.3 Piping insulation. All piping, other than refrigerant piping, serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.10.3.

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).

C403.10.3.1 Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. ~~((Adhesives))~~ Adhesive tape shall not be permitted.

C403.10.4 Insulation of refrigerant piping. Refrigerant piping, other than piping factory installed in HVAC equipment, shall have minimum 1/2-inch insulation within conditioned spaces and 1-inch insulation outside of conditioned spaces, at a conductivity rating of 0.21 to 0.26 Btu x in/(h x ft² x °F) with a mean temperature rating of 75°F.

C403.11 Mechanical systems located outside of the building thermal envelope. Mechanical systems providing heat outside of the thermal envelope of a building shall be configured to comply with Section C403.11.1 through C403.11.3.

C403.11.1 Heating outside a building or in unheated spaces. Systems installed to provide heat outside a building or in unheated spaces 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 in the area heated by each individual device for a period not to exceed 20 minutes.

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))~~ option 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 motor horsepower shall not exceed 90 percent of the allowable HVAC *fan system bhp* (Option 2) 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 m²) and with an occupant load greater than or equal to 25 people per 1000 square feet (93 m²) 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 set point 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 set points 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 handling 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(7), 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) and C403.3.2(2).
 - 7.3.2. Have a gas-fired furnace with a thermal efficiency, η_t , 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) and C403.3.2(2).
 - 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 $\pm 2^\circ\text{F}$ (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.

C403.14 Compressed air and vacuum air. Compressed air and vacuum air systems shall comply with all of the following:

EXCEPTION: Compressed air and vacuum air systems used for medical purposes are exempt from this section.

1. Air Compressors (50-150 PSI), General: Air compressors operating at 50-150 PSI shall comply with the following:
 - a. All water drains shall be "no air loss" drains.
 - b. Timed unheated desiccant air driers shall not be allowed.
2. Rotary Screw Air Compressors over 10 hp (50-150 PSI): Rotary screw air compressors over 10 hp operating at 50-150 PSI shall not rely on modulation control and shall have one of the following:
 - a. Receiver capacity greater than three gallons per cfm to allow efficient load/unload control;
 - b. Variable speed drive controlled air compressor; or
 - c. Multiple air compressors using a smaller trim-air compressor to trim. The trim compressor shall use variable speed drive control, or shall use load/unload control with greater than three gallon receiver capacity per cfm for the trim air compressor.

C403.15 Commercial food service. The following types of equipment within the scope of the applicable Energy Star program shall comply with the energy-efficiency and water-efficiency criteria required to achieve the Energy Star label:

- a. Commercial fryers: Energy Star Program Requirements for Commercial Fryers.
- b. Commercial hot food holding cabinets: Energy Star Program Requirements for Hot Food Holding Cabinets.
- c. Commercial steam cookers: Energy Star Program Requirements for Commercial Steam Cookers.
- d. Commercial dishwashers: Energy Star Program Requirements for Commercial Dishwashers.

SECTION C404

SERVICE WATER HEATING AND PRESSURE-BOOSTER SYSTEMS

TABLE C404.2

MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED ^{a, b}	TEST PROCEDURE
Water heaters, electric	≤ 12 kW ^d	Tabletop ^e , ≥ 20 gal and < 120 gal	0.93 - 0.00132V, EF	DOE 10 CFR Part 430
		Resistance ≥ 20 gal and ≤ 55 gal	0.960 - 0.0003V, EF	
		Grid-enabled ^f > 75 gal and ≤ 120 gal	1.061 - 0.00168V, EF	
	> 12 kW	Resistance ≥ 20 gal	$\left(\frac{((0.3 + 27)/V_m \% / h^g)}{(0.3 + 27/V_m), \% / h^g} \right)$	Section G.2 of ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump	2.057 - 0.00113V, EF	DOE 10 CFR Part 430
Instantaneous water heaters, electric	All	Resistance	0.93 - 0.00132V, EF	DOE 10 CFR Part 430
Storage water heaters, gas	$\leq 75,000$ Btu/h	≥ 20 gal and ≤ 55 gal	0.675 - 0.0015V, EF	DOE 10 CFR Part 430
		> 55 gal and ≤ 100 gal	0.8012 - 0.00078V, EF	

	> 75,000 Btu/h	< 4,000 Btu/h/gal	80% E_t ($Q/800 + 110\sqrt{V}$)SL, Btu/h	Section G.1 and G.2 of ANSI Z21.10.3
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h	$\geq 4,000$ (Btu/h)/gal and < 2 gal	0.82 - 0.0019V, EF	DOE 10 CFR Part 430
	$\geq 200,000$ Btu/h ^c	$\geq 4,000$ Btu/h/gal and < 10 gal	80% E_t	Section G.1 and G.2 of ANSI Z21.10.3
	$\geq 200,000$ Btu/h	$\geq 4,000$ Btu/h/gal and ≥ 10 gal	80% E_t ($Q/800 + 110\sqrt{V}$)SL, Btu/h	
Storage water heaters, oil	$\leq 105,000$ Btu/h	≥ 20 gal	0.68 - 0.0019V, EF	DOE 10 CFR Part 430
	> 105,000 Btu/h	< 4,000 Btu/h/gal	80% E_t ($Q/800 + 110\sqrt{V}$)SL, Btu/h	Section G.1 and G.2 of ANSI Z21.10.3
Instantaneous water heaters, oil	$\leq 210,000$ Btu/h	$\geq 4,000$ Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	DOE 10 CFR Part 430
	> 210,000 Btu/h	$\geq 4,000$ Btu/h/gal and < 10 gal	80% E_t	Section G.1 and G.2 of ANSI Z21.10.3
	> 210,000 Btu/h	$\geq 4,000$ Btu/h/gal and ≥ 10 gal	78% E_t ($Q/800 + 110\sqrt{V}$)SL, Btu/h	
Hot water supply boilers, gas and oil	$\geq 300,000$ Btu/h and < 12,500,000 Btu/h	$\geq 4,000$ Btu/h/gal and < 10 gal	80% E_t	Section G.1 and G.2 of ANSI Z21.10.3
Hot water supply boilers, gas	$\geq 300,000$ Btu/h and < 12,500,000 Btu/h	$\geq 4,000$ Btu/h/gal and ≥ 10 gal	80% E_t ($Q/800 + 110\sqrt{V}$)SL, Btu/h	
Hot water supply boilers, oil	$\geq 300,000$ Btu/h and < 12,500,000 Btu/h	$\geq 4,000$ Btu/h/gal and > 10 gal	78% E_t ($Q/800 + 110\sqrt{V}$)SL, Btu/h	
Pool heaters, gas and oil	All	—	82% E_t	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160
Unfired storage tanks ^h	All	—	Minimum insulation requirement R-12.5 (h x ft ² x °F)/Btu	(none)

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

- Energy factor (EF) and thermal efficiency (E_t) are minimum requirements. In the EF equation, V is the rated volume in gallons.
- Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons and V_m is the measured volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.
- Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.
- Electric water heaters with an input rating of 12kW (40,950 Btu/h) or less that are designed to heat water to temperatures of 180°F or greater shall comply with the requirements for electric water heaters that have an input rating greater than 12 kW.
- A tabletop water heater is a water heater that is enclosed in a rectangular cabinet with a flat top surface not more than three feet (0.91 m) in height.
- 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 non-water 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."
- g. %/h is the energy consumed to replace the heat lost from the tank while on standby, expressed as a percentage of the total energy in the stored water per hour.
- h. In accordance with Section C404.6.1

C404.2.1 High input-rated service water heating systems for other than Group R-1 and R-2 occupancies. In new buildings where the combined input rating of the water-heating equipment serving other than Group R-1 and R-2 occupancies installed in a building is equal to or greater than 1,000,000 Btu/h (293 kW), the combined input-capacity-weighted-average efficiency of water-heating equipment shall be no less than the following for each water heating fuel source:

1. Electric: A rated COP of not less than 2.0. For air-source heat pump equipment, the COP rating will be reported at the design leaving heat pump water temperature with an entering air temperature of 60°F (15.6°C) or less.
2. Fossil Fuel: A rated E_t of not less than 90 percent as determined by the applicable test procedures in Table C404.2.

<p>[Jurisdiction] Informative Note. Section C404.2.1 will remain in force only until December 31, 2021.</p>
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Exceptions:

1. Permits applied for on or after January 1, 2022.

- ((4)) 2. Where not less than 25 percent of the annual service water-heating requirement is provided from any of the following sources:
 - ((4.4)) 2.1. Renewable energy generated on site that is not being used to satisfy another requirement of this code; or
 - ((4.2)) 2.2. Site recovered energy that is not being used to satisfy other requirements of this code.
- ((2)) 3. Redundant equipment intended to only operate during equipment failure or periods of extended maintenance.
- ((3)) 4. Electric resistance heated systems installed as part of an *alteration* where the water heating equipment is installed at the grade level in a building with a height of four stories or greater.
- ((4)) 5. Hot water heat exchangers used to provide service water heating from a district utility (steam, heating hot water).
- ((5)) 6. Water heaters provided as an integral part of equipment intended to only heat or boost the heat of water used by that equipment.

((6)) Z. For electric heat systems, supplemental water heaters not meeting this criteria that function as auxiliary heating only when the outdoor temperature is below 32°F (0°C) or when a defrost cycle is required are not required to have a rated COP of 2.0. Such systems shall be sized and configured to lock out electric resistance or fossil fuel heating from operation when the outdoor temperature is above 32°F (0°C) unless the system is in defrost operation.

8. Electric instantaneous water heaters that serve toilet room handwashing lavatory faucets or kitchenette sink faucets without service water heating circulation systems and without water storage.

C404.2.2 High input-rated service water heating system for Group R-1 and R-2 occupancies.

[Jurisdiction] Informative Note. Section C404.2.2 will remain in force only until December 31, 2021.

In new buildings with over 1,000,000 Btu/h installed service water heating capacity serving Group R-1 and R-2 occupancies, at least 25 percent of annual water heating energy shall be provided from any combination of the following water heating sources:

1. Renewable energy generated on site that is not being used to satisfy other requirements of this code; or
2. Site-recovered energy that is not being used to satisfy other requirements of this code.

Exceptions:

1. Permits applied for on or after January 1, 2022.
2. Compliance with this section is not required if the combined input-capacity-weighted average equipment rating for each service water heating fuel source type is not less than the following:
 - 2.1. Electric Resistance: An electric resistance water heater with a rating of 105% of the rated efficiency of Table C404.2.
 - 2.2. Electric Heat Pump (10 CFR Part 430): A heat pump water heater rated in accordance with 10 CFR Part 430 with a rating of 105% of the rated efficiency of Table C404.2.
 - 2.3. Electric Heat Pump (not listed in accordance with 10 CFR Part 430): A heat pump water heater not rated in accordance with 10 CFR Part 430 shall have a COP of not less than 2.0. For air-source heat pump equipment the COP rating will be reported at the design leaving heat pump water temperature with an entering air temperature of 60°F (15.6°C) or less. Supplemental water heaters not meeting the above criteria that function as auxiliary heating only when the outdoor temperature is below 32°F (0°C) or when a defrost cycle is required are not required to have a rated COP of 2.0. Such systems shall be sized and configured to lock out electric resistance or fossil fuel heating from operation when the outdoor temperature is above 32°F (0°C) unless the system is in defrost operation.
 - 2.4. Fossil Fuels: A rated E_i of not less than 90% as determined by the applicable test procedures in Table C404.2.
 - 2.5. Hot water heat exchangers used to provide service water heating from a district utility (steam, heating hot water).

C404.2.3 Group R-1 and R-2 occupancies with central service water heating systems. In buildings with central service water heating systems serving four or more Group R-1 or R-2 dwelling or sleeping units, the primary water heating equipment shall not use fossil fuel combustion or electric resistance. Service hot water shall be provided by an 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 in compliance with Section C404.2.3.4.

Exceptions.

1. Permits applied for prior to January 1, 2022.
2. Solar thermal, wastewater heat recovery, other approved waste heat recovery, ground source heat pump, watersource heat pump system 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 meeting the requirements of the Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specifications for central service water heating systems.

[Jurisdiction] Informative Note: As of the publication of this code, publication of the NEEA AWHS for central service water heating systems is still pending. See <https://neea.org/resources/advanced-water-heating-specification> for updated information.

C404.2.3.1 Primary heat pump system sizing. The system shall include a primary service minimum output at 40°F outdoor air temperature that provides sufficient hot water for R-1 and/or R-2 occupancy uses as calculated using the equipment manufacturer's selection criteria or another *approved* methodology. Air source heat pumps shall be sized to deliver no less than 50 percent of the calculated demand for hot water production during the peak demand period when entering air temperature is 24°F.

Exception. 50 percent sizing at 24°F is not required for 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 at any time.

[Jurisdiction] Informative Note: Estimates of the appropriate heat pump system sizing and hot water storage volume for HPHW systems, calculated per bedroom or per occupant, vary widely, depending on type of use, output capacity of the heat pumps, and other factors.

C404.2.3.2 Primary hot water storage sizing. The system shall provide sufficient hot water, as calculated using a *approved* methodology, to satisfy peak demand period requirements.

C404.2.3.3. System Design. The service water heating system shall be configured to conform to one of the following provisions.

1. For *single-pass* HPWHs, *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 or a separate dedicated heat pump system.
2. For *multi-pass* HPWHs, recirculated *temperature maintenance* water is permitted to be returned to the primary water storage tanks for reheating.

C404.2.3.3.1 Mixing valve. A thermostatic mixing valve capable of supplying hot water to the building at the user temperature set point 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.

C404.2.3.4. Supplemental Water Heaters. Total supplemental electric resistance water heating equipment shall not have an output capacity greater than the primary water heating equipment at

40°F entering air temperature. Supplemental electric resistance heating is permitted for the following uses:

1. *Temperature maintenance* of heated-water circulation systems, physically separate from the primary service water heating system. *Temperature maintenance* heating capacity shall be no greater than the primary water heating capacity at 40°F.
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:
 - a. The supplemental heating capacity is no greater than the primary service water heating capacity at 40°F.
 - b. 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, and the primary HPWH compressor continues to operate together with the supplemental heating when the entering air temperature is between 17°F and 40°F.
 - c. The primary water heating equipment cannot satisfy the system load due to equipment failure or entering air temperature below 40°F.
5. Supplemental heating downstream from a *multi-pass* HPWH system.
6. Stand-alone electric water heaters serving single zones not served by the central water heating system.

C404.2.3.5 Alarms. 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.

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	((2)) 8	43
5/8	2	((4)) 8	32
3/4	3	0.5	21
7/8	4	0.5	16
1	5	0.5	13
1 1/4	8	0.5	8
1 1/2	11	0.5	6
2 or larger	18	0.5	4

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 ~~((these))~~ such 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.

C404.6.1 Storage tank insulation. Unfired storage tanks used to store service hot water at temperatures above 130°F 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 increase in stored water temperature above 130°F. Such additional insulation is also permitted to be integral to the tank. The insulation is permitted to be discontinuous at structural supports.

C404.7.1 Circulation systems. Heated-water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe. Gravity and thermosyphon circulation systems shall be prohibited. Controls shall start the pump based on the identification of a demand for hot water within the occupancy , according to the requirements of Sections C404.7.1.1 and C404.7.1.2.

C404.7.1.2 Multiple riser systems. Where the circulation system serves multiple domestic hot water risers or piping zones, controls shall be provided such that they can be set to switch off the pump during extended periods when hot water is not required. System shall include means for balancing the flow rate through each individual hot water supply riser or piping zone. For heated water circulation systems that have multiple risers and use a variable flow circulation pump, each riser 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.

C404.7.3.1 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.

Exception. Where piping is centered within a wall, ceiling, or floor framing cavity with a depth at least 4" 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 are not permitted. ~~((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))~~

C404.11.1 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 db, 44.2°F wb outdoor air and 80°F entering water, determined in accordance with ((ASHRAE Standard 146)) AHRI Standard 1160, Performance Rating of Heat Pump Pool Heaters. 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.

SECTION C405

ELECTRICAL POWER AND LIGHTING SYSTEMS

C405.1 General. This section covers 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. Receptacles shall be controlled according to Section C405.10. Controlled receptacles and lighting systems shall be commissioned according to Section C405.12. Solar readiness shall be provided according to Section C411 and renewable energy shall be provided according to Section C412.

Dwelling units within multi-family buildings shall comply with Sections C405.1.1 and C405.7. All other *dwelling units* in dormitory, hotel and other residential occupancies that are not classified as multi-family residential occupancies shall comply with Section C405.2.5 and Section C405.1.1 or Section C405.4. *Sleeping units* shall comply with Section C405.2.5 and Section C405.1.1 or Section C405.4.

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.

C405.2 Lighting controls. Lighting systems shall be provided with controls that comply with ~~((one))~~ item 1 or item 2 of the following:

1. Lighting controls as specified in Sections C405.2.1 through C405.2.7. In addition, any contiguous open office area larger than 5,000 square feet shall have its general lighting controlled by either:
 - 1.1. An enhanced digital lighting control system conforming to the requirements of Section C406.4; or
 - 1.2. Luminaire-level lighting controls (LLLC) conforming to the requirements in Item 2 of this subsection.
2. Luminaire level lighting controls (LLLC) for all areas and lighting controls specified in Sections C405.2.1, C405.2.3 and C405.2.5. The LLLC luminaires shall be independently configured to:
 - 2.1. Monitor occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.

2.2. Monitor ambient light, 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*.

2.3. For each control strategy, be capable of configuration and re-configuration of performance parameters including: bright and dim set points, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configuration.

Exception to Section C405.2: Except for specific application controls required by Section C405.2.5, lighting controls are not required for the following:

1. Areas designated as security or emergency areas that are required to be continuously lighted.
2. Means of egress illumination serving the exit access that does not exceed ~~((0.02))~~ 0.01 watts per square foot of building area is exempt from this requirement.
3. Emergency egress lighting that is normally off.
4. Industrial or manufacturing process areas, as may be required for production and safety.

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 m²) 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 m²) within the open plan office space.
2. Automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.
3. General lighting power in each control zone is reduced by not less than 80 percent of the full zone general lighting power within 20 minutes of all occupants leaving that control zone. Control functions that switch control zone lights completely off when the zone is unoccupied meet this requirement.
4. *Daylight responsive controls* activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.
5. Lighting controls in open plan office areas larger than 5,000 square feet must also comply with Section C405.2(1).

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.
5. Include an override switching device that complies with the following:
 - 1.1 The override switch shall be a manual control.
 - 1.2 The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.
 - 1.3 Any individual override switch shall control the lighting for an area not larger than ~~((5,000))~~ 2,500 square feet ~~((465))~~ 232 m².

2. 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.

Exception: Within mall concourses, auditoriums, sales areas, manufacturing facilities, pools, gymnasiums, skating rinks and sports arenas:

- 1.1. The time limit shall be permitted to be greater than 2 hours provided the switch is a *captive key device*.
- 1.2. The area controlled by the override switch shall not be limited to 5,000 square feet (465 m²) provided that such area is less than 20,000 square feet (1860 m²).

C405.2.3 Manual controls. Stairwells and parking garages are not permitted to use manual switches. All other 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.

C405.2.3.1 Light reduction controls. Manual controls shall be configured to provide light reduction control that allows the occupant to reduce the connected lighting load between 30 and 70 percent. Lighting reduction shall be achieved by one of the following *approved* methods:

1. Controlling all lamps or luminaires.
2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps.
3. Switching the middle lamp in three-lamp luminaires independently of the outer lamps.
4. Switching each luminaire or each lamp.

Exceptions:

1. Light reduction controls are not required in *daylight zones* with *daylight responsive controls* complying with Section C405.2.4.
2. Where provided with manual control, the following areas are not required to have light reduction control:
 - 2.1. Spaces that have only one luminaire with a rated power of less than 100 watts.
 - 2.2. Spaces that use less than 0.6 watts per square foot (6.5 W/m²).
 - 2.3. Lighting in corridors, lobbies, electrical rooms, restrooms, storage rooms, airport concourse baggage areas, dwelling and sleeping rooms and mechanical rooms.

C405.2.4 Daylight responsive controls. *Daylight responsive controls* complying with Section C405.2.4.1 shall be provided to control the lighting within *daylight zones* in the following spaces:

1. Sidelit zones as defined in Section C405.2.4.2 with more than two general lighting fixtures within the combined primary and secondary sidelit zones.

2. Toplit zones as defined in Section C405.2.4.3 with more than two general lighting fixtures within the *daylight zone*.

Exception: *Daylight responsive controls* are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Lighting that is required to have specific application control in accordance with Section C405.2.5.
3. Sidelit zones on the first floor above grade in Group A-2 and Group 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.
4. *Daylight zones* where the total proposed lighting power density is less than 35 percent of the lighting power allowance per Section C405.4.2.

C405.2.4.1 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 zones shall be controlled independently of lights in secondary sidelit zones in accordance with Section C405.2.4.2.

Exception: Spaces enclosed by walls or ceiling height partitions with no more than three general lighting fixtures may have combined *daylight zone* control of primary and secondary *daylight zones* provided *uniform illumination* can be achieved.

2. Lights in toplit zones in accordance with Section C405.2.4.3 shall be controlled independently of lights in sidelit zones in accordance with Section C405.2.4.2.
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 be configured to completely shut off all controlled lights in that zone.
6. Lights in sidelit zones in accordance with Section C405.2.4.2 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 two light fixtures in each space are permitted to be controlled together with lighting in a *daylight zone* facing a different cardinal orientation.

7. Incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes.
8. The maximum area a single *daylight responsive control* device serves shall not exceed 2,500 square feet (232 m²) and no more than 60 lineal feet (18.3 m) of facade.
9. 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.
10. *Daylight responsive controls* shall be set initially to activate at 30 footcandles (323 lux) or not more than 110 percent of the illuminance level specified on the construction documents.

C405.2.5 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. Display and accent.
 - 1.2. Lighting in display cases.
 - 1.3. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting.
 - 1.4. Lighting equipment that is for sale or demonstration in lighting education.
2. *Sleeping units* shall have control devices or systems configured to automatically switch off all permanently installed luminaires and switched receptacles, including those installed within furniture, within 20 minutes after all occupants have left the unit.

Exceptions:

1. Lighting and switched receptacles controlled by card key controls.
 2. Spaces where patient care is directly provided.
3. Permanently installed luminaires within *dwelling units* shall be provided with controls complying with either Section C405.2.1.1 or C405.2.3.1.
 4. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space. ~~((Each control zone shall be no greater than the area served by a single luminaire or 4,000 square feet, whichever is larger.))~~
 5. Luminaires serving the exit access and providing means of egress illumination required by Section 1006.1 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 ~~((0.02))~~ 0.01 watts per square foot of building area is exempt from this requirement.

C405.2.6.2 Facade and landscape lighting shutoff. Building facade 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 business closing to not earlier than one hour before business opening, whichever is less))~~ between midnight or business/facility closing, whichever is later, and 6 a.m. or business/facility opening, whichever is earlier.

Exception: Areas where an *automatic* shutoff would endanger safety or security.

C405.4.1 Total connected interior lighting power. The total connected interior lighting power shall be determined in accordance with Equation 4-10.

As an option, in areas of the building where all interior lighting equipment is fed from dedicated lighting branch circuits, the total connected interior lighting power is permitted to be calculated as the sum of the capacities of the lighting branch circuits serving those areas. For the purposes of this section, the connected interior lighting power of a 20-ampere circuit is considered to be 16 amperes.

and that of a 15-ampere circuit is 12 amperes. Use of this alternative and the boundaries of the applicable areas shall be clearly documented on the electrical construction documents.

(Equation 4-10)

$$TCLP = [LVL + BLL + TRK + POE + \text{Other}]$$

Where:

$TCLP$ = Total connected lighting power (watts)
 P

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. Emergency lighting automatically off during normal building operation.
3. 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. General area lighting power in industrial and manufacturing occupancies dedicated to the inspection or quality control of goods and products.
6. Mirror lighting in dressing rooms.

7. Task lighting for medical and dental purposes that is in addition to general lighting and controlled by an independent control device.
8. Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting and controlled by an independent control device.
9. Lighting for theatrical purposes, including performance, stage, film production and video production.
10. Lighting for photographic processes.
11. Lighting integral to equipment or instrumentation and installed by the manufacturer.
12. ~~((Task lighting))~~ Lighting for plant growth or maintenance where the lamp ((efficacy is not less than 90 lumens per watt)) has a tested photosynthetic photon efficacy (PPE) per watt of not less than 1.70 micromoles per joule for greenhouses and 1.90 micromoles per joule for indoor plant growth spaces.
13. Advertising signage or directional signage.
14. Lighting for food warming.
15. Lighting equipment that is for sale.
16. Lighting demonstration equipment in lighting education facilities.
17. Lighting *approved* because of safety considerations.
18. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
19. Furniture mounted supplemental task lighting that is controlled by *automatic* shutoff.
20. Exit signs.
21. Lighting used for aircraft painting.
22. Germicidal lighting that is in addition to and controlled independently from the general lighting.

C405.4.2.2 Space-by-space method. For the Space-by-Space Method, the interior lighting power allowance is determined by multiplying the floor area of each space times the value for the space type in Table C405.4.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Tradeoffs among spaces other than covered parking areas are permitted.

Each area enclosed by partitions that are 80 percent of the ceiling height or taller shall be considered a separate space and assigned the appropriate space type from Table C405.4.2(2). If a space has multiple functions where more than one space type is applicable, that space shall be broken up into smaller subspaces, each using their own space type. Any of these subspaces that are smaller in floor area than 20 percent of the *enclosed space* and less than 1,000 square feet need not be broken out separately.

TABLE C405.4.2(1)

INTERIOR LIGHTING POWER ALLOWANCES: BUILDING AREA METHOD

Building Area Type	((LPD (w/ft²)))	<u>LPD (w/ft²)</u>
Automotive facility	((0.64))	0.58
Convention center	((0.64))	0.58
Court house	((0.79))	0.71
Dining: Bar lounge/leisure	((0.79))	0.71
Dining: Cafeteria/fast food	((0.72))	0.65
Dining: Family	((0.71))	0.64
Dormitory ^{a,b}	((0.46))	0.41
Exercise center	((0.67))	0.60
Fire station ^a	((0.54))	0.49
Gymnasium	((0.75))	0.68
Health care clinic	((0.70))	0.63
Hospital ^a	((0.84))	0.84
Hotel/motel ^{a,b}	((0.56))	0.50
Library	((0.83))	0.75
Manufacturing facility	((0.82))	0.74
Motion picture theater	((0.44))	0.40
Multifamily ^c	((0.41))	0.37
Museum	((0.55))	0.50
Office	((0.64))	0.58
Parking garage	((0.14))	0.13
Penitentiary	((0.65))	0.65
Performing arts theater	((0.84))	0.76
Police station	((0.66))	0.60
Post office	((0.65))	0.59
Religious building	((0.67))	0.60
Retail	((0.84))	0.76
School/university	((0.70))	0.63

Building Area Type	((LPD (w/ft²)))	<u>LPD (w/ft²)</u>
Sports arena	((0.62))	<u>0.54</u>
Town hall	((0.69))	<u>0.62</u>
Transportation	((0.50))	<u>0.45</u>
Warehouse	((0.40))	<u>0.36</u>
Workshop	((0.94))	<u>0.82</u>

- a. Where sleeping units are excluded from lighting power calculations by application of Section R404.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.
- b. Where *dwelling units* are excluded from lighting power calculations by application of Section R404.1, neither the area of the *dwelling units* nor the wattage of lighting in the *dwelling units* is counted.
- c. *Dwelling units* are excluded. Neither the area of the *dwelling units* nor the wattage of lighting in the dwelling units is counted.

TABLE C405.4.2(2)

INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

Common Space-by-Space Types ^a	((LPD- (w/ft²)))	<u>LPD</u> <u>(w/ft²)</u>
Atrium - Less than 20 feet in height	((0.39))	<u>0.35</u>
Atrium - 20 to 40 feet in height	((0.48))	<u>0.43</u>
Atrium - Above 40 feet in height	((0.60))	<u>0.54</u>
Audience/seating area - Permanent		
In an auditorium	((0.64))	<u>0.55</u>
In a gymnasium	((0.23))	<u>0.21</u>
In a motion picture theater	((0.27))	<u>0.24</u>
In a penitentiary	((0.67))	<u>0.67</u>
In a performing arts theater	((1.16))	<u>1.04</u>
In a religious building	((0.72))	<u>0.65</u>
In a sports arena	((0.33))	<u>0.30</u>
Otherwise	((0.23))	<u>0.21</u>
Banking activity area	((0.64))	<u>0.55</u>
Breakroom (see lounge/breakroom)		
Classroom/lecture hall/training room		
In a penitentiary	((0.89))	<u>0.89</u>
Otherwise ^m	((0.74))	<u>0.64</u>
Computer room, data center	((0.94))	<u>0.85</u>
Conference/meeting/multipurpose	((0.97))	<u>0.87</u>
Confinement cell	((0.70))	<u>0.63</u>
Copy/print room	((0.34))	<u>0.28</u>
Corridor		
In a facility for the visually impaired (and not used primarily by the staff) ^b	((0.74))	<u>0.71</u>
In a hospital	((0.74))	<u>0.71</u>
In a manufacturing facility	((0.44))	<u>0.37</u>
Otherwise ^{c,q}	((0.44))	<u>0.37</u>
Courtroom ^c	((1.20))	<u>1.08</u>
Dining area		
In a penitentiary	((0.42))	<u>0.42</u>

In a facility for the visually impaired (and not used primarily by the staff) ^b	((1.27))	<u>1.27</u>
In a bar/lounge or leisure dining ⁿ	((0.86))	<u>0.77</u>
In cafeteria or fast food dining	((0.40))	<u>0.36</u>
In a family dining area ⁿ	((0.60))	<u>0.54</u>
Otherwise	((0.43))	<u>0.39</u>
Electrical/mechanical	((0.43))	<u>0.39</u>
Emergency vehicle garage	((0.52))	<u>0.47</u>
Food preparation	((1.09))	<u>0.98</u>
Guest room ^{a,b}	((0.41))	<u>0.37</u>
Laboratory	((1.14))	<u>1.00</u>
In or as a classroom	((1.33))	<u>1.20</u>
Otherwise		
Laundry/washing area	((0.53))	<u>0.48</u>
Loading dock, interior	((0.88))	<u>0.79</u>
Lobby ^c		
In a facility for the visually impaired (and not used primarily by the staff) ^b	((1.69))	<u>1.69</u>
For an elevator	((0.65))	<u>0.59</u>
In a hotel	((0.51))	<u>0.46</u>
In a motion picture theater	((0.23))	<u>0.21</u>
In a performing arts theater	((1.25))	<u>1.13</u>
Otherwise	((0.84))	<u>0.76</u>
Locker room	((0.52))	<u>0.47</u>
Lounge/breakroom ⁿ	((0.42))	<u>0.42</u>
In a health care facility	((0.59))	<u>0.53</u>
Otherwise		
Office		
Enclosed ≤ 250	((0.74))	<u>0.67</u>
Enclosed > 250	((0.66))	<u>0.59</u>
Open plan	((0.61))	<u>0.55</u>
Parking area, interior	((0.15))	<u>0.14</u>
Pharmacy area	((1.66))	<u>1.66</u>
Restroom		
In a facility for the visually impaired (and not used primarily by the staff) ^b	((1.26))	<u>1.26</u>
Otherwise ⁿ	((0.63))	<u>0.57</u>

Sales area	((1.05))	<u>0.95</u>
Seating area, general	((0.23))	<u>0.21</u>
((Stairway (see space containing stairway)))		
Stairwell ⁿ	((0.49))	<u>0.44</u>
Storage room		
< 50 ft2	((0.54))	<u>0.46</u>
50-100 ft2	((0.38))	<u>0.34</u>
All other storage	((0.38))	<u>0.34</u>
Vehicular maintenance	((0.60))	<u>0.54</u>
Workshop	((1.26))	<u>1.13</u>

TABLE C405.4.2(2) (continued)

INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

Building Specific Space-by-Space Types ^a	LPD (w/ft²)	<u>LPD (w/ft²)</u>
Automotive (see vehicular maintenance)	((0.60))	
Convention center - Exhibit space	((0.61))	<u>0.55</u>
Dormitory living quarters ^{a,b}	((0.50))	<u>0.45</u>
Facility for the visually impaired ^b		
In a chapel (and not used primarily by the staff)	((0.70))	<u>0.70</u>
In a recreation room (and not used primarily by the staff)	((1.77))	<u>1.77</u>
Fire stations ^g		
Sleeping quarters	((0.23))	<u>0.21</u>
Gymnasium/fitness center		
In an exercise area	((0.90))	<u>0.83</u>
In a playing area	((0.85))	<u>0.77</u>
Health care facility		
In an exam/treatment room	((1.40))	<u>1.40</u>
In an imaging room	((0.94))	<u>0.94</u>
In a medical supply room	((0.62))	<u>0.62</u>
In a nursery	((0.92))	<u>0.92</u>
In a nurse's station	((1.17))	<u>1.17</u>
In an operating room	((2.26))	<u>2.26</u>
In a patient room ^g	((0.68))	<u>0.68</u>
In a physical therapy room	((0.91))	<u>0.91</u>
In a recovery room	((1.25))	<u>1.25</u>
Library ^f		
In a reading area ⁿ	((0.96))	<u>0.86</u>
In the stacks	((1.10))	<u>0.99</u>
Manufacturing facility		

In a detailed manufacturing area	((0.80))	<u>0.72</u>
In an equipment room	((0.76))	<u>0.68</u>
In an extra high bay area (greater than 50-foot floor-to-ceiling height)	((1.42))	<u>1.28</u>
In a high bay area (25 - 50-foot floor-to-ceiling height)	((1.24))	<u>1.12</u>
In a low bay (< 25-foot floor-to-ceiling height)	((0.86))	<u>0.77</u>
Museum		
In a general exhibition area	((0.31))	<u>0.28</u>
In a restoration room	((1.10))	<u>0.99</u>
Performing arts theater dressing/fitting room	((0.41))	<u>0.37</u>
Post office - Sorting area	((0.76))	<u>0.69</u>
Religious buildings		
In a fellowship hall ⁿ	((0.54))	<u>0.49</u>
In a worship/pulpit/choir area ⁿ	((0.85))	<u>0.77</u>
Retail facilities		
In a dressing/fitting room	((0.51))	<u>0.46</u>
In a mall concourse	((0.82))	<u>0.74</u>
Sports arena - Playing area		
For a Class 1 facility ⁱ	((2.94))	<u>2.94</u>
For a Class 2 facility ^j	((2.01))	<u>2.01</u>
For a Class 3 facility ^k	((1.30))	<u>1.30</u>
For a Class 4 facility ^l	((0.86))	<u>0.86</u>
Transportation		
In a baggage/carousel area	((0.39))	<u>0.35</u>
In an airport concourse	((0.25))	<u>0.23</u>
At a terminal ticket counter ⁿ	((0.51))	<u>0.46</u>
Warehouse - Storage area		
For medium to bulky palletized items	((0.33))	<u>0.30</u>

For smaller, hand-carried items	((0.69))	0.62
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Keys to Table C405.4.2(2)

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 11 W/m².

Footnotes to Table C405.4.2(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. For spaces in which lighting is specified to be installed in addition to, and controlled separately from, the general lighting for the purpose of highlighting art or exhibits, provided that the additional lighting power shall not exceed 0.5 W/ft² of such spaces.
- d. RESERVED.
- e. RESERVED.
- f. RESERVED.
- g. Where sleeping units are excluded from lighting power calculations by application of Section R404.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.
- h. Where *dwelling units* are excluded from lighting power calculations by application of Section R404.1, neither the area of the *dwelling units* nor the wattage of lighting in the *dwelling units* is counted.
- i. Class I facilities consist of professional facilities; and semi-professional, collegiate or club facilities with seating for 5,000 or more spectators.
- j. 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.
- k. Class III facilities consist of club, amateur league and high school facilities with seating for 2,000 or fewer spectators.
- l. Class IV facilities consist of elementary school and recreational facilities; and amateur league and high school facilities without provisions for spectators.
- m. For classrooms, additional lighting power allowance of 4.50 W/lineal foot of white or chalk boards for directional lighting dedicated to white or chalk boards.
- n. Additional lighting power allowance of 0.30 W/square foot for ornamental lighting. Qualifying ornamental lighting includes luminaires such as chandeliers, sconces, lanterns, neon and cold cathode, light emitting diodes, theatrical projectors, moving lights and light color panels when any of those lights are used in a decorative manner that does not serve as display lighting or general lighting.
- o. For scientific laboratories, additional lighting power allowance of 0.35 Watts per square foot for specialized task work – lighting that provides for small-scale, cognitive or fast performance visual tasks; lighting required for operating specialized equipment associated with pharmaceutical/laboratorial activities.
- p. For offices, additional lighting power allowance of 0.20 W/square foot for portable lighting, which includes under shelf or furniture-mounted supplemental task lighting qualifies when controlled by a time clock or an occupancy sensor.
- q. For corridors, additional lighting power allowance of 0.25 W/square foot for display lighting and decorative lighting where provided for aesthetic purposes. Decorative lighting fixtures in corridors are also permitted to provide general lighting. This additional allowance is not permitted to be used together with the allowance in footnote c for highlighting art or exhibits.

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 and automatically controlled separately from the general lighting, to be turned off during nonbusiness hours. This additional power shall be used only for the specified luminaires and shall not be used for any other purpose. An increase in the interior lighting power allowance is permitted for lighting equipment to be installed in sales areas specifically to highlight merchandise. The additional lighting power shall be determined in accordance with Equation 4-11:

$$\text{Additional interior lighting power allowance} = 500 \text{ watts} + (\text{Retail Area 1} \times 0.45 \text{ W/ft}^2) + (\text{Retail Area 2} \times 0.45 \text{ W/ft}^2) + (\text{Retail Area 3} \times 1.05 \text{ W/ft}^2) + (\text{Retail Area 4} \times 1.87 \text{ W/ft}^2)$$

(Equation 4-11)

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*.

C405.5.2 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.

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.
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 *dwelling units*, where the lighting complies with Section R404.1.

C405.5.3 Exterior lighting power allowance. The total exterior lighting power allowance is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated by lighting that is powered through the energy service for the building. Covered parking garage lighting is not considered exterior lighting for the purposes of this calculation. Lighting power allowances are

as specified in Table C405.5.3(2). The lighting zone for the building exterior is determined in accordance with Table C405.5.3(1) unless otherwise specified by the *code official*.

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)) <u>Not used</u>	((High activity commercial districts in major metropolitan areas as designated by the local land use planning authority))

C405.5.5 Full cutoff luminaires. For open parking and outdoor areas and roadways, luminaires mounted more than 15 feet above the ground shall have a luminaire light distribution in which zero candela intensity occurs at an angle of 90 degrees above nadir, and all greater angles from nadir.

C405.7.1 Electric receptacles at dwelling unit gas appliances. Where *dwelling unit* appliances are served by natural gas, an electrical receptacle 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 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 electrical code 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. Each gas domestic water heater location shall be served by a dedicated 240/208 volt, 30-amp outlet 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.

Fractional hp fan motors that are 1/12 hp or greater and 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(12)))~~ C403.3.2(13), 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.

C405.9.2 Escalators and moving walks. Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have *automatic* controls configured to reduce speed to the minimum permitted speed in accordance with ASME A17.1/CSA B44 or applicable local code when not conveying passengers.

Exception: A variable voltage drive system that reduces operating voltage in response to light loading conditions ~~((may))~~ is permitted to be provided in ~~((place))~~ lieu of the variable speed function.

C405.10 Controlled receptacles. At least 50 percent of all 125 volt 15- and 20-ampere receptacles installed in private offices, open offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, individual workstations and classrooms, including those installed in modular partitions and modular office workstation systems, shall be controlled as required by this section. ~~((In rooms larger than 200 square feet (19 m²),))~~ Either split receptacles shall be provided, with the top receptacle(s) controlled, or a controlled receptacle shall be located within ((72)) 12 inches (((4-8)) 0.3 m) of each uncontrolled receptacle. *Controlled receptacles* shall be visibly differentiated from standard receptacles using the standard symbol required by the Electrical Code and shall be controlled by one of the following *automatic control devices*:

1. An occupant sensor that turns receptacle power off when no occupants have been detected for a maximum of 20 minutes.
2. 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 not to exceed 5,000 square feet (465 m²) and not to exceed one full floor. The device shall be capable of being overridden for periods of up to two hours by a timer in a location with access to occupants. Any individual override switch shall control the *controlled receptacles* for a maximum area of 5,000 square feet (465 m²). Override switches *for controlled receptacles* are permitted to control the lighting within the same area.

Exceptions:

1. Receptacles designated for specific equipment requiring 24-hour operation, for building maintenance functions, or for specific safety or security equipment are not required to be controlled by an *automatic control device* and are not required to be located within ~~((72))~~ 12 inches of a *controlled receptacle*.
2. Within a single modular office workstation, non-controlled receptacles are permitted to be located more than 12 inches, but not more than 72 inches, from the controlled receptacles serving that workstation.

[Jurisdiction] Informative Note: The requirements of this section also apply to rooms and spaces that have substantially similar functions to those listed even when they are labeled with different names. For example, an area designed for office functions that is labeled “work room,” or a room used as a classroom that is labeled “student learning” would each be required to provide *controlled receptacles*.

SECTION C406

EFFICIENCY PACKAGES

C406.1 Additional energy efficiency credit requirements. New buildings and changes in space conditioning, *change of occupancy* and building *additions* in accordance with Chapter 5 shall comply with sufficient packages from Table C406.1 so as to achieve a minimum number of ~~((six))~~ 8 credits. Each area shall be permitted to apply for different packages provided all areas in the building comply with the requirement for ~~((six))~~ 8 credits. Areas included in the same permit within mixed use buildings shall be permitted to demonstrate compliance by an area weighted average number of credits by building occupancy achieving a minimum number of ~~((six))~~ 8 credits.

Exceptions:

1. Low energy spaces in accordance with Section C402.1.1.1 and equipment buildings in accordance with Section C402.1.2 shall comply with sufficient packages from Table C406.1 to achieve a minimum number of ~~((three))~~ 4 credits.
2. Building additions that have less than 1,000 square feet of *conditioned floor area* shall comply with sufficient packages from Table C406.1 to achieve a minimum number of ~~((three))~~ 4 credits.

C406.1.1 Tenant spaces. Initial tenant improvement shall comply with sufficient packages from Table C406.1 to achieve a minimum number of ~~((six))~~ 8 credits when the space is fully built out. In buildings with multiple tenant spaces, each tenant space is permitted to apply for different packages provided all areas in the building comply with the requirement for ~~((six))~~ 8 credits when the space is fully built-out. This provision only applies to the initial buildout of a tenant space.

[Jurisdiction] Informative Note: In this section “tenant space” means any conditioned area within a new building that is constructed for first occupancy under a separate permit from the shell and core permits.

TABLE C406.1
EFFICIENCY PACKAGE CREDITS

Code Section	Commercial Building Occupancy					
	Group R-1	Group R-2	Group B	Group E	Group M	All Other
	Additional Efficiency Credits					
1. More efficient HVAC performance in accordance with Section C406.2	2.0	3.0	3.0	2.0	1.0	2.0
2. Reduced lighting power: Option 1 in accordance with Section C406.3.1	1.0	1.0	2.0	2.0	3.0	2.0
3. Reduced lighting power: Option 2 in accordance with Section C406.3.2 ^a	2.0	3.0	4.0	4.0	6.0	4.0
4. Enhanced lighting controls in accordance with Section C406.4	NA	NA	1.0	1.0	1.0	1.0
5. On-site supply of renewable energy in accordance with C406.5	3.0	3.0	3.0	3.0	3.0	3.0
5.1. 1/3 of renewable energy required by C406.5	1.0	1.0	1.0	1.0	1.0	1.0
5.2. 2/3 of renewable energy required by C406.5	2.0	2.0	2.0	2.0	2.0	2.0
6. Dedicated outdoor air system in accordance with Section C406.6 ^b	4.0	(4.0) 2.0 ^a	4.0	NA	NA	4.0
7. High performance dedicated outdoor air system in accordance with Section C406.7	4.0	4.0	4.0	4.0	4.0	4.0
8. High-efficiency service water heating in accordance with Sections C406.8.1 and C406.8.2	4.0 NA after 1/1/2022	5.0 NA after 1/1/2022	NA	NA	NA	8.0
9. High performance service water heating in ((multi-family)) R-1 and R-2 buildings in accordance with Section C406.9	7.0 prior to 1/1/2022 5.0 after 1/1/2022	8.0 prior to 1/1/2022 5.0 after 1/1/2022	NA	NA	NA	NA
10. Enhanced envelope performance in accordance with Section C406.10 ^c	3.0	6.0	3.0	3.0	3.0	4.0
11. Reduced air infiltration in accordance with Section C406.11 ^c	1.0	2.0	1.0	1.0	1.0	1.0
((12. Enhanced commercial kitchen equipment in accordance with Section C406.12))	((5.0))	((NA))	((NA))	((NA))	((5.0))	((5.0- (Group A-2 only)))

a. Projects using this option may not use Item 2.

b. This option is not available to buildings subject to the prescriptive requirements of Section C403.3.5 or C403.6.

- c. Buildings or building areas that are exempt from thermal envelope requirements in accordance with Sections C402.1.1 and C402.1.2 do not qualify for this package.
- d. 4.0 credits, instead of 2.0 credits, are permitted to be applied to areas of R-2 occupancy buildings other than dwelling units, including corridors, lobbies and tenant amenity spaces, where those areas comply with the requirements for this credit.

C406.2 More efficient HVAC equipment 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, building area, occupancy type, or tenant space in accordance with Section C406.1.1, shall comply with Sections C406.2.1 through C406.2.3. ~~((For))~~ In addition, systems required to comply with Section C403.1.1, HVAC total system performance ratio, shall exceed the ((minimum requirement)) HVAC TSPR of the standard reference design by 10 percent. This credit shall not be utilized for low energy or semi-heated space conditioning categories.

~~((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. Stand-alone supply, return and exhaust fans shall comply with Section C406.2.3.))~~

C406.2.1 HVAC system selection. Equipment installed shall be types that are listed in Tables C403.3.2(1) through ~~((C403.3.2(12)))~~ C403.3.2(13) or a combination thereof. Electric resistance heating does not meet this requirement. No HVAC systems incorporating fossil fuel-fired equipment, or heat from district energy systems that are primarily heated by fossil fuel combustion, are permitted to utilize this credit.

~~((Exception: Allowed equipment not listed in Tables C403.3.2(1) through ((C403.3.2(12))) C403.3.2(13).))~~

- ~~1. Air to water heat pumps.~~
- ~~2. Heat recovery chillers.))~~

C406.2.2 Minimum equipment efficiency. Equipment shall exceed the minimum efficiency requirements listed in Tables C403.3.2(1) through ~~((C403.3.2(12)))~~ C403.3.2(13) by 15 percent, in addition to the requirements of Section C403. Where multiple performance requirements are provided, the equipment shall exceed all requirements by 15 percent.

Exceptions:

1. Equipment that is larger than the maximum capacity range indicated in Tables C403.3.2(1) through ~~((C403.3.2(12)))~~ C403.3.2(13) shall utilize the values listed for the largest capacity equipment for the associated equipment type shown in the table.
2. Equipment complying with the exception to Section C406.2.1 is not required to comply with the minimum equipment efficiency requirement.
3. Compliance may be demonstrated by calculating a total weighted average percentage for all heating and cooling equipment combined. All equipment shall have efficiency that is no less than 5 percent better than the minimum required efficiency in Tables C403.3.2(1) through ~~((C403.3.2(12)))~~ C403.3.2(13), and the resulting weighted average percentage for all equipment performance requirements shall exceed 15 percent. Calculation shall include heating and cooling capacities for all equipment, percentage better or worse than minimum required efficiency per Tables C403.3.2(1) through ~~((C403.3.2(12)))~~ C403.3.2(13) for each performance requirement (SEER, EER/IEER, COP, HSPF, E_h, E_c and AFUE), and the total weighted average efficiency percentage.
4. ~~((Hot water boilers with input capacity greater than 2,500,000 Btu/h shall be considered to comply with this section with a minimum thermal efficiency of 95 percent E_t per the test procedure in 10 CFR Part 431.))~~

C406.3 Reduced lighting power. Interior lighting within the whole building, building area, occupancy type, building addition or tenant space shall comply with Section C406.3.1 or C406.3.2. Dwelling units and sleeping units within the building shall comply with Section C406.3.3.

C406.3.3 Lamp fraction. No less than 95 percent of the permanently installed light fixtures in *dwelling units* and sleeping units shall be provided by high efficacy lamps with a minimum efficacy of 65 lumens per watt. Where the conditioned floor area of residential dwelling units or sleeping units is separated from other building occupancies or building areas for the purposes of the C406 area weighted credit calculation, these dwelling or sleeping unit areas receive the credit weighting for reduced lighting power Option 1, referencing Section C406.3.1, in Table C406.1.

C406.4 Enhanced digital lighting controls. ~~((Not))~~ Not less than 90 percent of the total installed interior lighting power within the whole building, building *addition* or tenant space shall comply with Section C406.4.1. Open office areas subject to Section C405.2, item 1 are not permitted to take credit for this option.

C406.4.1 Lighting controls function. Interior lighting shall be located, scheduled and operated in accordance with Section C405.2, and shall be configured with the following enhanced control functions:

1. Luminaires shall be configured for continuous dimming.
2. Each luminaire shall be individually addressed.

Exceptions to Item 2:

1. Multiple luminaires mounted on no more than 12 linear feet of a single lighting track and addressed as a single luminaire.
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. No more than eight luminaires within a *daylight zone* are permitted to be controlled by a single *daylight responsive control*.
4. Luminaires shall be controlled by a digital control system configured with the following capabilities:
 - 4.1. Scheduling and illumination levels of individual luminaires and groups of luminaires are capable of being reconfigured through the system.
 - 4.2. Load shedding.
 - 4.3. In open and enclosed offices, the illumination level of overhead general illumination luminaires are configured to be individually adjusted by occupants.
 - 4.4. Occupancy sensors and *daylight responsive controls* are capable of being reconfigured through the system.
5. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions required by this section.
6. These control functions shall be commissioned in accordance with Sections C408.1 and C408.3.

C406.5 On-site renewable energy. ((A)) In addition to the renewable energy required by Section C412 and to renewable energy used to comply with any other requirement of this code, a whole building, building addition, building area, occupancy type, or tenant space shall be provided with on-site renewable energy systems with a rated peak renewable energy generating capacity ((an annual production per square foot)) of no less than ((the value specified in Table C406.5)) 0.25 watts (or 0.85 BTU/h) per square foot of conditioned floor area based on the total conditioned floor area of the whole building, building addition or tenant space. The on-site renewable energy ((used in)) provided to

comply with this option shall be separate from on-site renewables ((used as part of Section C406.7)) provided to comply with C406.8 or used to qualify for any exception in this code.

((TABLE C406.5

ON-SITE RENEWABLE ENERGY SYSTEM RATING

(PER SQUARE FOOT)

Building Area Type	kBTU per year	kWh per year
Assembly	1.8	0.53
Dining	10.7	3.14
Hospital	9.6	1.06
Hotel/Motel	2.0	0.59
Multi-family residential	0.50	0.15
Office	0.82	0.24
Other	2.02	0.59
Retail	1.31	0.38
School/University	1.17	0.34
Supermarket	5.0	1.47
Warehouse	0.43	0.13))

C406.6 Dedicated outdoor air system (DOAS). No less than 90 percent of the total *conditioned floor area* of the whole building, **building area, occupancy type**, building *addition* or tenant space, excluding floor area of unoccupied spaces that do not require ventilation per the *International Mechanical Code*, shall be served by DOAS installed in accordance with Section C403.3.5. This option is not available to buildings subject to the prescriptive requirements of Section C403.3.5. **No HVAC systems incorporating fossil fuel-fired equipment, or heat from district energy systems that are primarily heated by fossil fuel combustion, are permitted to utilize this credit.**

C406.7 High performance dedicated outdoor air system (DOAS). A whole building, **building area, occupancy type**, building *addition* or tenant space which includes a DOAS complying with Section C406.6 shall also provide minimum sensible effectiveness of heat recovery of 80 percent and DOAS total combined fan power less than 0.5 W/cfm of outdoor air. For the purposes of this section, total combined fan power includes all supply, exhaust, recirculation and other fans utilized for the purpose of ventilation. **No HVAC systems incorporating fossil fuel-fired equipment, or heat from district energy systems that are primarily heated by fossil fuel combustion, are permitted to utilize this credit.**

C406.8 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 comply with Sections C406.8.1 and C406.8.2. **No service water heating systems incorporating fossil fuel-fired equipment, or heat from district energy systems that are primarily heated by fossil fuel combustion, are permitted to utilize this credit.**

C406.8.1 Building type. Not less than 90 percent of the *conditioned floor area* of the whole building, *building area*, *occupancy type*, *building addition* or tenant space shall be of the following types:

1. Group R-1: Boarding houses, hotels or motels. (Not applicable after 1/1/2022)
2. Group I-2: Hospitals, psychiatric hospitals and nursing homes.
3. Group A-2: Restaurants and banquet halls or buildings containing food preparation areas.
4. Group F: Laundries.
5. Group R-2. (Not applicable after 1/1/2022)
6. Group A-3: Health clubs and spas.
7. Buildings with a service hot water load of 10 percent or more of total building energy loads, as shown with an energy analysis as described in Section C407 or as shown through alternate service hot water load calculations showing a minimum service water energy use of 15 k/Btu per square foot per year, as *approved* by the building official..

C406.8.2 Load fraction. Not less than 60 percent of the annual service hot water heating energy use, or not less than 100 percent of the annual service hot water heating energy use in buildings with water-cooled systems subject to the requirements of Section C403.9.5 or qualifying for one of its exceptions, shall be provided by one or more of the following:

1. Service hot water system delivering heating requirements using heat pump technology with a minimum COP of 3.0. For air-source equipment, the COP rating will be reported at the design leaving heat pump water temperature with an entering air temperature of 60°F (15.6°C) or lower. For water-source equipment, the COP rating will be reported at the design leaving load water temperature with an entering water temperature of 74°F (23.3°C) or lower.
2. 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.
3. On site renewable energy water-heating systems, where those systems are in addition to the renewable energy required by Section C412 and any renewable energy used to comply with other requirements of this code.

C406.9 High performance service water heating in hotel and multifamily buildings. For a whole building, *building area*, *occupancy type*, *building addition*, or tenant space with not less than 90 percent of the *conditioned floor area* being Group R-1 or R-2 occupancy, not less than 90 percent of the annual building service hot water energy use shall be provided by a heat pump system ((with a minimum COP 3.0-)) meeting the requirements of Section C404.2.3 plus the following:

1. The refrigerant used in the heat pump system shall have a global warming potential (GWP) no greater than 675.
2. No electric resistance heating capacity shall be provided.

Exceptions to item 2.

1. Electric resistance heating is permitted for circulating system *temperature maintenance* and heat tracing of service hot water supply and return piping.
2. On-demand electric resistance water heaters for hand washing facilities are permitted in public toilet rooms.

((This)) Prior to January 1, 2022, this efficiency package is allowed to be taken in addition to Section ((C406.8.2)) C406.8.

C406.10 Enhanced envelope performance. The Proposed Total UA of the thermal envelope of the whole building, *building area*, *occupancy type*, or *building addition* shall be 15 percent lower than the Allowable Total UA for an area of identical configuration and fenestration area in accordance with Section C402.1.5 and Equation 4-2. Where exception 3 for Section C412 is also being used, the Proposed Total UA shall be 30 percent lower than the Allowable Total UA as defined in Section C402.1.5.

C406.11 Reduced air ((infiltration)) leakage. Measured air infiltration of the total *conditioned floor area* of the whole building, fully isolated building *addition*, ((*or tenant space*)) *building area, or occupancy type* shall comply with Section C406.11.1.

C406.11.1 Air leakage testing and verification. Air ((*infiltration*)) *leakage* shall be verified by whole building pressurization testing conducted in accordance with ASTM E779 or ASTM E1827, *or an equivalent method approved by the code official*, by an independent third party. The measured air leakage rate of the *building envelope* shall not exceed 0.17 cfm/ft² under a pressure differential of 0.3 in. water (75 Pa), with the calculated surface area being the sum of the above and below grade building envelope. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the *code official* and the building owner.

((**Exception:** Where the *conditioned floor area* of the building is not less than 250,000 ft² (25,000 m²), air leakage testing shall be permitted to be conducted on representative above grade sections of the building provided the *conditioned floor area* of tested areas is no less than 25 percent of the *conditioned floor area* of the building and are tested in accordance with this section.))

((**C406.12 Enhanced commercial kitchen equipment.** For buildings and spaces 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, 2018.
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.))

[Jurisdiction] Informative Note: Energy Star commercial kitchen equipment is required for all commercial kitchen projects by Section C403.15.

SECTION C407

TOTAL BUILDING PERFORMANCE

C407.2 Mandatory requirements. Compliance with ((*this section*)) *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 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 the same in both the proposed building and the *standard reference design* and shall comply with the requirements of this code.

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 Section G1.2.1a of Standard 90.1 are not required to be met.
2. The reduction in annual carbon emissions of the proposed building design associated with on-site renewable energy shall not be more than 3 percent of the total carbon emissions of the baseline building design. This limitation only applies to onsite renewable energy provided in excess of the renewable energy required by Section C412.
 - a. The equation $PCI + [(PBP_{nre} - PBP)/BBP] - 0.05 < PCI$ in Section 4.2.1.1 shall be modified to read $PCI + [(PBP_{nre} - PBP)/BBP] - 0.03 < PCI$.
 - b. The term PBP_{nre} shall be defined as the proposed building performance without credit for reduced annual energy emissions from on-site renewable energy generation system capacity in excess of that installed to satisfy the requirements of Section C412.
3. References to energy cost in Section 4.2.1.1 and Appendix G shall be replaced by carbon emissions calculated by multiplying site energy consumption by the carbon emission factor from Table C407.3(1).
4. The building performance factors in Table C4.2.1.1 shall be replaced with those in Table C407.3(2).
5. Schedules and plug and process loads shall be modeled using the default values listed in Appendix B or in the ASHRAE 90.1 User's Manual and shall be assumed to be identical in the proposed design and baseline building design.

Exception to item 5. Alternative schedules and plug and process loads shall be permitted where approved by the code official.
6. Documentation requirements in Section G1.3.2.d shall be replaced by a list showing compliance with the mandatory provisions of Table C407.2.
7. Documentation requirements in Section G1.3.2.e shall be replaced by a list of aspects of the proposed design that are less stringent than the prescriptive requirements of the Energy Code.
8. 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 Energy Code in lieu of the requirements of Standard 90.1, in the following sections of the table:
 1. Design Model, subclause c.
 6. Lighting, subclause c.
 11. Service Water-Heating Systems, subclause c.
 12. Receptacle and Other Loads, subclause b.
9. HVAC Systems, subclauses c and d of Table G3.1, shall meet the following requirements:
 - a. 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 shall meet but not exceed those shown in Table D602.11 Standard Reference Design HVAC Systems.
 - b. 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 Standard 90.1.

c. 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.

[Jurisdiction] Informative Note. The permit applicant is encouraged to schedule a pre-application meeting to discuss the modeling approach for any yet-to-be designed areas that are not included in the C407 permit submissions. In general, future permit submissions should not contribute energy savings to the C407 submission beyond prescriptive code requirements, assuming use of the base building HVAC systems. Future systems must be modeled for the base building permit as being no better than the current prescriptive code, because plans often change and [the Jurisdiction] the City does not have a mechanism for ensuring that future tenant projects meet any beyond-code performance modeled in the original C407 submission.

TABLE C407.2

MANDATORY COMPLIANCE MEASURES FOR TOTAL BUILDING PERFORMANCE METHOD^a

Section	Title	Comments
Envelope		
C402.5	Air Leakage	
Mechanical		
C403.1.2	Calculation of heating and cooling loads	
C403.1.3	<i>Data centers</i>	
C403.1.4	Use of electric resistance and fossil fuel-fired heating equipment	
C403.2	System design	
C403.3.1	Equipment and system sizing	
C403.3.2	HVAC equipment performance requirements	
C403.3.6	Ventilation for Group R occupancy	
C403.3.7	Hydronic system flow rate	
C403.4	HVAC system controls	
C403.4.1	Thermostatic controls	Except for C403.4.1.4
C403.4.2	Off-hour controls	Except for Group R
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 <i>dwelling units</i>	
C403.4.10	Group R-2 sleeping units	
C403.4.11	Direct digital control systems,	
C403.4.12	Pressure independent control valves	
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	Heat rejection equipment (partial)	Only the prohibition on single-pass water cooling systems is mandatory
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 <i>building thermal envelope</i>	
C403.15	Commercial food service	
Service Water Heating		
C404	Service Water Heating	
Lighting and Electrical		
C405.1	General	
C405.2	Lighting controls	
C405.3	Exit signs	
C405.4	Interior lighting power	
C405.5	Exterior building lighting power	
C405.6	Electrical transformers	
C405.7	<i>Dwelling unit</i> energy consumption	

C405.8	Electric motor efficiency	
C405.9	Vertical and horizontal transportation	
C405.10	<i>Controlled receptacles</i>	
C405.11	Voltage drop in feeders	
Other Requirements		
Section	Title	Comments
C407	Total Building Performance	
C408	System commissioning	
C409	Energy metering	
C410	Refrigeration requirements	
C411	Solar readiness	
C412	Renewable energy	All on-site renewable energy production is included in the proposed building performance, but not in the baseline building performance.

a. Compliance with any of these sections includes compliance with any exception to that section.

TABLE C407.3(1)
CARBON EMISSIONS FACTORS

	CO ₂ e (lb/unit)	Unit
Electricity	0.70	kWh
Natural Gas	11.7	Therm
Oil	19.2	Gallon
Propane	10.5	Gallon
Other ^a	195.00	mmBtu
On-site renewable energy ^b	0.00	

a. District energy systems may use alternative emission factors supported by calculations approved by the code official.

b. The TSPR calculation does not separately account for the use of renewable energy.

TABLE C407.3(2)
**BUILDING PERFORMANCE FACTORS (BPF) TO BE USED
FOR COMPLIANCE WITH SECTION C407.3**

Building Area Type	Building Performance Factor
Multifamily	((0.58)) 0.52

Healthcare/hospital	((0.54)) 0.49
Hotel/motel	((0.64)) 0.58
Office	((0.56)) 0.51
Restaurant	((0.70)) 0.63
Retail	((0.47)) 0.43
School	((0.36)) 0.32
Warehouse	((0.48)) 0.43
All Others	((0.54)) 0.49

C407.3.1 Limits on ~~((nonmandatory measures))~~ substandard building envelopes. The Proposed Total UA of the proposed building shall be no more than ~~((20 10))~~ percent higher than the Allowable Total UA as defined in Section C402.1.5. Where either Section C402.4.1.1.1 or C402.4.1.1.2 is used to establish the maximum allowable fenestration area for compliance with this section, all of the requirements of the selected section shall be met.

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))~~ 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 are exempt from the commissioning process where the building's installed total mechanical equipment capacity is less than 240,000 Btu/h cooling capacity and less than 300,000 Btu/h heating 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 no pools or permanent spas.
3. Lighting control systems are exempt from the commissioning process in buildings where both the total installed lighting load is less than 20 kW and the lighting load controlled by occupancy sensors or *automatic* daylighting controls is less than 10 kW.
4. Refrigeration systems are exempt from the commissioning process if they are limited to self-contained units.

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 and controlled receptacles 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.

SECTION C409

ENERGY METERING AND ENERGY CONSUMPTION MANAGEMENT

C409.1 General. All new buildings and *additions* shall have the capability of metering 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 ~~((50,000))~~ 20,000 square feet shall comply with Section C409. Buildings 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. For Group R-2 buildings, the floor area of dwelling units and sleeping units shall be excluded from the total conditioned floor area for the purposes of determining the 20,000 square foot threshold. Alterations and additions to existing buildings shall conform to Section C506.

Exceptions:

1. Tenant spaces smaller than ~~((50,000))~~ 20,000 ft² within buildings if the tenant space has its own utility service and utility meters.
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.

C409.1.2 Conversion factor. Any threshold stated in kW or kVA shall include the equivalent BTU/h heating and cooling capacity of installed equipment at a conversion factor of 3,412 Btu per kW ~~((at 50 percent demand))~~ or 2,730 Btu per kVA.

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.

Exception: Where site lighting and other exterior non-building electrical loads are served by an electrical service and meter that are separate from the building service and meter, the metering data from those loads is permitted to be either combined with the building's electrical service load data or delivered to a separate data acquisition system.

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, and waste heat reclaimed from sewers or other off-site 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 ((C409.3.5)) 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 land 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,

C409.4.3 Energy display. For each building subject to Section C409.2 and C409.3, either a visible display in a location with *ready access*, or a single web page or other electronic document available for access to building management or to a third-party energy data analysis service shall be provided in the building available for access to building operation and management personnel. The display shall graphically provide the current energy consumption rate for each whole building energy source, plus each end use category, as well as the total and ~~((peak))~~ maximum hourly consumption values for any day, week, month and year.

The display shall ~~((graphically provide the current energy consumption rate for each whole building energy source, plus each end use category, as well as the total and peak values for any day, week, month and year))~~ be capable of and configured to graphically display the energy use data for any source or end use category or any combination of sources and end uses for any selected daily, weekly, monthly or annual time period, and to view the selected time period

simultaneously with another selected time period or a reference benchmark time period. The display shall be capable of weather-normalizing data in the comparison time periods and facilitate display of energy use trends and identification of anomalies.

C409.4.4 Commissioning. Energy metering and energy consumption management systems shall be commissioned in accordance with Section ~~((C408))~~ C408.6.

~~((C409.5 Metering for existing buildings.~~

~~C409.5.1 Existing buildings that were constructed subject to the requirements of this section.~~

~~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 C409.3. This includes systems or equipment added in conjunction with additions or alterations to existing buildings.~~

~~C409.5.1.1 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.)~~

[Jurisdiction] Informative Note: Section C409.5 regarding metering for existing buildings is relocated to Section 506.1.

SECTION C410

REFRIGERATION SYSTEM REQUIREMENTS

C410.2 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers. *Refrigerated warehouse coolers, refrigerated warehouse freezers, and all walk-in coolers and walk-in freezers* including site assembled, site constructed and prefabricated units shall comply with the following. ~~((:))~~ Where they comprise any portion of the thermal envelope of the building, they shall comply with the requirements of Section C402, using the R-values or U-values listed in this Section C410.2. Section C402.1.5 component performance alternative is permitted to be used where approved by the code official.

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*-0.040. 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 windows 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 windows and reach-in doors for *walk-in coolers* and windows for *walk-in cooler* doors shall be provided with double-pane or triple-pane glass, with interstitial spaces 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/ft² (76 W/m²) of door opening for *walk-in freezers* and not greater than 3.0 W/ft² (32 W/m²) 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 turns off the lights within 15 minutes of when the *walk-in cooler* or *walk-in freezer* space is not occupied.
12. Evaporator fans in refrigerated warehouses shall be variable speed, and the speed shall be controlled in response to space conditions.

EXCEPTION: Evaporators served by a single compressor without unloading capability.

C410.2.1 Performance standards. Site-assembled and site-constructed walk-in coolers and walk-in freezers shall meet the requirements of Tables C410.2.1.1(1), C410.2.1.1(2) and C410.2.1.1(3).

C410.3 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 C410.3.1, C410.3.2, 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.

C410.3.2 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 set point 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 ((C403.2.40)) C403.10.3.

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

4. Compressor systems utilized in refrigerated warehouses shall conform to the following:

4.1. Compressors shall be designed to operate at a minimum condensing temperature of 70°F or less.

4.2. The compressor speed of a screw compressor greater than 50 hp shall be controllable in response to the refrigeration load or the input power to the compressor shall be controlled to use no more than 60 percent of full load input power when operated at 50 percent of full refrigeration capacity.

EXCEPTION. Refrigeration plants with more than one dedicated compressor per suction group.

SECTION C411

SOLAR READINESS

C411.1 General. ((A)) In addition to the requirements of Section C412, a *solar zone* shall be provided on ((non-residential)) 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 Sections C411.2 through C411.8 and the *International Fire Code*.

Exception. A *solar zone* is not required 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 C411.5, in the same location, as measured by one of the following:

1. Incident solar radiation expressed in kWh/ft²-yr using typical meteorological year (TMY) data;
2. Annual sunlight exposure expressed in cumulative hours per year using TMY data;
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.

C411.2 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, 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 C411.2 to the maximum practicable area.

Example: A building with a 10,000 SF total roof area, 1,000 SF skylight area, and a 400 Amp, 240 volt single phase electrical service is required to provide a solar zone area of the smaller of the following:

1. $[40\% \times (10,000 \text{ SF roof area} - 1,000 \text{ SF skylights})] = 3,600 \text{ SF}$; or
2. $[400 \text{ Amp} \times 240 \text{ Volts} \times 20\% / 10 \text{ watts per SF}] = 1,920 \text{ SF}$

Therefore, a solar zone of 1,920 square feet is required.

C411.3 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.

C411.4 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* and the [Jurisdiction] Land Use Code. Photovoltaic or solar water heating systems are permitted to be installed within the solar zone.

C411.5 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.

C411.6 Access. Areas contiguous to the solar zone shall provide access pathways and provisions for emergency smoke ventilation as required by the *International Fire Code*.

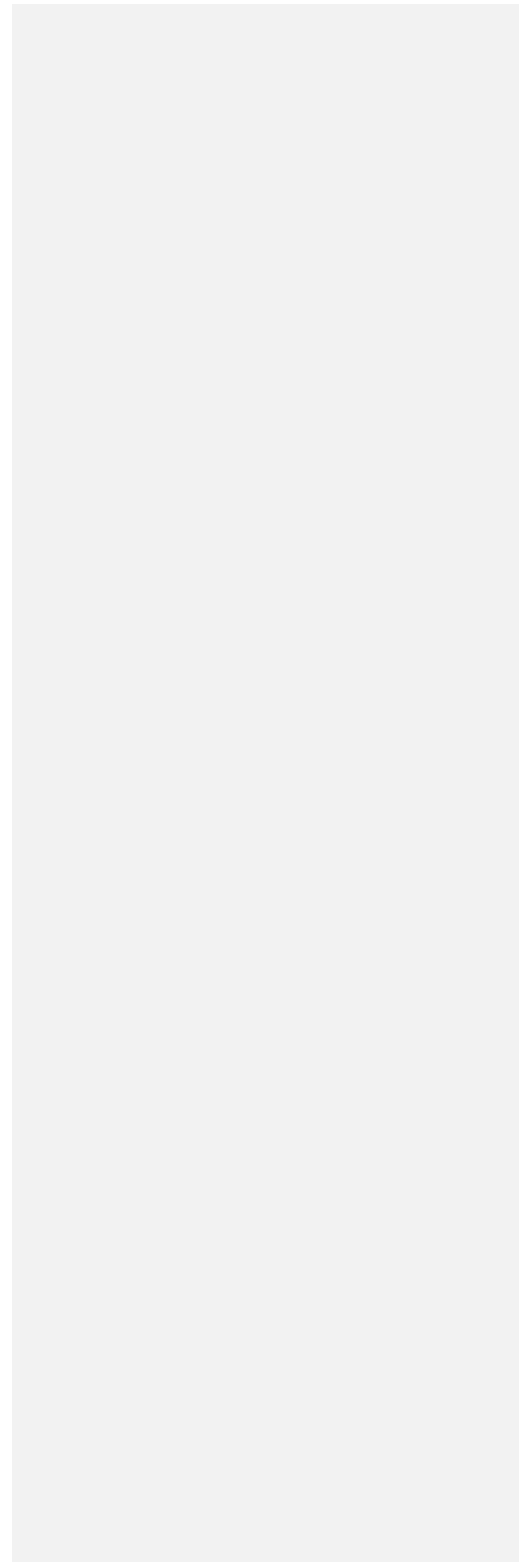
C411.7 Structural integrity. The as-designed dead load and live load for the solar zone shall be clearly marked on the record drawings and shall accommodate future photovoltaic system arrays at an assumed dead load of 4 pounds per square foot in addition to other required live and dead loads. A location 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.

C411.8 Photovoltaic interconnection. A minimum 2-inch diameter roof penetration conduit shall be provided, with threaded caps above and below the roof deck and minimum R-10 insulation wrapping the lower portion, within each 2,500 square foot section of the required solar zone area. 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 RENEWABLE ENERGY

C412.1 On-site renewable energy systems. Each new building or *addition* larger than 5,000 square feet of gross *conditioned floor area* shall include a renewable energy generation system consisting of not less than 0.25 watts rated peak photovoltaic energy production per square foot of *conditioned space*.

Exceptions:

1. Increased additional energy credits. Where 3.0 additional energy credits from Table C406.1 are provided in addition to those required by other sections of this code, the on-site renewable energy generation system is not required.

1.1. Where 1.0 additional energy credits from Table C406.1 is provided in addition to those required by other sections of this code, the size of the on-site renewable energy generation system is permitted to be reduced by 1/3.

1.2. Where 2.0 additional energy credits from Table C406.1 are provided in addition to those required by other sections of this code, the size of the on-site renewable energy generation system is permitted to be reduced by 2/3.

1.3 Where approved by [the Jurisdiction], interpolation between exceptions 1, 1.1, and 1.2 is permitted.

2. Reduced Building Performance Factor. For projects utilizing the Section C407 Total Building Performance compliance path, the on-site renewable energy generation system is not required where the building performance factor (BPF) is not less than 3 percent lower than the maximum BPF permitted cumulatively by all other sections of this code.

Example: To use this exception, a building with a required BPF of 50 would be required to provide a BPF of $(50 \times 0.97 =) 48.5$ instead.

2.1 Where the BPF is not less than 1 percent lower than the BPF required cumulatively by other sections of this code, the size of the on-site renewable energy generation system is permitted to be reduced by 1/3.

2.1 Where the BPF is not less than 2 percent lower than the BPF required cumulatively by other sections of this code, the size of the on-site renewable energy generation system is permitted to be reduced by 2/3.

3. Transfer to an *affordable housing* project. Where *approved* by [the Jurisdiction], all or part of the required on-site renewable energy generation system is permitted to be replaced by construction of a system that is 50 percent of the required system size when located on an existing *affordable housing* project within [the Jurisdiction], or 75 percent of the required system size when located on a new construction *affordable housing* project within [the Jurisdiction]. Documentation demonstrating that the renewable energy generation system has been installed on the *affordable housing* project site, the system is fully operational, and ownership has been transferred to the owner of the *affordable housing* project, must be submitted prior to issuance of the certificate of occupancy.

Commented [PK9]: Note to RCC: Please note the places across this code that say "[Jurisdiction]" where your department of jurisdiction name needs to be inserted

[Jurisdiction] Informative Note: Option 3 will only be available if an affordable housing project is available to accept the renewable energy system. There is no assurance that such a project location will be available. It is the owner's responsibility to locate and coordinate with the affordable housing project, and to ensure that the installation is completed in a timely manner.

4. Transfer to a Washington state agency program. Where *approved* by [the Jurisdiction], all or part of the required renewable energy generation system is permitted to be replaced by a contribution of \$2.50 for each required watt of installed capacity, to a solar energy fund managed by a Washington state agency that will provide solar energy installations for *affordable housing* projects. Documentation demonstrating that the contribution has been received by the state agency must be submitted prior to issuance of the certificate of occupancy.

[Jurisdiction] Informative Note: Option 4 will only be available if a solar energy fund for affordable housing is created by the Housing Trust Fund, Washington State Housing Finance Commission, or another state agency program for which the project is qualified to participate. There is no assurance that such a program will be available.

5. *Affordable housing.* The on-site renewable energy generation system is not required for *affordable housing* projects.

CHAPTER 5 EXISTING BUILDINGS

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. *Additions using the prescriptive path in Section C401.2, item 1, shall also comply with Sections C402, C403, C404, C405, C406, C409.5, C410 and C502.2.*

C502.1.1 Additional efficiency package options. *Additions shall comply with Section C406, either for the addition only or for the total of the existing building plus addition.*

Exception: *Additions smaller than 500 square feet of conditioned floor area are not required to comply with Section C406.*

C502.2.2 Skylight area. *Additions with skylights that result in a total building skylight area less than or equal to that specified in Section C402.4.1 shall comply with Section ((C402.4)) C402. Additions with skylights that result in a total building skylight area greater than that specified in Section C402.4.1 shall comply with one of the following:*

1. ~~((Vertical fenestration alternate per Section C402.4.1.1 or C402.4.1.3 for the addition area of the building only))~~
- 2-)) Component performance alternative with the target area adjustment per Section C402.1.5 for the *addition* area of the building only.
- ((3)) 2. Existing building and *addition* area combined to demonstrate compliance with the component performance alternative for the whole building.
- ((4)) 3. Total building performance in accordance with Section C407 for the *addition* area of the building only.
- ((5)) 4. Total building performance for the whole building.

C502.2.6.2 Exterior lighting power. The total exterior lighting power for the *addition* shall comply with Section ((C405.5.4)) C405.5.2 for the *addition* alone, or the existing building and the *addition* shall comply as a single 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*.

Exceptions:

1. The following *alterations* need not comply with the requirements for new construction provided the energy use of the building is not increased:
 - ((4)) a. Storm windows installed over existing fenestration.
 - ((2)) b. 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)) c. 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)) d. Construction where the existing roof, wall or floor cavity is not exposed.
 - ((5)) e. *Roof recover*.
 - ((6)) f. *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 envelope.
 - ((7)) g. 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.
2. *Alterations* are not required to comply with Section C406 except where specifically noted in Sections C503.2, C503.8.3 and C505.1.

C503.2 Change in space conditioning. Any 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. Any *semi-heated space* in accordance with Section C402.1.1.2 that is altered to become *conditioned space*, or any heated but not cooled space that is altered to become both heated and cooled, shall be brought into full compliance with this code. Compliance shall include the provisions of Section C406, applied only to the portion of the building undergoing a change in space conditioning.

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.

A change in space conditioning project shall be deemed to comply with this code if the project area alone complies or if the existing building and the project area combined comply with this code as a whole building.

Exception: Buildings or spaces that were permitted prior to the 2009 WSEC, 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 Section C407 is used to demonstrate compliance with this section, the total annual carbon emissions from energy consumption of the proposed design is allowed to be up to 110 percent of the annual carbon emissions from energy consumption allowed by Section C407.3. This exception may be applied to the

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project area alone, or to the existing building and project area combined as a whole building.

3. The addition of cooling equipment serving rooms or spaces totaling less than 2000 square feet in floor area does not trigger the requirement to comply with this section.

C503.3 Building envelope. New building envelope assemblies that are part of the *alteration* shall comply with Sections C402.1 through C402.5 as applicable. Where an opaque envelope assembly is altered or replaced, the new assembly shall in no case have a higher overall U-value than the existing.

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 replacement. *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 contains insulation entirely above the roof deck.

C503.3.2 Vertical fenestration. The addition of *vertical fenestration* that results in a total building vertical fenestration area less than or equal to that specified in Section C402.4.1 shall comply with Section C402.4. *Alterations* that result in a total building vertical fenestration area greater than specified in Section C402.4.1 shall comply with one of the following:

1. Vertical fenestration alternate in accordance with Section C402.4.1.3 for the new vertical fenestration added, where the calculation of vertical fenestration area and gross above-grade wall area shall include either the entire building or, where approved, only those areas ((in the addition)) of the building involved in the alteration.
2. ((Vertical fenestration alternate in accordance with Section C402.4.1.1 for the area adjacent to the new vertical fenestration added.)) (Reserved)
3. Existing building and ((alteration)) 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. The Proposed Total UA is allowed to be up to 110 percent of the Allowed Total UA.
4. Total building performance in accordance with Section C407 for the whole building. The total annual carbon emissions from energy consumption of the proposed design is allowed to be up to 110 percent of the annual carbon emissions from energy consumption allowed in accordance with Section C407.3.

Exception: ((Additional)) 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 vertical fenestration does not cause ((a reduction in overall building energy efficiency, as approved by the code official)) an increase in the overall energy use of the building.

C503.3.2.1 Application to 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. In addition, the area-weighted U-value of the new fenestration shall be equal to or lower than the U-value of the existing fenestration.

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.

C503.4 Mechanical systems. Those parts of systems which are altered or replaced shall comply with Section C403. Additions or *alterations* shall not be made to an existing mechanical system that will cause the existing mechanical system to become out of compliance.

Exceptions:

1. Existing mechanical systems which are altered or where parts of the system are replaced are not required to be modified to comply with Section C403.3.5 as long as mechanical cooling capacity is not added to a system that did not have cooling capacity prior to the *alteration*.
2. 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(42))) C403.3.2(13).
3. Only those components of existing HVAC systems that are altered or replaced shall be required to meet the requirements of Section C403.8.1, Allowable fan motor horsepower. Components replaced or altered shall not exceed the fan power limitation pressure drop adjustment values in Table C403.8.1(2) at design conditions. Section C403.8.1 does not require the removal and replacement of existing system ductwork.

C503.4.2 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) through (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 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(7), 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))~~ 72,000 Btu/h (141 kW) per building, or 20 percent of the building total *air economizer* capacity, whichever is greater.

Notes and exclusions for Exception ((4)) 2:

- 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 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 when either the individual cooling unit capacity ~~((and))~~ or the building total capacity of all cooling equipment without economizer ~~((de))~~ does not comply with Sections C403.3.5 or C403.5.

TABLE C503.4

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 Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: CC403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b
2. Split Systems	Efficiency: min. ^a Economizer: C403.5 ^b	For units ≤ 60,000 Btuh, comply with two of two measures: 1. Efficiency: + 10% ^e 2. Economizer: shall not decrease existing economizer capability For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b	For units ≤ 60,000 Btuh replacing unit installed prior to 1991, comply with at least one of two measures: 1. Efficiency: + 10% ^e 2. Economizer: 50% ^f For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b
3. Water Source Heat Pump	Efficiency: min. ^a Economizer: C403.5 ^b	For units ≤ 72,000 Btuh, comply with at least two of three measures: 1. Efficiency: + 10% ^e 2. Flow control valve ^g 3. Economizer: 50% ^f For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b	For units ≤ 72,000 Btuh, comply with at least two of three measures: 1. Efficiency: + 10% ^e 2. Flow control valve ^g 3. Economizer: 50% ^f (except for certain pre-1991 systems ^h) For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b (except for certain pre-1991 systems ^h)
4. Water Economizer using Air-Cooled Heat Rejection Equipment (Dry Cooler)	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: +5% ^d Economizer: shall not decrease existing economizer capacity	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b
5. Air-Handling Unit (including fan coil units) where the system has an air-cooled chiller	Efficiency: min. ^a Economizer: C403.5 ^b	Economizer: shall not decrease existing economizer capacity	Efficiency: min. ^a Economizer: C403.5 ^b (except for certain pre-1991 systems ^h)	Efficiency: min. ^a Economizer: C403.5 ^b (except for certain pre-1991 systems ^h)
6. Air- Handling Unit (including fan coil units) and Water-	Efficiency: min. ^a Economizer: C403.5 ^b	Economizer: shall not decrease existing economizer capacity	Efficiency: min. ^a Economizer: C403.5 ^b (except for certain	Efficiency: min. ^a Economizer: C403.5 ^b (except for certain

Unit Type	Option A	Option B (alternate to A)	Option C (alternate to A)	Option D (alternate to A)
	Any <i>alteration</i> 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
cooled Process Equipment, where the system has a water-cooled chiller ⁱ			pre-1991 systems ^h and certain 1991-2016 systems ⁱ .)	pre-1991 systems ^h and certain 1991-2016 systems ⁱ .)

TABLE C503.4 (continued)

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 <i>alteration</i> 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
7. Cooling Tower	Efficiency: min. ^a Economizer: C403.5 ^b	No requirements	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: min. ^a Economizer: C403.5 ^b
8. Air-Cooled Chiller	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: + 10% ^k Economizer: shall not decrease existing economizer capacity	Efficiency: Comply with two of two measures: 1. + 10% ^{k,l} 2. Multistage Economizer: shall not decrease existing economizer capacity	Efficiency: min. ^a Economizer: C403.5 ^b
9. Water-Cooled Chiller	Efficiency: min. ^a Economizer: C403.5 ^b	Efficiency: Comply with at least one of two measures: 1. Part load IPLV + 15% ⁿ 2. Plate frame heat exchanger ^o Economizer: shall not decrease existing economizer capacity	Efficiency: Comply with two of two measures: 1. Part load IPLV + 15% ⁿ 2. Plate frame heat exchanger ^o Economizer: shall not decrease existing economizer capacity	Efficiency: min. ^a Economizer: C403.5 ^b

- a. Minimum equipment efficiency shall comply with Section C403.3.2 and Tables C403.3.2(1) through ((C403.3.2(12))) C403.3.2(13).
- 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 Tables C403.3.2(1) and C403.3.2(2) (1.05 x values in Tables C403.3.2(1) and C403.3.2(2)).
- e. Equipment shall have a capacity-weighted average cooling system efficiency that is 10 percent better than the requirements in Tables C403.3.2(1)A and C403.3.2(2) (1.10 x values in Tables C403.3.2(1)A and C403.3.2(2)).
- 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(2) (1.15 x values in Table C403.3.2(2)).
- 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(8) and C403.3.2(9) (1.10 x values in Tables C403.3.2(8) and C403.3.2(9)).
- 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(7) (1.10 x IPLV values in EER in Table C403.3.2(7)).
- 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(7) (1.05 x IPLV values in Table C403.3.2(7))))~~ Reserved.
- 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(7), ~~((1.15))~~ 0.85 x IPLV values in Table C403.3.2(7)). 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 C403.3.2.1 ~~((1.15))~~ 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.

C503.4.6 New and replacement HVAC heating system equipment. For substantial alterations as defined in Section C503.8.1, or where a building's central HVAC heating system equipment is augmented or replaced, the building shall comply with Section C403.1.4.

Exception. Where only one heating appliance is failing and is replaced by another having the same or lesser heating capacity and the same or higher efficiency, no other alterations

are made to the central HVAC system, and this exception has not been used within the same building in the previous 24-month period, this provision does not apply.

[Jurisdiction] Informative Note: The term “central HVAC heating system” for the purposes of this section means a heating system that provides heating to multiple spaces or multiple dwelling or sleeping units (as opposed to a distributed heating system such as a baseboard heater or PTHP that provides heating to only a single space). A central heating system may include multiple pieces of heating equipment. The exception permits like-for-like replacement of a single boiler, furnace or heat pump, where no other HVAC work is planned, so that a failed heating appliance can be expediently replaced.

Commented [PK11]: Note to RCC: Only insert if you have something comparable to Seattle’s “Substantial Alterations” concept.

If used, this item is a part of the decarbonization package

C503.5 Service hot water systems. New service hot water systems that are part of the alteration shall comply with Section C404.

Exception. Where only one service hot water appliance is failing and is replaced by another having the same or lesser heating capacity and the same or higher efficiency, no other alterations are made to the central service hot water system, and this exception has not been used within the same building in the previous 24-month period, this provision does not apply.

C503.6 Lighting, (~~controlled~~) receptacles and motors. Alterations or the addition of lighting, (~~controlled~~) receptacles and motors shall comply with Sections C503.6.1 through C503.6.6.

C503.6.1 Luminaire additions and alterations. Alterations that add, alter or replace ((50)) 20 percent or more of the luminaires or of the lamps plus ballasts alone in a space enclosed by walls or ceiling-height partitions, replace ((50)) 20 percent or more of parking garage luminaires, or replace ((50)) 20 percent or more of the total installed wattage of exterior luminaires shall comply with Sections C405.4 and C405.5. Where less than ((50)) 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 ((50)) 20 percent of the installed exterior wattage is replaced, the installed lighting wattage shall be maintained or reduced.

C503.6.3 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, controls shall also comply with, in addition to the requirements of Section C503.6.2, all (~~remaining~~) requirements in Sections C405.2 and C408.3.

C503.6.5 Motors. Those motors which are altered or replaced shall comply with Section C405.8. In no case shall the energy efficiency of the building be decreased.

C503.6.6 Controlled receptacles. Where electric receptacles are added or replaced, controlled receptacles shall be provided in accordance with Section C405.10.

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 ~~((the))~~ exception 1 to Section C405.10, they are not required to be *controlled receptacles* or be located within 12 inches of non-*controlled receptacles*.

C503.8 Substantial alterations or repairs. In addition to meeting the requirements of this code, any building or structure to which substantial alterations or repairs are made shall comply with the requirements of this section.

Exceptions:

1. *Alterations and repairs to landmark buildings shall comply with this section to the extent that the code official determines that such compliance does not have an adverse effect on the designated historic features of the building. The energy use allowed by subsections 2 or 3 of Section C503.8.3 is permitted to be increased in proportion to the additional energy use required for preservation of such designated features.*
2. *A project that is defined as a substantial alteration primarily due to the seismic retrofitting of a building's unreinforced masonry walls is exempt from the requirements of this section.*
3. *A building constructed in compliance with the 2003 or more recent edition of the Seattle Building Code that would be classified as a substantial alteration only due to being reoccupied after being substantially vacant for more than 24 months is exempt from the requirements of this section.*

C503.8.1 Definition. For the purposes of this section, substantial alterations or repairs means items 1, 2 or 4, or any combination thereof, of the definition of substantial alterations or repairs in Chapter 3 of the Seattle amendments to the IEBC, as determined by the *code official*.

[Jurisdiction] Informative Note: Definitions 1, 2 and 4 of "substantial alterations or repairs" in the Seattle Existing Building Code are as follows:

1. Repair of a building with a damage ratio of 60 percent or more.
2. Remodeling or *additions* that substantially extend the useful physical and/or economic life of the building or a significant portion of the building, other than typical tenant remodeling.
4. Re-occupancy of a building that has been substantially vacant for more than 24 months in occupancies other than Group R-3.

C503.8.2 Pre-submittal conference. The applicant shall attend a pre-submittal conference to discuss the selected compliance path. Prior to this conference, the applicant shall meet with each energy utility serving the building to determine whether technical assistance or financial incentives are available for energy efficiency upgrades, and shall submit documentation of these meetings at the pre-submittal conference.

C503.8.3 Energy Efficiency. Buildings undergoing substantial alterations shall comply with Section C503.4.6 and one of the following:

1. **Full code compliance.** Fully comply with the requirements of this code for new construction, including Section C406.

2. **Envelope thermal performance within 15 percent of code.** Demonstrate that heat loss through the building envelope is no more than 15 percent greater than allowed by the Seattle Energy Code, using the Component Performance Building Envelope Option in Section C402.1.5, and meet all other prescriptive requirements of the Seattle Energy Code for new construction, including Section C406.
 - 2.1. **Default U-values.** The values listed in Appendix A and Section C303 shall be used as the default U-values for existing building envelope components. For buildings whose original construction permits were applied for after January 1, 1992, existing building envelope components are deemed to meet the minimum U-values required by the edition of the Seattle Energy Code in effect at the time of permit application, where visual inspection by the *code official* reveals that those components appear to be equal to or better than code-compliant components.
 - 2.2. **Disproportionality.** Where *approved by the code official*, the cost of required thermal improvements to the building envelope are not required to exceed 20 percent of the valuation of the substantial alterations project, determined in accordance with the Fee Subtitle, when using this envelope thermal performance compliance method. Envelope improvement costs shall be documented using standard cost estimating software and methodology.
3. **Total building performance within 10 percent of code.** Demonstrate that the Building Performance Factor is no more than 10 percent higher than that permitted by Table C407.3.2.

C503.8.4 Impracticality. In cases where full compliance with all the requirements of Section C503.8 is impractical, the applicant is permitted to arrange a pre-design conference with the design team and the *code official* to seek modifications. The applicant shall identify specific requirements that are impractical, and shall identify design solutions and modifications that achieve a comparable level of energy efficiency. The *code official* is authorized to waive specific requirements in this code to the extent that the *code official* determines those requirements to be impractical.

Commented [PK12]: Note to RCC: Only insert if you have something comparable to Seattle's "Substantial Alterations" concept, and modify references to Seattle

SECTION C504

REPAIRS

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 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.)~~

[Jurisdiction] Informative Note: Exceptions 3 and 4 appear in the exceptions to Section C503.1.

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.))~~

[Jurisdiction] Informative Note: For exception 5, see Section C503.6.1.

SECTION C505 CHANGE OF OCCUPANCY OR USE

C505.1 General. Spaces undergoing a change in occupancy shall be brought up to full compliance with this code in the following cases:

1. Any space that is converted from an F, S or U occupancy to an occupancy other than 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.

Exception: Buildings or spaces that were permitted prior to the 2009 WSEC, 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 Section C407 is used to demonstrate compliance with this section, the total annual carbon emissions from energy consumption of the proposed design is allowed to be 110 percent of the annual carbon emissions from energy consumption 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.
3. Where the building or space is altered to become a bakery, commercial kitchen or commercial laundry, and the proposed design uses only all-electric Energy Star-rated process equipment and code compliant all-electric HVAC equipment, improvements to the building envelope immediately adjoining the spaces containing that use shall not be required. For the purposes of this exception, no fossil fuel burning equipment of any kind may be installed within the building or space undergoing the *change of occupancy*.

Compliance shall include the provisions of Section C406, applied only to the portion of the building undergoing a *change of occupancy* or 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 shall comply with Section C405.4.

SECTION C506 METERING FOR EXISTING BUILDINGS

[Jurisdiction] Informative Note: Section C506.1 was relocated from Section C409.5.

C506.1 Existing buildings that were constructed subject to the requirements of this section. 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 C409.3. This includes systems or equipment added in conjunction with *additions* or *alterations* to existing buildings.

C506.1.1 Small existing buildings. In buildings that were constructed subject to Section C409, metering and *data acquisition systems* shall be provided for *additions* over 10,000 square feet in accordance with the requirements of sections C409.2, C409.3 and C409.4.

C506.2 Metering for the addition or replacement of HVAC equipment in existing buildings. Where HVAC equipment is added or replaced, metering shall be provided according to Sections C506.2.1 or C506.2.2, as applicable.

C506.2.1 Addition or replacement of individual HVAC equipment pieces. Where HVAC equipment is added or replaced, but compliance with Section C506.2.2 is not required, metering shall be provided as follows, and 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.

1. Electrical metering shall be provided for all of the following:
 - a. Each new or existing branch circuit serving a new piece of HVAC equipment with minimum circuit ampacity (MCA) that equates to 50 kVA or more. A single meter is permitted to serve multiple circuits of the same submetering category from Section C409.3.
 - b. Each new or existing branch circuit supplied by a new electrical panel that is dedicated to serving HVAC equipment. It shall be permitted to meter the circuits individually or in aggregate.
 - c. Each new HVAC fan or pump on a variable speed drive, where the fan, pump, or variable speed drive are new, unless the variable speed drive is integral to a packaged HVAC unit or the existing variable speed drive does not have the capability to provide electric metering output.
2. Natural gas metering shall be provided for each new natural gas connection that is rated at 1,000 kBTU or higher. A single meter is permitted to serve multiple equipment pieces of the same sub-metering category from Section C409.3; HVAC, water heating or process.

C506.2.2 Addition or replacement of the majority of HVAC equipment in a building. Where permits are issued for new or replacement HVAC equipment that has a total heating and cooling capacity greater than 1,200 kBTU/hour and greater than 50 percent of the building's existing HVAC heating and cooling capacity, within any 12-month period, the following shall be provided for the building:

1. Energy source metering required by Section C409.2.
2. HVAC system end-use metering required by Section C409.3.1
3. Data acquisition and display system per the requirements of Section C409.4.

Each of the building's existing HVAC chillers, boilers, cooling towers, air handlers, packaged units and heat pumps that has a capacity larger than 5 tons or that represents more than 10 percent of the total heating and cooling capacity of the building shall be included in the calculation of the existing heating and cooling capacity of the building. Where heat pumps are configured to deliver both heating and cooling, the heating and cooling capacities shall both be included in the calculation of the total capacity.

Each of the building's existing and new HVAC chillers, boilers, cooling towers, air handlers, packaged units and heat pumps that has a heating or cooling capacity larger than 5 tons or that represents more than 10 percent of the total heating and cooling capacity of the building shall be included in the HVAC system end-use metering.

Construction documents for new or replacement heating and cooling equipment projects shall indicate the total heating and cooling capacity of the building's existing HVAC equipment and the total heating and cooling capacity of the new or replacement equipment. Where permits have been issued for new or replacement heating and cooling equipment within the 12-month period prior to the permit application date, the heating and cooling capacity of that equipment shall also be indicated. For the purpose of this tabulation, heating and cooling capacities of all equipment shall be expressed in kBTU / hour.

C506.3 Tenant space electrical sub-metering for existing buildings. For tenant improvements in which a single tenant will occupy a full floor or multiple floors of a building, the electrical consumption for the tenant space on that floor shall be separately metered, and the metering data provided to the tenant with a display system per the requirements of Section C409.4.3. For the purposes of this section, separate end use categories need not be segregated.

EXCEPTION: Where an existing branch circuit electrical panel serves tenant spaces on multiple full floors of a building, the floors served by that panel are not required to comply with this section.

C506.4 Metering for complete electrical system replacement. If all, or substantially all, of the existing electrical system is replaced under a single electrical permit or within a 12-month period, all of the provisions of Section C409 shall be met.

CHAPTER 6 REFERENCED STANDARDS

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	Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners.....	C403.4.1
Standard 183—2007	Peak Cooling and Heating Load Calculations in Buildings, Except Low-rise Residential Buildings	C403.1.2
ANSI/ASHRAE/ASHE		
<u>Standard 170-2017</u>	<u>Ventilation of Health Care Facilities.....</u>	<u>C403.1.1</u>
ASHRAE—2016	ASHRAE HVAC Systems and Equipment Handbook—2004.....	C403..1.2
ISO/AHRI/ASHRAE		
13256-1 (2011)	Water-source Heat Pumps—Testing and Rating for Performance— Part 1: Water-to-air and Brine-to-air Heat Pumps	Table C403.3.2(2)
ISO/AHRI/ASHRAE		
13256-2 (2011)	Water-source Heat Pumps—Testing and Rating for Performance— Part 2: Water-to-water and Brine-to-water Heat Pumps	Table C403.3.2(2)
ASHRAE --continued		
90.1—((2016)) <u>2019</u>	Energy Standard for Buildings Except Low-rise Residential Buildings.....	C402.1.5.1, C407.3
90.4—((2016)) <u>2019</u>	Energy Standard for Data Centers.....	C403.1.3
146—2011	Testing and Rating Pool Heaters	Table C404.2

HVI

Home Ventilating Institute
1740 Dell Range Blvd., Ste H.450
Chevenne, WY 82009

Standard reference number	Title	Referenced in code section number
<u>HVI 916—2015</u>	<u>Home Ventilating Institute Airflow Test Procedure 916-2015</u>	<u>C403.8.4</u>
<u>HVI 920—2020</u>	<u>Product Performance Certification Procedure Including Verification and Challenge 920-2020</u>	<u>C403.3.6</u>

APPENDIX A DEFAULT HEAT LOSS COEFFICIENTS

TABLE A102.2.6(1)
ASSEMBLY U-FACTORS FOR ROOFS WITH TAPERED INSULATION ENTIRELY ABOVE DECK
SINGLE SLOPE RECTANGULAR TO ONE-SIDE ~~((e,f,g,h,i)) a,b,c,d,h,i~~
(UNINTERRUPTED BY FRAMING)

[The remainder of the table is not shown]

TABLE A102.2.6(2)
ASSEMBLY U-FACTORS FOR ROOFS WITH TAPERED INSULATION ENTIRELY ABOVE DECK
SLOPED TRIANGLE (ROOF WITH CENTER DRAIN) ~~((e,f,g,h,i)) a,b,c,d,h,i~~
(UNINTERRUPTED BY FRAMING)

[The remainder of the table is not shown]

TABLE A102.2.6(3)
ASSEMBLY U-FACTORS FOR ROOFS WITH TAPERED INSULATION ENTIRELY ABOVE DECK
SLOPED TRIANGLE (ROOF WITH PERIMETER DRAINS) ~~((e,f,g,h,i)) a,c,f,g,h,i~~
(UNINTERRUPTED BY FRAMING)

[The remainder of the table is not shown]

Footnotes to Tables A102.2.6.1, A102.2.6.2, and A102.2.6.3:

- a. R_{max} and R_{min} are determined along the linearly tapered cross section for the respective ~~((minimum and))~~ maximum and minimum thickness values for the roof section being analyzed.
- b. For triangular roof sections with insulation sloping to the center, R_{max} refers to the insulation value along the long edge of the triangle and R_{min} to the insulation at the point of the triangle ~~((which assumes that the insulation slopes to the center))~~.
- c. For triangular roof sections with insulation sloping to the perimeter, R_{max} refers to the insulation value at the point of the triangle and R_{min} to the insulation along the long edge of the triangle which assumes that the insulation slopes to the perimeter.
- d. Effective ~~((U-factor for))~~ R-value of rectangular tapered insulation is calculated as follows:

$$R_{eff} = (R_{max} - R_{min}) / \ln \left[\frac{R_{max}}{R_{min}} \right]$$

- e. Effective ~~((U-factor for))~~ R-value of triangular tapered insulation sloping to the center is calculated as follows:

$$R_{eff} = \left[\frac{2}{R_{max} - R_{min}} \left[1 + \frac{R_{min}}{R_{max} - R_{min}} \ln \left[\frac{R_{min}}{R_{max}} \right] \right] \right]^{-1}$$

- f. Effective R-value of triangular tapered insulation sloping to the perimeter is calculated as follows:

$$R_{eff} = \left[\frac{2}{R_{min} - R_{max}} \left[1 + \frac{R_{max}}{R_{min} - R_{max}} \ln \left[\frac{R_{max}}{R_{min}} \right] \right] \right]^{-1}$$

- ~~((f))~~ g. Assembly U-factors include the effective R-value of the tapered insulation, an exterior air film ($R=0.17$) and an interior air film, horizontal with heat flow

up (R=0.61).

((g)) h. For effective U-factors of roof assemblies with different Rmax or Rmin values not listed in the tables interpolation is allowed. For effective U-factors of roof assemblies with Rmax greater than the values listed in the tables, the effective U-factor must be calculated using the effective R-value calculations above.

((h)) i. This table shall only be applied to tapered insulation that is tapered along only one axis.

((i)) j. In areas of differing insulation slopes/configurations, individual ((U-values)) U-factors shall be calculated and an area weighted ((U-value)) U-factor calculation shall be used to determine the effective value of the roof.

APPENDIX D CALCULATION OF HVAC TOTAL SYSTEM PERFORMANCE RATIO

D101 Scope. This appendix establishes criteria for demonstrating compliance using the *HVAC total system performance ratio (HVAC TSPR)* for systems serving office, retail, library and education occupancies and buildings, which are subject to the requirements of Section C403.3.5 without exceptions and dwelling units and common areas within multifamily buildings. Those HVAC systems shall comply with Section C403 and this appendix as required by Section C403.1.1.

**TABLE C407.3(1)
CARBON EMISSIONS FACTORS**

Type	CO2e (lb/unit)	Unit
Electricity	0.70	kWh
Natural Gas	11.7	Therm
Oil	19.2	Gallon
Propane	10.5	Gallon
Other ^a	195.00	mmBtu
On-site renewable energy ^b	0.00	

a. District energy systems may use alternative emission factors supported by calculations *approved by the code official*

b. The TSPR calculation does not separately account for the use of renewable energy.

D601.2.1 Number of blocks. One or more *blocks* may be required per building based on the following restrictions:

1. Each *block* can have only one occupancy type (multifamily dwelling unit, multifamily common area, office, library, education or retail). Therefore, at least one single *block* shall be created for each unique use type.

D601.4.1 Occupancy type. The occupancy type for each *block* shall be consistent with the building area type as determined in accordance with Section C405.4.2.1. Portions of the building that are building area types other than multifamily, office, school (education), library, or retail shall not be included in the simulation.

D601.4.2 Occupancy schedule, density, and heat gain. The occupant density, heat gain, and schedule shall be for multifamily, office, retail, library, or school as specified by ASHRAE Standard 90.1 Normative Appendix C.

D601.6 Lighting. Interior lighting power density shall be equal to the allowance in Table C405.4.2(1) for multifamily, office, retail, library, or school. The lighting schedule shall be for multifamily, office, retail, library, or school as specified by ASHRAE Standard 90.1 Normative Appendix C. The impact of lighting controls is assumed to be captured by the lighting schedule and no explicit controls shall be modeled. Exterior lighting shall not be modeled.

D601.7 Miscellaneous equipment. The miscellaneous equipment schedule and power shall be for multifamily, office, retail, library, or school as specified by ASHRAE Standard 90.1 Normative Appendix C. The impact of miscellaneous equipment controls is assumed to be captured by the equipment schedule and no explicit controls shall be modeled.

Exceptions.

1. Multifamily dwelling units shall have a miscellaneous load density of 0.42 W/ft²
2. Multifamily common areas shall have a miscellaneous load density of 0 W/ft²

TABLE D601.11.2

PROPOSED BUILDING SYSTEM PARAMETERS

Category	Parameter	Fixed or User Defined	Required	Applicable Systems
HVAC System Type	System Type	User Defined	Selected from Table D601.11.1	All
System Sizing	Design Day Information	Fixed	99.6% heating design and 1% dry-bulb and 1% wet-bulb cooling design	All
	Zone Coil Capacity	Fixed	Sizing factors used are 1.25 for heating equipment and 1.15 for cooling equipment	All
	Supply Airflow	Fixed	Based on a supply-air-to-room-air temperature set-point difference of 20°F	1-11

		Fixed	Equal to required outdoor air ventilation	12
Outdoor Ventilation Air	Outdoor Ventilation Air Flow Rate	Fixed	As specified in ASHRAE Standard 90.1 Normative Appendix C, adjusted for proposed DCV control	All
System Operation	Space Temperature Setpoints	Fixed	As specified in ASHRAE Standard 90.1 Normative Appendix C, <u>except multifamily which shall use 68°F heating and 76°F cooling setpoints</u>	1-11
	Fan Operation – Occupied	User Defined	Runs continuously during occupied hours or cycled to meet load	1-11
	Fan Operation – Occupied	Fixed	Fan runs continuously during occupied hours	12
	Fan Operation – Night Cycle	Fixed	Fan cycles on to meet setback temperatures	1-11
Packaged Equipment Efficiency	DX Cooling Efficiency	User Defined	Cooling COP without fan energy calculated in accordance with ASHRAE Standard 90.1 Section 11.5.2c ^b	1, 2, 3, 4, 5, 7, 8, 9, 11, 12
	Heat Pump Efficiency	User Defined	Heating COP without fan energy calculated in accordance with ASHRAE Standard 90.1 Section 11.5.2c ^c	2, 4, 5, 7, 8
	Furnace Efficiency	User Defined	Furnace thermal efficiency ^c	3, 11
Heat Pump Supplemental Heat	Control	Fixed	Supplemental electric heat locked out above 40°F. Runs in conjunction with compressor between 40°F and 0°F.	2, 4
System Fan Power	Design Fan Power (W/cfm)	User Defined	Input electric power for all fans in required to operate at <i>fan system design conditions</i> divided by the supply airflow rate	All
	Single Zone System Fan Power During Dead band (W/cfm)	User Defined	W/cfm during dead band for VAV or multispeed single zone fans	3, 4, 5, 6, 7, 8
Variable Air Volume Systems	Part Load Fan Controls	User Defined	VFD included. User specifies presence of static pressure reset.	9, 10, 11
	Supply Air Temperature Controls	User Defined	If not SAT reset constant at 55°F. SAT reset results in 60°F SAT during low load conditions	9, 10, 11
	Minimum Terminal Unit airflow percentage	User Defined	Average minimum terminal unit airflow percentage for <i>block</i> weighted by cfm	9, 10, 11
	Terminal Unit Heating Source	User Defined	Electric or hydronic	9, 10, 11
	Fan Powered Terminal Unit (FPTU) Type	User Defined	Series or parallel FPTU	11
	Parallel FPTU Fan	Fixed	Sized for 50% peak primary air at 0.35 W/cfm	11
	Series FPTU Fan	Fixed	Sized for 50% peak primary air at 0.35 W/cfm	11
Economizer	Economizer Presence	User Defined	Yes or No	3, 4, 9, 10, 11

	Economizer (High Limit) Control Type	Fixed	(75°F fixed) Differential dry-bulb	3, 4, 9, 10, 11
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[The remainder of the table is not shown]

Table D602.11

Standard Reference Design HVAC Systems

Parameter	Building Type				
	Large Office ^a	Small Office and Libraries ^a	Retail	School	Multifamily
System Type	Water-source Heat Pump	Packaged air-source Heat Pump	Packaged air-source Heat Pump	Packaged air-source Heat Pump	Packaged air-source Heat Pump
Fan control ^b	Cycle on load	Cycle on load	Cycle on load	Cycle on load	Cycle on load
Space condition fan power (W/cfm)	0.528	0.528	0.522	0.528	0.528
Heating/Cooling sizing factor ^c	1.25/1.15	1.25/1.15	1.25/1.15	1.25/1.15	1.25/1.15
Supplemental heating availability	NA	<40°F	<40°F	<40°F	<40°F
Modeled cooling COP (Net of fan) ^d	4.46	3.83	4.25	3.83	3.83
Modeled heating COP (Net of fan) ^d	4.61	3.81	3.57	3.81	3.86
Cooling Source	DX (heat pump)	DX (heat pump)	DX (heat pump)	DX (heat pump)	DX (heat pump)
Heat source	Heat Pump	Heat Pump	Heat Pump	Heat Pump	Heat Pump
OSA Economizer ^e	No	No	Yes	Yes	Yes
Occupied ventilation source ^f	DOAS	DOAS	DOAS	DOAS	DOAS
DOAS Fan Power (W/cfm of outside air)	0.819	0.819	0.730	0.742	0.78
DOAS temperature control ^{g, h}	Bypass	Wild	Bypass	Bypass	Wild
ERV efficiency (sensible only)	70%	70%	70%	70%	70%
WSHP Loop Heat Rejection	Cooling Tower ⁱ	NA	NA	NA	NA
WSHP Loop Heat Source	Gas Boiler ^j	NA	NA	NA	NA
WSHP Loop Temperature Control ^k	50°F to 70°F	NA	NA	NA	NA
WSHP circulation Pump W/gpm ^l	16	NA	NA	NA	NA
WSHP Loop Pumping Control ^m	HP Valves & pump VSD	NA	NA	NA	NA

a. Offices <50,000 ft² use "Small Office" parameters; otherwise use "Large Office" parameters.

b. Space conditioning system shall cycle on to meet heating and cooling set point schedules as specified in ASHRAE Standard 90.1 Normative Appendix C. One space conditioning system is modeled in each zone. Conditioning system fan operation is not necessary for ventilation delivery.

c. The equipment capacities (i.e. system coil capacities) for the *standard reference design* building design shall be based on design day sizing runs and shall be oversized by 15% for cooling and 25% for heating.

- d. COPs shown are direct heating or cooling performance and do not include fan energy use. See 90.1 appendix G (G3.1.2.1) for separation of fan from COP in packaged equipment for units where the efficiency rating includes fan energy (e.g., SEER, EER, HSPF, COP).
- e. Economizer on space conditioning systems shall be simulated when outdoor air conditions allow free cooling. Economizer high limit shall be based on differential dry-bulb control. DOAS system continues to operate during economizer mode.
- f. Airflow equal to the outside air ventilation requirements is supplied and exhausted through a separate DOAS system including a supply fan, exhaust fan, and sensible only heat exchanger. No additional heating or cooling shall be provided by the DOAS. A single DOAS system will be provided for each *block*. The DOAS supply and return fans shall run whenever the HVAC system is scheduled to operate in accordance with ASHRAE Standard 90.1 Normative Appendix C.
- g. "Wild" DOAS control indicates no active control of the supply air temperature leaving the DOAS system. Temperature will fluctuate based only on entering and leaving conditions and the effectiveness of ERV.

WA STATE INTERNATIONAL RESIDENTIAL CODE

APPENDIX T SOLAR-READY PROVISIONS DETACHED ONE- AND TWO-FAMILY DWELLINGS, MULTIPLE SINGLE-FAMILY DWELLINGS (TOWNHOUSES)

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance

SECTION AW101

SCOPE

AW101.1 General. These provisions shall be applicable for new construction where solar-ready provisions are required.

SECTION AT102

GENERAL DEFINITIONS

SOLAR-READY ZONE. A section or sections of the roof or building overhang designated and reserved for the future installation of a solar photovoltaic or solar water-heating system.

SECTION AU103

SOLAR READY ZONE

AT103.1 General. New detached one- and two-family dwellings, and multiple single-family dwellings (townhouses) with not less than 600 square feet (55.74 m²) of roof area oriented between 90 degrees and 270 degrees of true north shall comply with Sections AT103.2 through AT103.10.

Exceptions:

1. New residential buildings with a permanently installed on-site renewable energy system.
2. A building where all areas of the roof that would otherwise meet the requirements of Section AT103 are in full or partial shade for more than 70 percent of daylight hours annually.

AT103.2 Construction document requirements for solar ready zone. Construction documents shall indicate the solar ready zone.

AT103.3 Solar-ready zone area. The total solar-ready zone area shall be not less than 300 square feet (27.87 m²) exclusive of mandatory access or set back areas as required by this code. New multiple single-family dwellings (townhouses) three stories or less in height above grade plane and with a total floor area less than or equal to 2,000 square feet (185.8 m²) per dwelling shall have a solar-ready zone area of not less than 150 square feet (13.94 m²). The solar-ready zone shall be composed of areas not less than 5 feet (1.52 m) in width and not less than 80 square feet (7.44 m²) exclusive of access or set back areas as required in this code or the applicable provisions of the International Fire Code. 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.

AT103.4 Obstructions. Solar-ready zones shall be free from obstructions including, but not limited to, vents, chimneys, and roof-mounted equipment.

AT103.5 Shading. The solar-ready zone shall be set back from any existing or new permanently affixed 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.

AT103.6 Capped roof penetration sleeve. A capped roof penetration sleeve shall be provided adjacent to a solar-ready zone when the solar-ready zone has a roof slope of 2:12 or less. The capped roof penetration sleeve shall be sized to accommodate the future photovoltaic system conduit, but shall have an inside diameter not less than 1 1/4 inches.

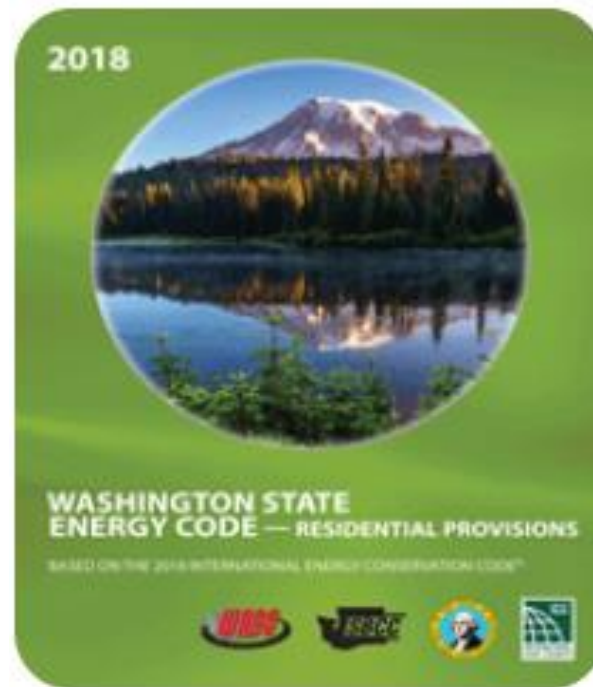
AT103.7 Roof load documentation. The structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents.

AT103.8 Interconnection pathway. Construction documents shall indicate pathways for routing of conduit or plumbing from the solar-ready zone to the electrical service panel or service hot water system.

AT103.9 Electrical service reserved space. The main electrical service or feeder panel for each dwelling unit shall have a reserved space to allow installation of a dual pole circuit breaker for future solar electric installation and shall be labeled "For Future Solar Electric." The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.

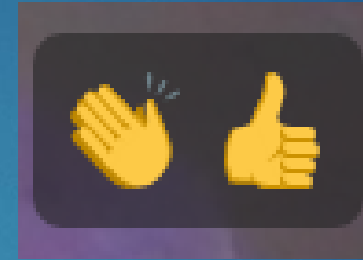
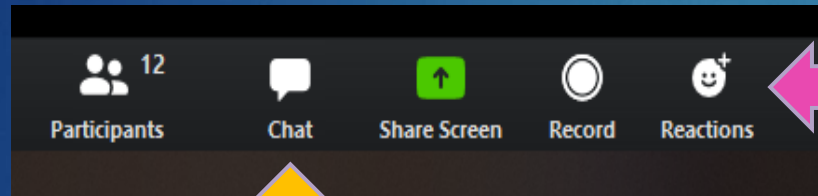
AT103.10 Construction documentation certificate. A permanent certificate, indicating the solar-ready zone and other requirements of this section, shall be posted near the electrical distribution panel, water heater or other conspicuous location by the builder or registered design professional.

RCC Recommended Local Amendments to the 2018 WA State Energy Code



February 18, 2021

Communication Methods Today...



If you wish to speak, please
“give a clap”

...Or feel free to enter comments and
questions in the chat box

** Please know today's session will be recorded. Public & private chats will all show in the resulting transcript*

Guiding Policies for this Work



Washington state Targets:

- 70% less building energy use by 2030
- Statewide GHG emission reduction:
 - 45% reduction by 2030, 95% reduction by 2050

King County Strategic Climate Action Plan:

- 50% reduction by 2030, 80% reduction by 2050

K4C Policy Commitments:

- Adopt codes that lead the way to “net-zero carbon” buildings
- Develop energy codes that support the transition to highly efficient/low carbon non-residential and multifamily buildings through reduced fossil fuels, renewable natural gas, and electrification

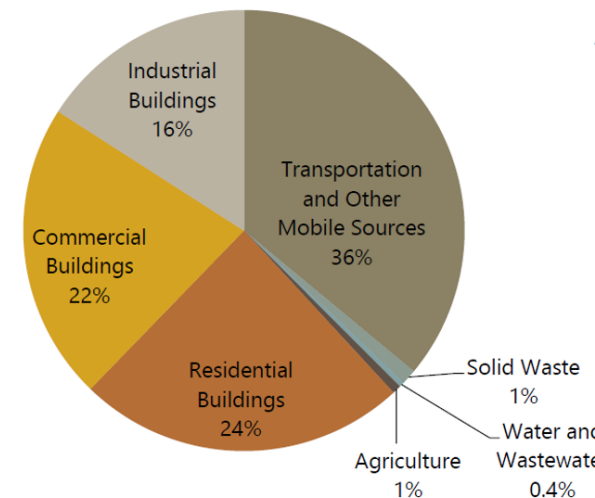


Why Us?

Attachment B

- The State will always be more conservative than we need to meet our carbon goals
- If your neighbor adopts these provisions, it will be easier to substantiate local adoption to your Council
- Broader adoptions build the case for State adoption
- More of us adopting these provisions removes the fear that development will move to somewhere else
- Equitable Action
- It's doable

Emissions from the built environment are **nearly half of countywide emissions**



Why Base the RCC Amendments on Seattle's?

Seattle established guiding principles

- Build great envelope
- Eliminate combustion
- Use electricity wisely
- Generate power

Conducted an extremely comprehensive stakeholder process

- Technical expertise (5 E/M Review Staff + Duane Jonlin)
- Public feedback sessions
- Presentations
- High industry participation & co-development

- 2018 WA State Energy Code was published February 2021
- Seattle Energy Code Adoption: March 2021
- King County Ordinance transmittal: July 2021
- These proposed amendments only apply to multifamily and nonresidential buildings
- In this PPT, “*” means the amendment is merely a change in value or a modest tweak from 2015 WSEC

RCC Recommended 2018 Energy Code Amendments

King County is currently proposing to adopt all of Seattle's amendments

Local amendments only apply to multifamily & nonresidential buildings

Amendment Highlights include:

- *Heat Pump Space Heating*
- *Hot Water Heat Pumps*
- *Identified C406 Credits*
- *Electrical Outlets at Gas Appliances*
- *Multi Family Solar Readiness*
- *Renewable Energy Requirement*
- Reduce allowable fenestration U-values
- Total System Performance Ratio (TSPR)
- Lighting Power Allowance
- Heat Recovery
- Demand Control Ventilation
- Cooling System Alterations
- Sub-Standard Envelopes
- Total Building Performance (BPF)
- Thermal Bridging
- Efficiency Package Credits
- Envelope Exemption for Kitchens
- Metering for Existing Buildings
- Service Hot Water
- DOAS

These focus on decarbonization

These Are current WSEC requirements where only values have been modified

Amendment Highlights Focusing Specifically on Decarbonization

WA State's Clean Energy Transformation Act (CETA)

- ***By 2025**, utilities must eliminate coal-fired electricity from their state portfolios*
- ***By 2030**, utilities can use limited amounts of electricity from natural gas if it is offset by other actions*
- ***By 2045**, utilities must supply electricity that is 100% renewable or non-emitting*

Heat Pump Space Heating

No electric
resistance or
fossil fuel
combustion for
space heating in
MF/Comm bldgs

=



Heat Pump



- Installed Costs vary by equipment type*
- *Variable Refrigerant Package: \$11,500/unit*
 - *Air-to-water heat pump: \$19,000/unit*

Table 3-1: Greenhouse gas savings achieved in an all-electric home relative to a natural gas-fueled home, tonnes of CO₂e annually saved, and percent reduction relative to gas

	2020	2030	2050
Single family	1.0-2.6 (33%-56%)	1.2-2.7 (52%-72%)	1.4-2.9 (76%-88%)
Low-rise multifamily	0.4-1.4 (25%-46%)	0.6-1.5 (49%-65%)	0.7-1.7 (74%-85%)

Percentages show the percent reduction of GHG emissions achieved in an all-electric home relative to a natural gas-fueled home. Ranges represent the spread across climate zones and across vintages. Homes without AC in the mixed fuel case (new construction in climate zone 3) are excluded.

Heat Pump Water Heating (HPWH)

- Required for multifamily
- delayed implementation until 1/1/2022



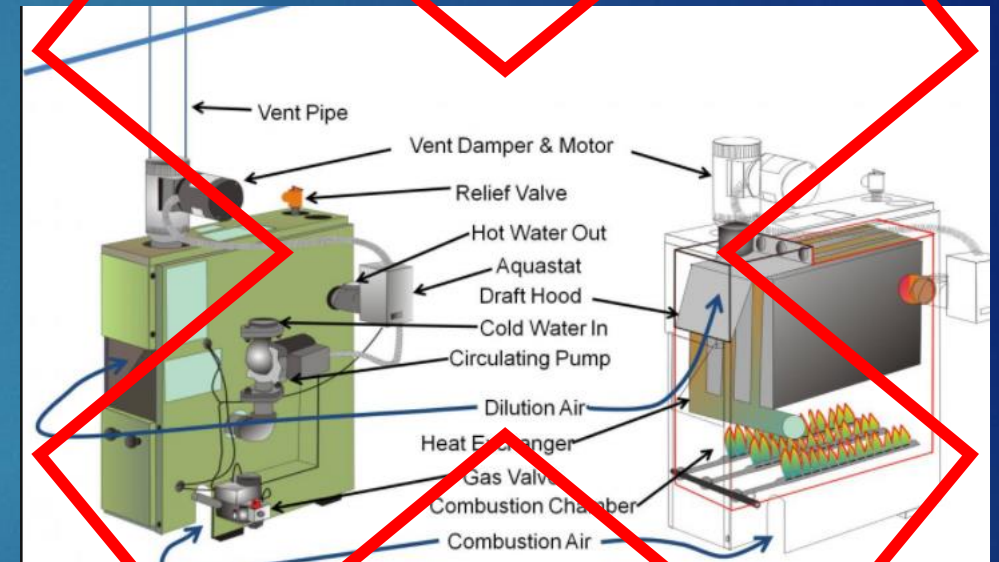
Cost to change from gas boiler to HWHP (delta)

- *Installed reverse cycle chiller system = \$1,900/unit*
- *Installed modular CO2 refrigerant system. = \$900/unit*

Disallow C406 Credit Achievement for Fossil Fuel Fired Equipment

Associated with:

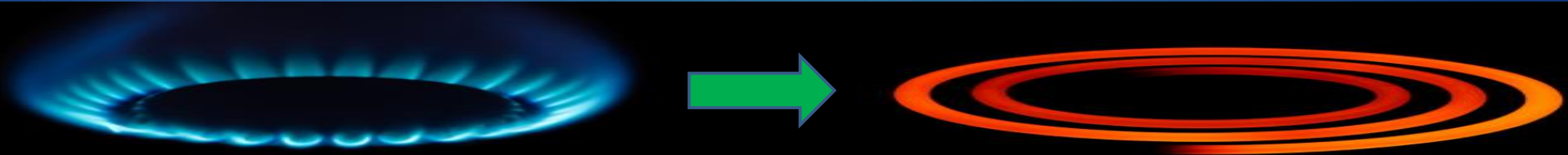
- Dedicated outdoor air system (DOAS)
- HVAC system selection
- Service water heating



Electrical Outlets at Gas Appliances

- “Where dwelling unit appliances are served by natural gas, an electrical receptacle and circuit shall be provided at each gas appliance with sufficient capacity to serve a future electric appliance in the same location”
- Applies to multifamily only

Cost: \$250/receptacle



Onsite Solar Requirements

- Applies only to multifamily & commercial buildings
- New buildings/additions >\$5,000
- Required 0.25 W/sf, based on area of all floors
- Affordable housing exempted



Cost: 10,000 sf building = \$6,500 after tax credits

How much space does this take up?

Building Stories	Roof Area Required
1	1.8%
2	3.6%
4	7.2%
6	10.9%
8	14.5%
10	18.1%
12	21.7%

Content Credit: Duane Jonlin, City of Seattle & FSI Engineers

Solar-ready Requirements in 2 Codes...

Energy Code Requirement

- Now applies to both commercial and multifamily < 20 stories
- Designate an unobstructed solar zone equal to:
 - 40 percent of roof area
 - 20 percent of electrical service size

Cost: \$100

Also adopt Appendix T in the Residential Code

- Requires a solar zone for one- and two-family residential buildings:
- 300 sf for single-family
- 150 sf for duplexes

Cost: \$75

Other Amendment Highlights

Total Building Performance *

Attachment B

Seattle's
Building
performance
values are
10% less than
WA State

TABLE C407.3(2)

BUILDING PERFORMANCE FACTORS (BPF) TO BE USED FOR COMPLIANCE WITH SECTION C407.3

Building Area Type	Building Performance Factor
Multifamily	((0.58)) <u>0.52</u>
Healthcare/hospital	((0.54)) <u>0.49</u>
Hotel/motel	((0.64)) <u>0.58</u>
Office	((0.56)) <u>0.51</u>
Restaurant	((0.70)) <u>0.63</u>
Retail	((0.47)) <u>0.43</u>
School	((0.36)) <u>0.32</u>
Warehouse	((0.48)) <u>0.43</u>
All Others 8a-147	((0.54)) <u>0.49</u>

Substandard Building Envelope Limits *

Attachment B

Seattle: Modeled envelope UA cannot be more than 10% worse than prescriptive

*WA State: Modeled envelope UA cannot be more than **20% worse** than prescriptive (allowable total UA)*



Allowable Vertical Glazing *

Attachment B

Maximum total building
vertical fenestration
area allowed = 35%

Reduced U-Values



Additional energy efficiency credit requirements *

Attachment B

C406: Must achieve 8 credits – an increase from WA State's 6 credits

EFFICIENCY PACKAGE CREDITS						
Code Section	Commercial Building Occupancy					
	Group R-1	Group R-2	Group B	Group E	Group M	All Other
	Additional Efficiency Credits					
1. More efficient HVAC performance in accordance with Section C406.2	2.0	3.0	3.0	2.0	1.0	2.0
2. Reduced lighting power: Option 1 in accordance with Section C406.3.1	1.0	1.0	2.0	2.0	3.0	2.0
3. Reduced lighting power: Option 2 in accordance with Section C406.3.2 ^a	2.0	3.0	4.0	4.0	6.0	4.0
4. Enhanced lighting controls in accordance with Section C406.4	NA	NA	1.0	1.0	1.0	
5. On-site supply of renewable energy in accordance with C406.5	3.0	3.0	3.0	3.0	3.0	
5.1 1/3 of renewable energy required by C406.5	1.0	1.0	1.0	1.0	1.0	
5.2 2/3 of renewable energy required by C406.5	2.0	2.0	2.0	2.0	2.0	
6. Dedicated outdoor air systems						

For an Apartment...

Credit: Duane Jonlin

Getting to 8 Credits (after 1/1/22)

No.	Credits	Description
#2	1	Lighting
#9	5	Advanced HPWH
#11	2	Reduced air leakage
	8	Total

8a-150

Lighting Power Allowance *

Attachment B

Reduce all interior lighting table values by 10% (from State)

- Except health care facilities, penitentiaries, & facilities for the visually impaired



Change of Occupancy

Attachment B

Where a building/space (permitted prior to 2009) is altered to become a bakery or commercial kitchen/laundry, improvements to the building envelope immediately adjoining the spaces containing that use shall not be required if the proposed design uses only:

- All-electric Energy Star-rated process equipment, and
- code compliant all-electric HVAC equipment



Metering for Existing Buildings

Metering required when:

- Area greater than 10,000 SF
- Select individual HVAC parts are added or replaced
 - Electrical meters for certain branch circuits or fan/pump on a variable speed drive
 - Natural gas meters for each new natural gas connection that is rated at 1,000+ kBTU
- Adding/replacing the majority of HVAC equipment in a building
- Tenant space electrical sub-metering for existing buildings



Amendment Highlights Continued

- Clarify that cooling system alterations must comply with the economizer compliance table, both at the individual equipment level and the total system level.
- Use ASHRAE minimum efficiency requirements table for heat pump/recovery chiller packages *
- The Demand Control Ventilation (DCV) shall now include energy recovery ventilation for spaces > 650 sf, and the threshold reduced from 25 to 15 occupants/1000 sf
- Require service hot water circulation controls and pipe/tank insulation
- Thermal bridging: Provide relaxed requirement for cantilevered concrete decks & add requirements for control of thermal bridging around glazing perimeter
- Increase the scope of the Total System Performance Ratio (TSPR) to include R-2 MF, medical office, and exempt other service areas

How Local Adoption Can be Supported

- Sharing of technical knowledge
- Ordinance language preparation
- Sharing of research/resources/findings
- Pairing jurisdictions with partners willing to provide letters/testimony of support to local Councils

Thank You!



Regional Code Collaboration

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