SEATTLE ADOPTION AND AMENDMENT OF THE 2012 EDITION OF THE INTERNATIONAL ENERGY CONSERVATION CODE, COMMERCIAL

Draft Version 2 – September 3, 2013

Chapter 1 Scope and administration
Section C101
Scope and general requirements.

C101.1 Title. This code, consisting of Chapter 1 [CE] through Chapter 5 [CE] and Appendices A through D, shall be known as the "Commercial Portions of the *International Energy Conservation Code* of Seattle" ((~~[NAME OF JURISDICTION]~~)) or the "Seattle Commercial Energy Code"**,** and shall be cited as such. It is referred to herein as "this code."

C101.2 Scope. This code applies to *commercial buildings* and the buildings sites and associated systems and equipment.

> **EXCEPTION**: The provisions of this code do not apply to temporary growing structures used solely for the commercial production of horticultural plants including ornamental plants, flowers, vegetables, and fruits. "Temporary growing structure" means a structure that has the sides and roof covered with polyethylene, polyvinyl, or similar flexible synthetic material and is used to provide plants with either frost protection or increased heat retention. A temporary growing structure is not considered a building for purposes of this code.

C101.3 Intent. This code shall regulate the design and construction of buildings for the effective use and conservation of energy over the useful 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 C101.4
Applicability.

C101.4 Applicability. Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

C101.4.1 Existing buildings. Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing building or building system lawfully in existence at the time of adoption of this code.

C101.4.2 ((~~Historic~~)) *Landmark* buildings. The ((~~building official~~)) *code official* may modify the specific requirements of this code for ((~~historic buildings~~)) *landmarks* and require in lieu thereof alternate requirements ~~which~~ that the *code official* determines will not have an adverse effect on the designated historic features of the building and will result in a reasonable degree of energy efficiency.

((~~This modification may be allowed for those buildings or structures that are listed in the state or national register of historic places; designated as a historic property under local or state designation law or survey; certified as a contributing resource with a national register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the national or state registers of historic places either individually or as a contributing building to a historic district by the state building, building system or portion~~

~~thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this code.~~))

C101.4.3 Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this code. Additions, alterations, renovations or repairs shall not create an unsafe or hazardous condition or overload existing building systems. An addition shall be deemed to comply with this code if the addition alone complies or if the existing building and addition comply with this code as a single building. *Substantial alterations* and repairs shall comply with the provisions of Section C101.4.7.

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

1. Storm windows installed over existing *fenestration*.
2. Glass only replacements in an existing sash and frame.
3. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are insulated to full depth with insulation having a minimum nominal value of R-3.0 per inch installed per Section C402.
4. Construction where the existing roof, wall or floor cavity is not exposed.
5. Reroofing for roofs where neither the sheathing nor the insulation is exposed. Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either above or below the sheathing.
6. Replacement of existing doors that separate *conditioned space* from the exterior shall not require the installation of a vestibule or revolving door, provided, however, that an existing vestibule that separates a *conditioned space* from the exterior shall not be removed.
7. Alterations to lighting systems only that replace less than ((~~60~~)) 20 percent of the luminaires in a space, provided that such alterations do not increase the installed interior lighting power.
8. ~~Alterations that replace only the bulb and ballast within the existing luminaires in a space provided that the *alteration* does not increase the installed interior lighting power.~~

C101.4.3.1 Lighting and motors. Alterations that add, alter or replace ((~~60~~)) 20 percent or more of the luminaires or of the lamps plus ballasts alone in a space enclosed by walls or ceiling-height partitions, or on the exterior of the building, shall comply with Sections C405.5 and C405.6. Where less than ((~~60~~)) 20 percent of the fixtures in a space enclosed by walls or ceiling-height partitions, or on the exterior of the building, are new or altered, the installed lighting wattage shall be maintained or reduced.

New lighting control devices shall comply with the requirements of Section C405.2. Where new wiring is being installed to serve added fixtures and/or fixtures are being relocated to a new circuit, controls shall comply with Sections C405.2.1, C405.2.2.3, C405.2.3, C405.2.4 ((~~C405.3.4~~)), and as applicable C408.3. In addition, office areas less than 300 ft^2 enclosed by walls or ceiling-height partitions, and all meeting and conference rooms, and all school classrooms, shall be equipped with occupancy sensors that comply with Section C405.2.2 and C408.3. 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

the other requirements in Sections C405.2.2 and C408.3.

Where new walls or ceiling-height partitions are added to an existing space and create a new enclosed space, but the lighting fixtures are not being changed, other than being relocated, the new enclosed space shall have controls that comply with Sections C405.2.1, C405.2.2, C405.2.3 and C408.3.

Those motors which are altered or replaced shall comply with Section C403.2.13. In no case shall the energy efficiency of the building be decreased.

C101.4.3.2 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.

All new systems in existing buildings, including packaged unitary equipment and packaged split systems, shall comply with Section C403.

Where mechanical cooling is added to a space that was not previously cooled, the mechanical cooling system shall comply with the economizer requirements in Section C403.3.1 or C403.4.1.

EXCEPTION: Alternate designs that are not in full compliance with this code may be approved when the building official determines that existing building or occupancy constraints make full compliance impractical or where full compliance would be economically impractical.

Alterations to existing mechanical cooling systems shall not decrease economizer capacity unless the system complies with Section C403.3.1 or C403.4.1. In addition, for existing mechanical cooling systems that do not comply with Sections C403.3.1 or Section C403.4.1, including both the individual unit size limits and the total building capacity limits on units without economizer, other alterations shall comply with Table ((~~C101.4.3.1~~)) C101.4.3.2.

When space cooling equipment is replaced, controls shall be installed to provide for integrated operation with economizer in accordance with Section C403.3.

Existing equipment currently in use may be relocated within the same floor or same tenant space if removed and reinstalled within the same permit.

C101.4.4 Change in occupancy or use. Spaces undergoing a change in occupancy from an F, S or U occupancy to an occupancy other than F, S or U shall comply with this code. Any space that is converted to a residential dwelling unit or portion thereof, from another use or occupancy shall comply with this code. Where the use in a space changes from one use in Table C405.5.2(1) or (2) to another use in Table C405.5.2(1) or (2), the installed lighting wattage shall comply with Section C405.5.

EXCEPTION: Where the component performance building envelope option in Section C402.1.3 is used to comply with this section, the Proposed UA is allowed to be up to 110 percent of the Target UA. Where the total building performance option in Section C407 is used to comply with this section, the annual energy consumption of the proposed design is allowed to be 110 percent of the annual energy consumption otherwise allowed by Section C407.3 and Section C401.2 (3).

C101.4.5 Change in space conditioning. Any nonconditioned space that is altered to become *conditioned space* or *semi-heated* space shall be required to be brought into full compliance with this code. Any semi-heated space 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 required to be brought into full compliance with this code.

EXCEPTION: Where the component performance building envelope option in Section C402.1.3 is used to comply with this section, the Proposed UA is allowed to be up to 110

percent of the Target UA. Where the total building performance option in Section C407 is used to comply with this section, the annual energy consumption of the proposed design is allowed to be 110 percent of the annual energy consumption otherwise allowed by Section C407.3 and Section C401.2 (3).

C101.4.6 Mixed occupancy. Where a building includes both *residential* and *commercial* occupancies, each occupancy shall be separately considered and meet the applicable provisions of IECC-Commercial Provisions or IECC--Residential Provisions.

Table ((~~C101.4.3.1~~)) C101.4.3.2
Economizer Compliance Options for Mechanical Alterations

	Option A	**Option B (alternate to A)**	**Option C (alternate to A)**	**Option D** [17] **(alternate to A)**
Unit Type	**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. (reserved)				
2. Split Systems	Efficiency: min.[1] Economizer: C403.4.1[2]	Efficiency: + 10/5%[5] Economizer: Shall not decrease existing economizer capability	Only for new units < 54,000 Btu/h replacing unit installed prior to 1991 (one of two): Efficiency: + 10/5%[5] Economizer: 50%[6] For units > 54,000 Btu/h or any units installed after 1991: Option A	Efficiency: min.[1] Economizer: C403.4.1[2, 4]
3. Water Source Heat Pump	Efficiency: min.[1] Economizer: C403.4.1[2]	(two of three): Efficiency: + 10/5%[5] Flow control valve[7] Economizer: 50%[6]	(three of three): Efficiency: + 10/5%[5] Flow control valve[7] Economizer: 50%[6] (except for certain pre-1991 systems[8])	Efficiency: min.[1] Economizer: C403.4.1[2, 4] (except for certain pre-1991 systems[8])
4. Hydronic Economizer using Air-Cooled Heat Rejection Equipment (Dry Cooler)	Efficiency: min.[1] Economizer: 1433[2]	Efficiency: + 10/5%[5] Economizer: Shall not decrease existing economizer capacity	Option A	Efficiency: min.[1] Economizer: C403.4.1[2, 4]
5. Air-Handling Unit (including fan coil units) where the system has an air-cooled chiller	Efficiency: min.[1] Economizer: C403.4.1[2]	Economizer: Shall not decrease existing economizer capacity	Option A (except for certain pre-1991 systems[8])	Option A (except for certain pre-1991 systems[8])
6. Air-Handling Unit (including fan coil units) and Water-cooled Process Equipment, where the system	Efficiency: min.[1] Economizer: C403.4.1[2]	Economizer: Shall not decrease existing economizer capacity	Option A (except for certain pre-1991 systems[8] and certain 1991-2004 systems[9])	Efficiency: min.[1] Economizer: C403.4.1[2, 4] (except for certain pre-1991 systems[8] and certain 1991-2004 systems[9])

has a water-cooled chiller[10]				
7. Cooling Tower Unit Type	Efficiency: min.[1] Economizer: C403.4.1[2] Any alteration with new or replacement equipment	No requirements Replacement unit of the same type with the same or smaller output capacity	Option A Replacement unit of the same type with a larger output capacity	Option A New equipment added to existing system or replacement unit of a different type
8. Air-Cooled Chiller	Efficiency: min.[1] Economizer: C403.4.1[2]	Efficiency: .+ 5%[11] Economizer: Shall not decrease existing economizer capacity	Efficiency (two of two): (1) .+ 10%[12] and (2) multistage Economizer: Shall not decrease existing economizer capacity	Efficiency: min.[1] Economizer: C403.4.1[2, 4]
9. Water- Cooled Chiller	Efficiency: min.[1] Economizer: C403.4.1[2]	Efficiency (one of two): (1) .+ 10%[13] or (2) plate frame heat exchanger[15] Economizer: Shall not decrease existing economizer capacity	Efficiency (two of two): (1) .+ 15%[14] and (2) plate frame heat exchanger[15] Economizer: Shall not decrease existing economizer capacity	Efficiency: min.[1] Economizer: C403.4.1[2, 4]
10. Boiler	Efficiency: min.[1] Economizer: C403.4.1[2]	Efficiency: .+ 8%[16] Economizer: Shall not decrease existing economizer capacity	Efficiency: .+ 8%[16] Economizer: Shall not decrease existing economizer capacity	Efficiency: min.[1] Economizer: C403.4.1[2, 4]

[1] Minimum equipment efficiency shall comply with Section C403.2.3 and Tables C403.2.3(1) through C403.2.3(9).

[2] System and building shall comply with Section C403.4.1 (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 C403.4.1.

[3] All equipment replaced in an existing building shall have air economizer complying with Sections C403.3.1 and C403.4.1 unless both the individual unit size and the total capacity of units without air economizer in the building is less than that allowed in Exception 1 to Section C403.3.1.

[4] All separate new equipment added to an existing building shall have air economizer complying with Sections C403.3.1 and C403.4.1 unless both the individual unit size and the total capacity of units without air economizer in the building is less than that allowed in Exception 1 to Section C403.4.1.

[5] Equipment shall have a capacity-weighted average cooling system efficiency:

a. For units with a cooling capacity below 54,000 Btu/h, a minimum of 10% greater than the requirements in Tables C403.2.3(1) and C403.2.3(2) (1.10 x values in Tables C403.2.3(1) and C403.2.3(2)).

b. For units with a cooling capacity of 54,000 Btu/h and greater, a minimum of 5% greater than the requirements in Tables C403.2.3(1) and C403.2.3(2) (1.05 x values in Tables C403.2.3(1) and C403.2.3(2)).

[6] Minimum of 50% 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 capable of providing this additional outside air and equipped with economizer control.

[7] Have flow control valve to eliminate flow through the heat pumps that are not in operation with variable speed pumping control complying with Section C403.4.3 for that heat pump.

a. When the total capacity of all units with flow control valves exceeds 15% of the total system capacity, a variable frequency drive shall be installed on the main loop pump.

b. As an alternate to this requirement, have a capacity-weighted average cooling system efficiency that is 5% greater than the requirements in note 5 (i.e., a minimum of 15%/10% greater than the requirements in Tables C403.2.3(1) and C403.2.3(2) (1.15/1.10 x values in Tables C403.2.3(1) and C403.2.3(2)).

[8] 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 Btu/h.

[9] Economizer not required for systems installed with water economizer plate and frame heat exchanger complying with previous codes between 1991 and June 2013, provided that the total fan coil load does not exceed the existing or added capacity of the heat exchangers.

[10] For water-cooled process equipment where the manufacturers' specifications require colder temperatures than available with waterside economizer, that portion of the load is exempt from the economizer requirements.

[11] The air-cooled chiller shall have an IPLV efficiency that is a minimum of 5% greater than the IPLV requirements <u>in EER</u> in Table C403.2.3(7) (1.05 x IPLV values <u>in EER</u> in Table C403.2.3(7)).

[12] The air-cooled chiller shall:

a. Have an IPLV efficiency that is a minimum of 10% greater than the IPLV requirements <u>in EER</u> in Table C403.2.3(7) (1.10 x IPLV values <u>in EER</u> in Table C403.2.3(7)); and

b. Be multistage with a minimum of two compressors.

[13] The water-cooled chiller shall have an IPLV efficiency that is a minimum of 10% greater than the IPLV requirements <u>in kW/ton</u> in Table C403.2.3(7) (1.10 x IPLV values <u>in kW/ton</u> in Table C403.2.3(7)). <u>Water cooled centrifugal chillers designed for non-standard conditions shall have an NPLV efficiency that is at least 10 percent greater than the adjusted maximum NPLV rating in kW/ton defined in paragraph C403.2.3.1 (1.10 x NPLV).</u>

[14] The water-cooled chiller shall have an IPLV efficiency that is a minimum of 15% greater than the IPLV requirements <u>in kW/ton</u> in Table C403.2.3(7), (1.15 x IPLV values <u>in kW/ton</u> in Table C403.2.3(7)). <u>Water cooled centrifugal chillers designed for non-standard conditions shall have an NPLV efficiency that is at least 10% greater than the adjusted maximum NPLV rating in kW/ton defined in paragraph C403.2.3.1 (1.10 x NPLV).</u>

[15] Economizer cooling shall be provided by adding a plate-frame heat exchanger on the waterside with a capacity that is a minimum of 20% of the chiller capacity at standard AHRI

rating conditions.

[16] The replacement boiler shall have an efficiency that is a minimum of 8% higher than the value in Table C403.2.3(5) (1.08 x value in Table C403.2.3(5)), except for electric boilers.

[17] Economizers are not required for the following qualifying small equipment: This exception shall not be used for unitary cooling equipment installed outdoors or in a mechanical room adjacent to the outdoors. This exception is allowed to be used for other cooling units and split systems with a total cooling capacity rated in accordance with Section C403.2.3 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 C403.2.3 (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 its air economizer capacity, whichever is greater. That portion of the equipment serving residential occupancies is not included in determining the total capacity of all units without economizers in a building. Redundant units are not counted in the capacity limitations. This exception shall not be used for the shell-and-core permit or for the initial tenant improvement or for Total Building Performance.

C101.4.7 Substantial alterations or repairs. In addition to meeting the applicable requirements of this code, any building or structure to which substantial alterations or repairs are made shall comply with the requirements of this section. A permit application for a voluntary energy upgrade to the building envelope is permitted to be made separately from the permit application for a substantial alterations project, provided that the threshold determination for substantial alterations includes the value of any such building envelope work.

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, 3 or 4 of Section C101.4.7.3 is permitted to be increased in proportion to the additional energy use required for protection 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.

C101.4.7.1 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*.

Informative Note: Definitions 1, 2 and 4 of "substantial alterations or repairs" in the Seattle amendments to the IEBC 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.

C101.4.7.2 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.

C101.4.7.3 Energy Efficiency. Buildings undergoing substantial alterations shall comply with one of the following:

1. Full code compliance. Fully comply with the requirements of this code for new construction.

2. Envelope thermal performance within 20 percent of code. Demonstrate that heat loss through the altered building envelope is no more than 20 percent greater than allowed by the Seattle Energy Code, using the Component Performance Building Envelope Option in Section C402.1.3, and meet all other prescriptive requirements of the Seattle Energy Code for new construction.

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 with permits issued 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.

3. Total building performance within 15 percent of code. Demonstrate that the building energy consumption will be less than 108 percent of the standard reference design using the Total Building Performance methodology in Section C407 of the Seattle Energy Code.

4. Operating energy alternative. The *code official* may allow a calculated building energy consumption 20 percent greater than the standard reference design calculated in accordance with the Total Building Performance methodology in Section C407, provided that:

a. The applicant demonstrates that constructability, economic, or historic preservation considerations preclude conformance with any of the above options; and

b. The owner agrees to operate the altered building at or below the annual energy use level predicted for that calculated energy performance during a period of 12 consecutive months, concluding no later than three years after issuance of the certificate of occupancy, adjusted as allowed by Sections C402.1.5.6 through C402.1.5.10, and to meet the requirements of Sections C402.1.5.11 through C402.1.5.13, substituting the energy consumption standard in option 4 of this Section C101.4.7.3 for the energy consumption targets set out in Section C402.1.5.2.

4.1. Reporting. The building owner shall report the energy consumption in kBTU/square foot using automated reporting directly from utilities via Energy Star Portfolio Manager, and shall authorize the *code official* to view the reports directly in Portfolio Manager during the demonstration period.

C101.4.7.4 Impracticality. In cases where full compliance with all the requirements of Section C101.4.7 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.

C101.5 Compliance. *Residential buildings* shall meet the provisions of IECC--Residential Provisions. *Commercial buildings* shall meet the provisions of IECC--Commercial Provisions.

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

C101.5.2 Low energy buildings. The following buildings, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this code shall be exempt from all thermal envelope provisions of this code:

1. Those that are heated and/or cooled with a peak design rate of energy usage less than 3.4 Btu/h/ft^2 (10.7 W/m^2) or 1.0 watt/ft^2 (10.7 W/m^2) of floor area for space conditioning purposes.
2. Those that do not contain *conditioned space*.
3. Greenhouses isolated from any conditioned space and not intended for occupancy.

C101.5.2.1 Semi-heated spaces. A *semi-heated* space shall meet all of the *building thermal envelope* requirements, except that insulation is not required for opaque wall assemblies. *Fenestration* shall comply with building thermal envelope requirements. Component performance calculations involving semi-heated spaces shall calculate fully insulated opaque walls for the Target UA calculation, and Total Building Performance calculations involving semi-heated spaces shall calculate fully insulated opaque walls for the Standard Reference Design.

> **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-ft^2 heating capacity are not required to be insulated. The opaque walls of spaces that meet the definition of "semi-heated" in Chapter 2 are not required to be insulated, but otherwise the thermal envelope of semi-heated spaces must meet all requirements for conditioned space. Spaces with any mechanical cooling or with more than 8 BTU/h-ft^2 heating capacity must meet all the building thermal envelope requirements for conditioned space.

C102.1 General. This code does not ((~~is not intended to~~)) prevent the use of any material, method of construction, design or insulating system prohibited by this code or not specifically ((~~prescribed~~)) allowed herein, provided that such construction, design or insulating system has been *approved* by the *code official* ((~~as meeting the intent of this code~~)).

The *code official* may approve an alternate material, method of construction, design or insulating system, provided the *code official* finds that the proposed alternate complies with the provisions of this code, and that the alternate, when considered together with other safety features of the building or other relevant circumstances, will provide at least an equivalent level of strength, effectiveness, fire resistance, durability, safety and sanitation.

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.

Section C103
Applications and permits ((~~Construction documents.~~))

C103.1 General. A permit for work performed according to this code shall be obtained in accordance with Chapter 1 of the International Building Code, International Mechanical Code or Seattle Electrical Code.

C103.2 Construction documents. Construction documents and other supporting data shall comply with this section and the International Building Code, International Mechanical Code, International Existing Building Code and Seattle Electrical Code. ((~~be submitted in one or more sets with each application for a permit. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the *code official* is authorized to require necessary construction documents to be prepared by a registered design professional.~~

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

C103.2.1 Information on construction documents. Construction documents shall be drawn to scale upon suitable material. Electronic media documents are permitted to be submitted when *approved* by the *code official*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, as applicable, insulation materials and their *R*-values; *fenestration* *U*-factors and SHGCs; area-weighted *U*-factor and SHGC calculations; mechanical system design criteria; mechanical and service water heating system and equipment types, sizes and efficiencies; economizer description; equipment and systems controls; fan motor horsepower (hp) and controls; duct sealing, duct and pipe insulation and location; lighting fixture schedule with wattage and control narrative; and air sealing details.

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

~~**C103.3.1 Approval of construction documents.** When the *code official* issues a permit where construction documents are required, the construction documents shall be endorsed in writing~~

~~and stamped "Reviewed for Code Compliance." Such *approved* construction documents shall not be changed, modified or altered without authorization from the *code official*. Work shall be done in accordance with the *approved* construction documents.~~

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

~~**C103.3.2 Previous approvals.** This code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.~~

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

~~**C103.4 Amended construction documents.** Changes made during construction that are not in compliance with the *approved* construction documents shall be resubmitted for approval as an amended set of construction documents.~~

~~**C103.5 Retention of construction documents.** One set of *approved* construction documents shall be retained by the *code official* for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.~~))

Section C104
Inspections.

C104.1 General. Construction or work for which a permit is required shall be subject to inspection by the *code official* in accordance with this section and the International Building Code, International Mechanical Code and Seattle Electrical Code.

C104.2 Required approvals. Work shall not be done beyond the point indicated in each successive inspection without first obtaining the approval of the *code official*. The *code official*, upon notification, shall make the requested inspections and shall either indicate the portion of the construction that is satisfactory as completed, or notify the permit holder or his or her agent wherein the same fails to comply with this code. Any portions that do not comply shall be corrected and such portion shall not be covered or concealed until authorized by the *code official*. Where applicable, inspections shall include at least:

C104.2.1 Envelope

C104.2.1.1 Wall Insulation Inspection: To be made after all wall insulation and air vapor retarder sheet or film materials are in place, but before any wall covering is placed.

C104.2.1.2 Glazing Inspection: To be made after glazing materials are installed in the building.

C104.2.1.3 Exterior Roofing Insulation: To be made after the installation of the roof insulation, but before concealment.

C104.2.1.4 Slab/Floor Insulation: To be made after the installation of the slab/floor insulation, but before concealment.

C104.2.2 Mechanical

C104.2.2.1 Mechanical Equipment Efficiency and Economizer: To be made after all equipment and controls required by this code are installed and prior to the concealment of such equipment or controls.
C104.2.2.2 Mechanical Pipe and Duct Insulation: To be made after all pipe and duct insulation is in place, but before concealment.
C104.2.3 Lighting and motors
C104.2.3.1 Lighting Equipment and Controls: To be made after the installation of all lighting equipment and controls required by this code, but before concealment of the lighting equipment.
C104.2.3.2 Motor Inspections: To be made after installation of all equipment covered by this code, but before concealment.
C104.3 Final inspection. The building shall have a final inspection and not be occupied until *approved*.
C104.4 Reinspection. A building shall be reinspected when determined necessary by the *code official*.
C104.5 Approved inspection agencies. The *code official* is authorized to accept reports of *approved* inspection agencies, provided such agencies satisfy the requirements as to qualifications and reliability.
C104.6 Inspection requests. It shall be the duty of the holder of the permit or their duly authorized agent to notify the *code official* when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this code.
C104.7 Reinspection and testing. Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made so as to achieve compliance with this code. The work or installation shall then be resubmitted to the *code official* for inspection and testing.
~~((**C104.8 Approval.** After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the *code official*.~~
~~**C104.8.1 Revocation.** The *code official* is authorized to, in writing, suspend or revoke a notice of approval issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the building or structure, premise, or portion thereof is in violation of any ordinance or regulation or any of the provisions of this code.~~))

Section C105
Validity.

C105.1 General. If a portion of this code is held to be illegal or void, such a decision shall not affect the validity of the remainder of this code.

Section C106
Referenced standards.

C106.1 Referenced codes and standards. The codes and standards referenced in this code shall be those listed in Chapter 5, and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections C106.1.1 and C106.1.2.
C106.1.1 **References to other codes.** Whenever an International, National or Uniform Code is referenced in this code, it means the Seattle edition of that code, which includes local amendments. References to the "Building Code", "Residential Code", "Fire Code", "Electrical Code", "Mechanical Code" and "Plumbing Code" mean the Seattle editions of those codes.

((~~**Conflicts.** Where differences occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.~~))

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

C106.2 Conflicting requirements. Where the provisions of this code and the referenced standards conflict, the provisions of this code shall take precedence.

C106.3 Application of references. References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

C106.4 Other laws. The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law. ((~~In addition to the requirements of this code, all occupancies shall conform to the provisions included in the State Building Code (chapter 19.27 RCW). In case of conflicts among the codes enumerated in RCW 19.27.031 (1) through (4) and this code, an earlier named code shall govern over those following.~~)) In the case of conflict between the duct sealing and insulation requirements of this code and the duct insulation requirements of Sections 603 and 604 of the *International Mechanical Code*, the duct insulation requirements of this code, or where applicable, a local jurisdiction's energy code shall govern.

Section C107
Fees.

C107.1 Fees. A fee for each permit and for other activities related to the enforcement of this code shall be paid as set forth in the Fee Subtitle, Seattle Municipal Code Title 22, Subtitle IX.

((~~A permit shall not be issued until the fees prescribed in Section C107.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.~~

~~**C107.2 Schedule of permit fees.** A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.~~

~~**C107.3 Work commencing before permit issuance.** Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the *code official*, which shall be in addition to the required permit fees.~~

~~**C107.4 Related fees.** The payment of the fee for the construction, *alteration*, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.~~

~~**C107.5 Refunds.** The *code official* is authorized to establish a refund policy.~~))

Section C108
((~~Stop work order.~~)) Enforcement

C108.1 Authority. The *code official* is authorized to enforce this code in accordance with the International Building Code, International Mechanical Code and Seattle Electrical Code. ((~~Whenever the *code official* finds any work regulated by this code being performed in a manner either contrary to the provisions of this code or dangerous or unsafe, the *code official* is authorized to issue a stop work order.~~

~~**C108.2 Issuance.** The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner's agent, or to the person doing the work. Upon issuance of a~~

~~stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order, and the conditions under which the cited work will be permitted to resume.~~

~~**C108.3 Emergencies.** Where an emergency exists, the *code official* shall not be required to give a written notice prior to stopping the work.~~

~~**C108.4 Failure to comply.** Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be liable to a fine of not less than **[AMOUNT]** dollars or more than **[AMOUNT]** dollars.~~))

Section C109

((~~Board of appeals.~~)) Administrative review

C109.1 Administrative review by the *code official*. Applicants may request administrative review by the *code official* of decisions or actions pertaining to the administration and enforcement of this code. Requests shall be addressed to the *code official*.

C109.2 Administrative review by the Construction Codes Advisory Board. Applicants may request review by the Construction Codes Advisory Board of decisions or actions pertaining to the application and interpretation of this code. The review will be performed by a panel of three or more members of the Construction Codes Advisory Board, chosen by the Board Chair. The Chair shall consider the subject of the review and members' expertise when selecting members to conduct a review. The decision of the review panel is advisory only; the final decision is made by the code official.

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

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

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

Section C110

Violations.

It shall be unlawful for any person, firm, or corporation to erect or construct any building, or remodel or rehabilitate any existing building or structure in the state, or allow the same to be done, contrary to or in violation of any of the provisions of this code. Violations shall be administered according to the procedures set forth in Section 103 of the International Building Code.

Section C111

Liability.

Nothing contained in this code is intended to be nor shall be construed to create or form the basis for any liability on the part of any city or county or its officers, employees or agents for any

injury or damage resulting from the failure of a building to conform to the provisions of this code, or by reason or as a consequence of any inspection, notice, order, certificate, permission or approval authorized or issued or done in connection with the implementation or enforcement of this code, or by reason of any action or inaction on the part of the City related in any manner to the enforcement of this code by its officers, employees or agents.

This code shall not be construed to relieve or lessen the responsibility of any person owning, operating or controlling any building or structure for any damages to persons or property caused by defects, nor shall the Department of Planning and Development or the City of Seattle be held to have assumed any such liability by reason of the inspections authorized by this code or any permits or certificates issued under this code.

Chapter 2 [CE]--Definitions.

Section C201--General.

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

C201.2 Interchangeability. Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural includes the singular.

C201.3 Terms defined in other codes. Terms that are not defined in this code but are defined in the *International Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *Uniform Plumbing Code* or the *International Residential Code* shall have the meanings ascribed to them in those codes.

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

Section C202--General definitions.

ABOVE-GRADE WALL. A wall enclosing *conditioned space* that is not a below-grade wall. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

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

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

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

ALTERATION. Any construction or renovation to an existing structure other than repair or

addition that requires a permit. Also, a change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.

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

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

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

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

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

BUILDING COMMISSIONING. A process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner's project requirements and construction documents, and to minimum code requirements.

BUILDING ENTRANCE. Any door, set of doors, doorway, or other form of portal (including elevator doors such as in parking garages) that is used to gain access to the building from the outside by the public. Where buildings have separate one-way doors to enter and leave, this also includes any doors ordinarily used to leave the building.

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

BUILDING THERMAL ENVELOPE. The below-grade walls, above-grade walls, floor, roof, and any other building elements that enclose *conditioned space* or provides a boundary between *conditioned space, semiheated space* and exempt or unconditioned space.

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

CODE OFFICIAL. The ((~~officer or other designated authority~~)) Director of the Seattle Department of Planning and Development charged with the administration and enforcement of this code, or a duly authorized representative.

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

COEFFICIENT OF PERFORMANCE (COP) - HEATING. The ratio of the rate of heat removal to the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump

system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.

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

COMPUTER ROOM. A room whose primary function is to house electronic equipment for the processing and storage of electronic data and that has a design electronic data equipment power density exceeding 20 watts/ft^2 of conditioned floor area (215 watts/m^2).

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

CONDITIONED SPACE. An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent *conditioned space*. 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 AIR BARRIER. A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

CONTINUOUS INSULATION (CI). Insulation that is continuous across all structural members without thermal bridges other than service openings and penetrations by metal fasteners with a cross-sectional area, as measured in the plane of the surface, of less than 0.04% of the opaque surface area of the assembly. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

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

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

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

DAYLIGHT ZONE. (See also Fig. C202.4)

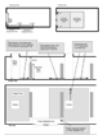
1. **Under skylights.** The area under skylights whose horizontal dimension, in each direction, is equal to the skylight dimension in that direction plus either 70 percent of the floor-to-ceiling height or the dimension to a ceiling height opaque partition, or to a partition that is more than 50 percent opaque, or one-half the distance to adjacent skylights or vertical *fenestration*, whichever is least.

2. **Adjacent to vertical *fenestration*.** The area adjacent to vertical *fenestration* which receives daylight through the *fenestration*. For purposes of this definition and unless more detailed analysis is provided, the primary daylight *zone* depth is assumed to extend into the space a distance equal to the window head height and the secondary daylighted zone extends from the edge of the primary zone to a distance equal to two times the window head height or to the nearest ceiling height opaque partition, or to a partition that is more than 50 percent opaque, whichever is less. The daylight *zone* width is assumed to be the width of the window plus 2 feet (610 mm) on each side, or the window width plus the distance to an opaque partition, or the window width plus one-half the distance to adjacent skylight or vertical *fenestration*, whichever is least.

3. **In parking garages.** The area within 20 feet of any portion of a perimeter wall that has a net opening to wall ratio of at least 40 percent and no exterior obstructions within 20 feet.

4. **Under atrium glazing.** The area at the floor directly beneath the atrium and the top floor under the atrium, whose horizontal dimension, in each direction, is equal to the distance between the floor and ceiling height. Levels below the top floor that are not directly beneath the atrium are unaffected.

Figure C202.4



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

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

DPD. The Seattle Department of Planning and Development.

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

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts,

includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

FENESTRATION PRODUCT, FIELD-FABRICATED. A *fenestration* product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a *fenestration* product or exterior door. Field fabricated does not include site-built *fenestration*.

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

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

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

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

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

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

HIGH-EFFICACY LUMINAIRES. Luminaires with compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

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

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

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

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

of R-2.

INSULATION ENTIRELY ABOVE DECK. A roof with all insulation:

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

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

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

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.

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

LANDMARK. A building or structure that is subject to a requirement to obtain a certificate of approval from the City Landmarks Preservation Board before altering or making significant changes to specific features or characteristics, that has been nominated for designation or has been designated for preservation by the City Landmarks Preservation Board, that has been designated for preservation by the State of Washington, has been listed or determined eligible to be listed in the National Register of Historic Places, or is located in a landmark or special review district subject to a requirement to obtain a certificate of approval before making a change to the external appearance of the structure.

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

LOW-VOLTAGE LIGHTING. A lighting system consisting of an isolating power supply, the low voltage luminaires, and associated equipment that are all identified for the use. The output circuits of the power supply operate at 30 volts (42.4 volts peak) or less under all load conditions.

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

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

METAL BUILDING ROOF. A roof that:

1. Is constructed with a metal, structural, weathering surface;
2. Has no ventilated cavity; and
3. Has the insulation entirely below deck (i.e., does not include composite concrete and

metal deck construction nor a roof framing system that is separated from the superstructure by a wood substrate) and whose structure consists of one or more of the following configurations:

a. Metal roofing in direct contact with the steel framing members;
b. Metal roofing separated from the steel framing members by insulation;
c. Insulated metal roofing panels installed as described in a or b.

METAL BUILDING WALL. A *wall* whose structure consists of metal spanning members supported by steel structural members (i.e., does not include spandrel glass or metal panels in curtain *wall systems*).

METER. A device that measures the flow of energy.

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

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

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

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

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

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

QUALIFIED COMMISSIONING AUTHORITY . A person qualified by formal training and at least two years' experience commissioning projects of similar scale and complexity, and who is a registered design professional, an ASHRAE Commissioning Process Management Professional, a Building Commissioning Association (BCA) Certified Commissioning Professional, or an AABC Commissioning Group (ACG) Certified Commissioning Authority.

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

REFRIGERATED WAREHOUSE COOLER. An enclosed storage space capable of being refrigerated to temperatures above 32°F that can be walked into and has a total chilled storage

area of 3,000 ft^2 or greater.

REFRIGERATED WAREHOUSE FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 32°F that can be walked into and has a total chilled storage area of 3,000 ft^2 or greater.

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

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

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

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

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

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

1. Is heated but not cooled, and has a maximum heating system output capacity ((~~of~~)) equal to or greater than 3.4 Btu/(h-ft^2) but not greater than 8 Btu/(h-ft^2);
2. Is not a cold storage space or frozen storage space.

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

SKYLIGHT. Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal. Glazing material in skylights, including unit skylights, solariums, sunrooms, roofs and sloped walls is included in this definition.

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

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

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

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

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

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

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

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

STOREFRONT. A nonresidential system of doors and windows mulled as a composite *fenestration* structure that has been designed to resist heavy use. *Storefront* systems include, but are not limited to, exterior *fenestration* systems that span from the floor level or above to the ceiling of the same story on commercial buildings, with or without mulled windows and doors.

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

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

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

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

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

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

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

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

VERTICAL FENESTRATION. All *fenestration* other than skylights.

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

WALK-IN COOLER. An enclosed storage space capable of being refrigerated to temperatures above 32°F that can be walked into and has a total chilled storage area of less than 3,000 ft^2.

WALK-IN FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 32°F that can be walked into and has a total chilled storage area of less than 3,000 ft^2.

WALL. That portion of the *building envelope*, including opaque area and *fenestration*, that is vertical or tilted at an angle of 60 degrees from horizontal or greater. This includes *above-grade walls* and *below-grade walls*, between floor spandrels, peripheral edges of floors,

and foundation *walls.*

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

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

Chapter 3 [CE]--General requirements.

Section C301--Climate zones.

C301.1 General. Climate zones from Table C301.1 shall be used in determining the applicable requirements from Chapter 4. Seattle is in Zone 4-C (4-Marine).

C301.2 Warm humid counties. Warm humid counties are identified in Table C301.1 by an asterisk.

C301.1 International climate zones. The climate zone for any location outside the United States shall be determined by applying Table C301.3(1) and then Table C301.3(2).

Table C301.1
Climate Zones and Moisture Regimes
Designations by State and County

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

WASHINGTON

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

C302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22 °C) for heating and minimum of 75° (24°C) for cooling.

C302.2 Exterior design conditions. The heating or cooling outdoor design temperatures shall be ~~selected from Appendix C~~ 24°F for heating and 82°F dry bulb and 66°F wet bulb for cooling.

Section C303--Materials, systems and equipment.

C303.1 Identification. Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

C303.1.1 Building thermal envelope insulation. An *R*-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and *R*-value of insulation installed in each element of the *building thermal envelope*. For blown or sprayed insulation (fiberglass and cellulose), the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be *listed* on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and *R*-value of installed thickness shall be

listed on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

C303.1.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed at least one for every 300 square feet (28 m^2) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed *R*-value shall be *listed* on certification provided by the insulation installer.

C303.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable upon inspection.

C303.1.3 *Fenestration* product rating. *U*-factors of *fenestration* products (windows, doors and skylights) shall be determined in accordance with NFRC 100 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled *U*-factor shall be assigned a default *U*-factor from Table C303.1.3(1), C303.1.3(2) or C303.1.3(4). The solar heat gain coefficient (SHGC) and *visible transmittance* (VT) of glazed *fenestration* products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled SHGC or VT shall be assigned a default SHGC or VT from Table C303.1.3(3).

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

C303.1.4 Insulation product rating. The thermal resistance (*R*-value) of insulation shall be determined in accordance with the U.S. Federal Trade Commission *R*-value rule (C.F.R. Title 16, Part 460) in units of h x ft^2 x °F/Btu at a mean temperature of 75°F (24°C).

Table C303.1.3(1)
Default Glazed *Fenestration U*-Factor

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKY-LIGHT
Metal	1.20	0.80	See Table C303.1.3(4)
Metal with Thermal Break	1.10	0.65	
Nonmetal or Metal Clad	0.95	0.55	
Glazed Block	0.60		

Table C303.1.3(2)
Default Door *U*-Factors
See Appendix A, Section A107

Table C303.1.3(3)
Default Glazed *Fenestration* SHGC and VT

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

Table C303.1.3(4)
Default *U*-Factors for Skylights [1 2 3]

Fenestration Type	Frame Type			
	Aluminum Without Thermal Break	Aluminum With Thermal Break [4]	Reinforced Vinyl/ Aluminum-Clad Wood or Vinyl	Wood or Vinyl-Clad Wood/Vinyl Without Reinforcing
Single Glazing				
glass	U-1.58	U-1.51	U-1.40	U-1.18
acrylic/polycarb	U-1.52	U-1.45	U-1.34	U-1.11
Double Glazing				
air	U-1.05	U-0.89	U-0.84	U-0.67
argon	U-1.02	U-0.86	U-0.80	U-0.64
Double Glazing, e = 0.20				
air	U-0.96	U-0.80	U-0.75	U-0.59
argon	U-0.91	U-0.75	U-0.70	U-0.54
Double Glazing, e = 0.10				
air	U-0.94	U-0.79	U-0.74	U-0.58

argon	U-0.89	U-0.73	U-0.68	U-0.52
Double Glazing, *e* = 0.05				
air	U-0.93	U-0.78	U-0.73	U-0.56
argon	U-0.87	U-0.71	U-0.66	U-0.50
Triple Glazing				
air	U-0.90	U-0.70	U-0.67	U-0.51
argon	U-0.87	U-0.69	U-0.64	U-0.48
Triple Glazing, *e* = 0.20				
air	U-0.86	U-0.68	U-0.63	U-0.47
argon	U-0.82	U-0.63	U-0.59	U-0.43
Triple Glazing, *e* = 0.20 on 2 surfaces				
air	U-0.82	U-0.64	U-0.60	U-0.44
argon	U-0.79	U-0.60	U-0.56	U-0.40
Triple Glazing, *e* = 0.10 on 2 surfaces				
air	U-0.81	U-0.62	U-0.58	U-0.42
argon	U-0.77	U-0.58	U-0.54	U-0.38
Quadruple Glazing, *e* = 0.10 on 2 surfaces				
air	U-0.78	U-0.59	U-0.55	U-0.39
argon	U-0.74	U-0.56	U-0.52	U-0.36
krypton	U-0.70	U-0.52	U-0.48	U-0.32

1 U-factors are applicable to both glass and plastic, flat and domed units, all spacers and gaps.
2 Emissivities shall be less than or equal to the value specified.
3 Gap fill shall be assumed to be air unless there is a minimum of 90 percent argon or krypton.
4 Aluminum frame with thermal break is as defined in footnote 1 to Table C303.1.3(5).

Table C303.1.3(5)
Small Business Compliance Table
Default *U*-Factors for Vertical Glazing

Vertical Glazing Description	Frame Type

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

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

2 Aluminum Thermal Break = An aluminum thermal break framed window shall incorporate the following minimum design characteristics:
a) The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft^2/°F;
b) The thermal break material must produce a gap in the frame material of not less than 0.210 inches; and
c) All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in a) and b) above.

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

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

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

C303.2 Installation. All materials, systems and equipment shall be installed in accordance with the manufacturer's installation instructions and the *International Building Code*.

C303.2.1 Protection of exposed foundation insulation. Insulation applied to the exterior of basement walls, crawlspace walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend a minimum of 6 inches (153 mm) below grade.

C303.3 Maintenance information. Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance actions shall

be clearly stated and incorporated on a *readily accessible* label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

Chapter 4 [CE]--Commercial energy efficiency.

Section C401--General.

C401.1 Scope. The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings.

C401.2 Application. Commercial buildings shall comply with one of the following:
1. The requirements of Sections C402, C403, C404, C405, C408, ((~~and~~)) C409 and C410.
2. The requirements of Sections C407, C408, C409, C410, C402.4, C403.2, C404, C405.2, C405.3, C405.4, C405.6 and C405.7. The building energy consumption shall be equal to or less than 93 percent of the standard reference design building.
3. The requirements of C402.1.5.

C401.2.1 Application to existing buildings. Additions, alterations and repairs to existing buildings shall comply with Sections C402, C403, C404, C405, C408 and C409.

Section C402--Building envelope requirements.

C402.1 General (Prescriptive). The building thermal envelope shall comply with Section C402.1.1. Section C402.1.2 or Section C402.1.3 shall be permitted as an alternative to the *R*-values specified in Section C402.1.1. Walk-in coolers and walk-in freezers shall comply with C402.5. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with C402.6.

> **EXCEPTION**: Unstaffed equipment shelters or cabinets used solely for personal wireless service facilities.

C402.1.1 Insulation and *fenestration* criteria. The *building thermal envelope* shall meet the requirements of Tables C402.2 and C402.3 based on the climate zone specified in Chapter 3. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *R*-values from the "Group R" column of Table C402.2. 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 C402.2.

> **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.

C402.1.2 *U*-factor alternative. An assembly with a *U*-factor, *C*-factor, or *F*-factor equal or less than that specified in Table C402.1.2 shall be permitted as an alternative to the *R*-value in Table C402.2. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *U*-factor, *C*-factor, or *F*-factor from the "Group R" column of Table

C402.1.2. Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *U*-factor, *C*-factor or *F*-factor from the "All other" column of Table C402.1.2. The U-factors for typical construction assemblies are included in Appendix A. These values shall be used for all calculations. Where proposed construction assemblies are not represented in Appendix A, values shall be calculated in accordance with the ASHRAE *Handbook--Fundamentals* using the framing factors listed in Appendix A where applicable and shall include the thermal bridging effects of framing materials. The U-values and R-values of foam insulation products used for the purpose of compliance with this code shall be based on the aged Long-Term Thermal Resistance (LTTR) values of the insulation.

Table C402.1.2
Opaque Thermal Envelope Assembly Requirements[a]

CLIMATE ZONE	5 AND MARINE 4		6	
	All Other	Group R	All Other	Group R
Roofs				
Insulation entirely above deck	((~~U-0.034~~)) U-0.026	((~~U-0.031~~)) U-0.026	U-0.032	U-0.031
Metal buildings	((~~U-0.031~~ U-0.027	((~~U-0.031~~)) U-0.027	U-0.029	U-0.031
Attic and other	U-0.021	U-0.021	U-0.021	U-0.021
Walls, Above Grade				
Mass	((~~U-0.078~~ [d])) U-0.057	((~~U-0.078~~)) U-0.057	U-0.078	U-0.071
Metal building	U-0.052	U-0.052	U-0.052	U-0.044
Steel framed	U-0.055	U-0.055	U-0.049	U-0.044
Wood framed and other	((~~U-0.054~~)) U-0.051	((~~U-0.054~~)) U-0.051	U-0.051	U-0.044
Walls, Below Grade				
Below-grade wall[b]	((~~Same as above grade~~)) U-0.070	((~~Same as above grade~~)) U-0.070	Same as above grade	Same as above grade
Floors				
Mass	((~~U-0.031~~)) U-0.029	((~~U-0.031~~)) U-0.029	U-0.031	U-0.031
Joist/framing	((~~U-0.029~~)) U-0.029 steel joist U-0.025 wood joist	((~~U-0.033~~)) U-0.029 steel joist U-0.025 wood joist	U-0.029	U-0.029

Slab-on-Grade Floors				
Unheated slabs	((~~F-0.528~~)) F-0.520	((~~F-0.510~~)) F-0.520	F-0.54	F-0.52
Heated slabs[e]	((~~F-0.55~~)) F-0.360	((~~F-0.55~~)) F-0.360	F-0.55	F-0.55

a Use of opaque assembly U-factors, C-factors, and F-factors from Appendix A is required unless otherwise allowed by Section C402.1.2.

b (Reserved) ((~~Where heated slabs are below grade, below-grade walls 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.

((~~dException: 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 U-factor from Table C402.1.2.~~))

C402.1.3 Component performance building envelope option.

C402.1.3.1 General. Buildings or structures whose design heat loss rate (UA_p) and solar heat gain coefficient rate (SHGC * A_p) are less than or equal to the target heat loss rate (UA_t) and solar heat gain coefficient rate (SHGC * A_t) shall be considered in compliance with this section. The stated *U*-factor, *F*-factor, or allowable area of any component assembly listed in Table C402.1.2 and Table C402.3, such as roof/ceiling, opaque wall, opaque door, *fenestration*, floor over conditioned space, slab-on-grade floor, radiant floor or opaque floor may be increased and the *U*-factor or *F*-factor for other components decreased, provided that the total heat gain or loss for the entire building envelope does not exceed the total resulting from compliance to the *U*-factors, *F*-factors or allowable areas specified in this section. Compliance shall be calculated in total for the building envelope for nonresidential spaces and for residential spaces.

EXCEPTION. A design heat loss rate in compliance with Equation C402-5 is permitted in lieu of a calculation in compliance with Equations C402.1 and C402.2

C402.1.3.2 Component *U*-factors. The *U*-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--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--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--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 90.1-2010 Normative Appendix A.

C402.1.3.3 UA calculations. The target UA_t and the proposed UA_p shall be calculated using Equations C402-1 and C402-2 and the corresponding areas and *U*-factors from Table C402.1.2 and Table C402.3. For the target UA_t calculation, the skylights shall be located in roof/ceiling area up to the maximum skylight area per Section C402.3.1, and the remainder of the *fenestration* allowed per Section C402.3.1 shall be located in the wall area.

C402.1.3.4 SHGC rate calculations. Solar heat gain coefficient shall comply with Table C402.3. The target $SHGCA_t$ and the proposed $SHGCA_p$ shall be calculated using Equations C402-3 and C402-4 and the corresponding areas and SHGCs from Table C402.3.

Equation C402-1
Target UA_t

$$UA_t = U_{radt}A_{radt}.+ U_{mrt}A_{mrt}.+ U_{rat}A_{rat}.+ U_{mwt}(A_{mwt}. +A_{mwbgt})+ U_{mbwt}(A_{mbwt}+A_{.mbwbgt}).+ U_{sfwt}(A_{sfwt}+A_{sfwbgt})..+ U_{wfwt}(A_{wfwt}.+A_{wfwbgt}).+ U_{fmt}A_{fmt}.+ U_{fjt}A_{fjt}.+ F_{st}P_{st}.+F_{srt}P_{srt}.+ U_{dst}A_{dst}.+ U_{drt}A_{drt}.+ U_{vgt}A_{vgt}.+ U_{vgmt}A_{vgmt}.+ U_{vgmot}A_{vgmot}.+ U_{vgdt}A_{vgdt}.+ U_{ogt}A_{ogt}$$

U_{at} = The target combined specific heat transfer of the gross roof/ceiling assembly, exterior wall and floor area.

Where:

U_{radt} = The thermal transmittance value for roofs with the insulation entirely above deck found in Table C402.1.2.

U_{mrt} = The thermal transmittance value for metal building roofs found in Table C402.1.2.

U_{rat} = The thermal transmittance value for attic and other roofs found in Table C402.1.2.

U_{mwt} = The thermal transmittance value for opaque mass walls found in Table C402.1.2.

U_{mbwt} = The thermal transmittance value for opaque metal building walls found in Table C402.1.2.

U_{sfwt} = The thermal transmittance value for opaque steel-framed walls found in Table C402.1.2.

U_{wfwt} = The thermal transmittance value for opaque wood framed and other walls found in Table C402.1.2.

U_{fmt} = The thermal transmittance value for mass floors over unconditioned space found in Table C402.1.2.

U_{fjt} = The thermal transmittance value for joist floors over unconditioned space found in Table C402.1.2.

F_{st} = The F-factor for slab-on-grade floors found in Table C402.1.2.

F_{srt} = The F-factor for radiant slab floors found in Table C402.1.2.

U_{dst} = The thermal transmittance value for opaque swinging doors found in Table C402.2.

U_{drt} = The thermal transmittance value for opaque roll-up or sliding doors found in Table C402.2.

U_{vgt} = The thermal transmittance value for vertical fenestration with nonmetal framing found in Table C402.3 which corresponds to the proposed vertical fenestration area as a percent of gross exterior wall area. * Buildings utilizing Section C402.3.1.3 shall use the thermal transmittance value specified there.

U_{vgmt} = The thermal transmittance value for vertical fenestration with fixed metal framing found in Table C402.3 which corresponds to the proposed vertical fenestration area as a percent of gross exterior wall area. * Buildings utilizing Section C402.3.1.3 shall use the thermal transmittance value specified there.

U_{vgmot} = The thermal transmittance value for vertical fenestration with operable metal framing found in Table C402.3 which corresponds to the proposed vertical fenestration area as a percent of gross exterior wall area. * Buildings utilizing Section C402.3.1.3 shall use the thermal transmittance value specified there.

U_{vgdt} = The thermal transmittance value for entrance doors found in Table C402.3 which corresponds to the proposed vertical fenestration area as a percent of gross exterior wall area. * Buildings utilizing Section C402.3.1.3 shall use the thermal transmittance value specified there.

U_{ogt} = The thermal transmittance for skylights found in Table C402.3 which corresponds to the proposed skylight area as a percent of gross exterior roof area.

A_{fmt} = The proposed mass floor over unconditioned space area, A_{fm}.

A_{fjt} = The proposed joist floor over unconditioned space area, A_{fj}.

P_{st} = The proposed linear feet of slab-on-grade floor perimeter, P_s.

P_{srt} = The proposed linear feet of radiant slab floor perimeter, P_{rs}.

A_{dst} = The proposed opaque swinging door area, A_{ds}.

A_{drt} = The proposed opaque roll-up or sliding door area, A_{dr}.

and

If the vertical fenestration area as a percent of gross above-grade exterior wall area does not exceed the maximum allowed in Section C402.3.1.3:

A_{mwt} = The proposed opaque mass above-grade wall area, A_{mw}.

A_{mwbgt} = The proposed opaque below-grade mass wall area, A_{mwbg}.

A_{mbwt} = The proposed opaque above-grade metal building wall area, A_{mbw}.

A_{sfwbgt} = The proposed opaque below-grade steel framed wall area, A_{sfwbg}.

A_{sfwt} = The proposed opaque above-grade steel framed wall area, A_{sfw}.

A_{sfwbgt} = The proposed opaque below-grade steel framed wall area, A_{sfwbg}.

A_{wfwt} = The proposed opaque above-grade wall wood framed and other area, A_{wfw}.

A_{wfwbgt} = The proposed opaque below-grade wall wood framed and other area, A_{wfwbg}.

A_{vgt} = The proposed vertical fenestration area with nonmetal framing, A_{vg} *

A_{vgmt} = The proposed vertical fenestration area with fixed metal framing, A_{vgm} *

A_{vgmot} = The proposed vertical fenestration area with operable metal framing * A_{vgmo} *

A_{vgdt} = The proposed entrance door area, A_{vgd} *

or

For buildings utilizing C402.3.1.2, vertical fenestration area as a percent of gross exterior above-grade wall may not exceed the amounted allowed by that section. For all other buildings, if the vertical fenestration area as a percent of gross exterior above-grade wall area exceeds the maximum allowed in Section C402.3.1, the area of each vertical fenestration element shall be reduced in the base envelope design by the same percentage and the net area of each above-grade wall type increased proportionately by the same percentage so that the total vertical fenestration area is exactly equal to the allowed percentage per Section C402.3.1 of the gross above-grade wall area. The target wall area of a given wall type shall be the sum of the proposed below grade area and the increased above-grade area.

and

If the skylight area as a percent of gross exterior roof area does not exceed the maximum allowed in Section C402.3.1:

A_{radt} = The proposed roof area with insulation entirely above the deck, A_{rad}.

A_{mrt} = The proposed roof area for metal buildings, A_{mr}.

A_{rat} = The proposed attic and other roof area, A_{or}.

A_{ogat} = The proposed skylight area, A_{ogor}.

or

If the skylight area as a percent of gross exterior roof area exceeds the maximum allowed in Section C402.3.1, the area of each skylight element shall be reduced in the base envelope design by the same percentage and the net area of each roof type increased proportionately by the same percentage so that the total skylight area is exactly equal to the allowed percentage per Section C402.3.1 of the gross roof area.

***NOTE**: The vertical fenestration area does not include opaque doors and opaque spandrel panels.

Equation C402-2
Proposed UAp

UAp = UradArad .+ UmrAmr .+ UraAra .+ UmwAmw .+ UmbwAmbw .+ UsfwAsfw .+ UwfowAwfow .+ UfmAfm .+ UfjAfj .+ FsPs .+ FsrPsr .+ UdsAds .+ UdrAdr .+ UvgAvg .+ UvgmfAvgmf .+ UvgmoAvgmo .+ UvgdAvgd.+ UogAog

Where:

UAp = The combined proposed specific heat transfer of the gross exterior wall, floor and roof/ceiling assembly area.

Urad = The thermal transmittance of the roof area where the insulation is entirely above = the roof deck.

Arad = Opaque roof area where the insulation is entirely above the roof deck.

Umr = The thermal transmittance of the metal building roof area.

Amr = Opaque metal building roof area.

Ura = The thermal transmittance of the roof over attic and other roof area.

Ara = Opaque roof over attic and other roof area.

Umw = The thermal transmittance of the opaque mass wall area.

Amw = Opaque mass wall area (not including opaque doors).

Umbw = The thermal transmittance of the opaque metal building wall area.

Ambw = Opaque metal building wall area (not including opaque doors).

Usfw = The thermal transmittance of the opaque steel framed wall area.

Asfw = Opaque steel framed wall area (not including opaque doors).

Uwfw = The thermal transmittance of the opaque wood framed and other wall area.

Awfw = Opaque wood framed and other wall area (not including opaque doors).

Ufm = The thermal transmittance of the mass floor over unconditioned space area.

Afm = Mass floor area over unconditioned space.

Ufj = The thermal transmittance of the joist floor over unconditioned space area.

Afj = Joist floor area over unconditioned space.

Fs = Slab-on-grade floor component F-factor.

Ps = Linear feet of slab-on-grade floor perimeter.

Fsr = Radiant floor component F-factor.

Psr = Lineal feet of radiant floor perimeter.

Uds = The thermal transmittance value of the opaque swinging door area.

Ads = Opaque swinging door area.

Udr = The thermal transmittance value of the opaque roll-up or sliding door area.

Adr = Opaque roll-up or sliding door area.

Uvg = The thermal transmittance of the vertical fenestration area with nonmetal framing.*
Avg = Vertical fenestration area with nonmetal framing.*
Uvgmf = The thermal transmittance of the vertical fenestration area with fixed metal framing.*
Avgmf = Vertical fenestration area with fixed metal framing.*
Uvgmo = The thermal transmittance of the vertical fenestration area with operable metal framing.*
Avgmo = Vertical fenestration area with operable metal framing.*
Uvgd = The thermal transmittance of the vertical fenestration area for entrance doors.*
Avgd = Vertical fenestration area for entrance doors.*
Uog = The thermal transmittance for the skylights.
Aog = Skylight area.

NOTE: Where more than one type of wall, window, roof/ceiling, door and skylight is used, the U and A terms for those items shall be expanded into subelements as: Umw1Amw1 .+ Umw2Amw2 .+ Usfw1Asfw1 .+ ...etc.

***NOTE**: The vertical fenestration area does not include opaque doors and opaque spandrel panels.

EQUATION C402-3
TARGET $SHGCA_t$

$$SHGCA_t = SHGC_{ogt}A_{ogort} + SHGC_{vgt}(A_{vgt} + A_{vgmt} + A_{vgmot} + A_{vgdt})$$

Where:

$SHGCA_t$ = The target combined ((~~specific~~)) solar heat gain of the target fenestration area.

$SHGC_{vgt}$ = The solar heat gain coefficient for vertical fenestration found in Table C402.3 which corresponds to the proposed total fenestration area as a percent of gross exterior wall area, and ((~~A_{ogort}~~)), A_{vgt}, A_{vgmt}, A_{vgmot} and A_{vgdt} are defined under Equation C402-1. Buildings utilizing Section C402.3.1.3 shall use the SHGC value specified there. The SHGC may be adjusted for projection factors per the requirements of C402.3.3.

$SHGC_{ogt}$ = The solar heat gain coefficient for skylight fenestration found in Table C402.3, and A_{ogort} as defined under Equation C402-1.

NOTE: The vertical fenestration area does not include opaque doors and opaque spandrel panels.

EQUATION C402-4
PROPOSED $SHGCA_p$

$SHGCA_p = SHGC_{og}A_{og} + SHGC_{vg}A_{vg}$

Where:

$SHGCA_p$ = The combined proposed ((~~specific~~)) solar heat gain of the proposed fenestration area.

$SHGC_{og}$ = The solar heat gain coefficient of the skylights.

A_{og} = The skylight area.

$SHGC_{vg}$ = The solar heat gain coefficient of the vertical fenestration.

A_{vg} = The vertical fenestration area.

NOTE: The vertical fenestration area does not include opaque doors and opaque spandrel panels.

Equation C402-5
Component Performance UxA

(UA Sum) + (FL Sum) + (CA Sum) + (XVG) + (XSky) < Zero. **(Equation 402-5)**

Where:

UA Sum = Sum of the (UA Dif) values for each assembly that comprises a portion of the building thermal envelope, other than assemblies included in FL Sum and CA Sum

- UA Dif = (UA Proposed) – (UA Table)
- UA Table = (Maximum allowable U-factor specified in Table C402.1.2 or Table C402.3) x (Area)[a]
- UA Proposed = (Proposed U-value) x (Area)

FL Sum = Sum of the (FL Dif) values for each slab on grade assembly that comprises a portion of the building thermal envelope

- FL Dif = (FL Proposed) – (FL Table)
- FL Table = (Maximum allowable F-factor specified in Table C402.1.2) x (Perimeter length)
- FL Proposed = (Proposed F-value) x (Perimeter length)

CA Sum = Sum of the (CA Dif) values for each below-grade wall assembly that comprises a portion of the building thermal envelope

- CA Dif = (CA Proposed) – (CA Table)
- CA Table = (Maximum allowable C-factor specified in Table C402.1.2) x (area)
- CA Proposed = (Proposed C-value) x (area)

XVG (Excess Vertical Glazing Value) = (XVGArea x UVG) – (XVGArea x UWall), but not less than zero.

- XVGArea (Excess Vertical Glazing Area) = (Proposed Vertical Glazing Area) – (Allowable Vertical Glazing Area determined in accordance with Section C402.3.1)
- UA Wall = Sum of the (UA Proposed) values for each opaque assembly comprising a portion of the above-grade exterior wall
- UWall = UA Wall / total above-grade opaque exterior wall area
- UA VG = Sum of the (UA Proposed) values for each vertical glazing assembly
- UVG = UA VG / total vertical glazing area

XSky (Excess Skylight Value) = (XSArea X USky) – (XSArea x U Roof), but not less than zero.

- XSArea (Excess Skylight Area) = (Proposed Skylight Area) – (Allowable Skylight Area determined in accordance with Section C402.3.1)
- UA Roof = Sum of the (UA Proposed) values for each opaque assembly comprising a portion of a roof
- URoof = UA Roof / total opaque roof area
- UA Sky = Sum of the (UA Proposed) values for each skylight assembly
- USky = UA Sky / total skylight area

Footnote

a: Fenestration U-factors in Table C402.3 may be modified by the exceptions to Sections C402.3, C402.3.1 and C402.3.1.2.

C402.1.4 Semi-heated spaces. All spaces shall comply with the requirements in Section C402 unless they meet the definition for semi-heated spaces. For semi-heated spaces, the building envelope shall comply with the same requirements as that for conditioned spaces in Section C402; however, for semi-heated spaces heated by other than electric resistance heating equipment, wall insulation is not required for those walls that separate semi-heated spaces from the exterior provided that the space meets all the requirements of semi-heated space. Semi-heated spaces shall be calculated separately from other conditioned spaces for compliance purposes. Building envelope assemblies separating conditioned space from semi-heated space shall comply with exterior envelope insulation requirements. When choosing the uninsulated wall option, the wall shall not be included in Component Performance Building Envelope Option calculation.

C402.1.5 Target Performance Path.

C402.1.5.1 Scope. Buildings of the following occupancy types are permitted to conform to the Target Performance Path and are not required to comply with Seattle Energy Code requirements other than the mandatory measures listed in Section C402.1.5.3 below.

1. B-occupancy office
2. B-occupancy medical office
3. R-2 occupancy multi-family over three stories
4. S-1 & S-2 occupancy warehouse (non-refrigerated)
5. E-occupancy school
6. M-occupancy retail
7. I-2 occupancy hospital
8. Other occupancy type, where specific permission is granted by the *code official*. Any such permission, if granted, shall be made either on the basis of an energy use target approved by the *code official* for that occupancy based on the best-performing local examples of that occupancy, or by provision of a metering system that segregates and separately reports the energy loads for the additional occupancy from those of the occupancies listed in 1 – 7 above.
9. Mixed use: A mixed use building is any building containing more than one of the occupancies listed in 1 – 8 above.

C402.1.5.2 Energy use targets. Buildings, including their initial tenant improvements, using the Target Performance Path shall be designed to use less energy than the weighted sum of the following energy use targets, as demonstrated by approved energy modeling. Energy use targets are expressed in terms of thousand BTU per square foot of conditioned floor area per year (kBTU/ft^2/yr).

1. B-occupancy office: 40 kBTU/ ft^2/yr
2. B-occupancy medical office: 50 kBTU/ ft^2/yr
3. R-2 occupancy multi-family: 35 kBTU/ ft^2/yr
4. S-1 & S-2 occupancy warehouse: 25 kBTU/ ft^2/yr
5. E-occupancy school: 45 kBTU/ ft^2/yr
6. M-occupancy retail: 60 kBTU/ ft^2/yr
7. I-2 occupancy hospital: 150 kBTU/ ft^2/yr
8. Parking garages, including unconditioned and conditioned spaces, within the above occupancies shall be calculated separately at: 10 kBTU/ ft^2/yr for enclosed garages and 6

kBTU/ ft^2/yr for open garages.

C402.1.5.2.1 Data Center Energy. Anticipated total data center energy use is permitted to be added to the overall building energy usage target in accordance with this section. The anticipated *IT energy* usage shall be multiplied by a factor of 1.45 to determine the anticipated total data center energy use. The *IT energy* usage shall be separately sub-metered in a secure manner approved by the *code official* and automatically exported to *DPD* showing daily, monthly and annual totals during the operational energy use demonstration period set forth in Section C402.1.5.6. Actual *IT energy* shall be adjusted in accordance with Section C402.1.5.7.

C402.1.5.3 Mandatory Measures. Buildings using the Target Performance Path shall:

1.Meet their assigned building energy use targets;

2. Have an area-weighted average U-value for all *fenestration* less than 0.40; and

3. Comply with the following portions of the Seattle Energy Code. Each of the code chapters and sections listed below includes all of its sub-sections.

3.1. Chapters 1, 2 and 3 (Scope and Administration, Definitions, and General Requirements) of the Seattle Energy Code, commercial section

3.2. C402.4 Air Leakage

3.3. C403.2.4 Thermostatic Controls

3.4. C404.9 Domestic hot water meters

3.5. C408 System Commissioning

3.6. C409 Energy Metering and Energy Consumption Management

C402.1.5.4 Energy Modeling Methodology. Energy use shall be modeled according to the following procedures from Section C407, Total Building Performance:

1. C407.1 Scope

2.C407.4 Documentation (requirements for "Standard Reference Design" are not applicable)

3. C407.5.2 Thermal Blocks

4. C407.6 Calculation Software Tools

Schedules, internal loads and other assumptions related to the operation of the building are permitted to be developed at the discretion of the design team and the energy modeler. For occupancy types listed in Appendix B of this code, where any of the following operating loads or schedules of operating hours used in modeling calculations is less than 80 percent of that listed in Appendix B, or where the occupant density in square feet per occupant is more than 120 percent of that listed in Appendix B, such deviations shall be clearly documented in the final analysis report and shall be subject to approval by the *code official*.

1. Occupant density and schedule

2. Lighting operation schedule

3. Receptacle loads and schedule

4. Elevator and escalator schedule

5. Water heating quantity and schedule

In addition to documenting modeling assumptions, the compliance report required by Section C407.4.1 shall include the following:

1. Summary of principal building characteristics that are above or below prescriptive energy code requirements.

2. Sensitivity analysis of principal internal load and other building operational assumptions that demonstrate a range of expected energy performance in the context of

typical meteorological year (TMY) conditions. The following sensitivity analyses shall be reported, in tabular format:

2.1. Occupant density +/- 20 percent (except residential occupancies)
2.2. Lighting Power Density +/- 20 percent
2.3. Miscellaneous Load Power Density +/- 20 percent
2.4. Infiltration Rates +/- 20 percent
2.5. Temperature Setpoints +/- 2 degrees F

Table C402.1.5.4 Example of Sensitivity Analysis Report Format

Allowable EUI: 45 kBTU/ft^2		
Predicted EUI: 40 kBTU/ft^2		
Input	EUI (Low Range)	EUI (High Range)
Occupant Density	35	42
Lighting Power Density	38	41
Misc. Load Power Density	35	45
Infiltration	38	44
Temperature Setpoints	36	48

Informative Note: Energy models completed for the sensitivity analysis are not required to meet the target EUI. The sensitivity analysis is intended to test the robustness of the results in the presence of uncertainty.

The annual modeled building site energy use, under nominal conditions, shall be lower than the building's assigned energy performance target.

C402.1.5.5 Energy Modeler Qualifications. Energy models shall be created only by persons qualified by education and training to perform such work and who have at least two years' experience modeling buildings of similar scale and complexity. The modeling documentation submitted shall be signed either by a licensed professional engineer who is qualified by training and experience to perform energy modeling or by an individual with an active certification from ASHRAE as a Building Energy Modeling Professional (BEMP).

C402.1.5.6 Demonstration of Operating Energy Use. Metered energy data shall be supplied directly via automated reporting from utilities to DPD using Portfolio Manager, and adjusted for the percentage of floor area occupied. While at least 75 percent occupied, the building shall operate at or below its assigned energy use target established in Section C402.1.5.2 or item 8 of Section 402.1.5.1 for any recording period of 12 consecutive months that is completed within three years of the date of the Certificate of Occupancy, as adjusted under this Section C402.1.5. The owner shall notify the *code official* when this 12-month period has been successfully completed.

C402.1.5.6.1 Extension of Demonstration Period. For good cause, including conditions where less than 75 percent of the building is occupied, the *code official* may extend the three-year period for one additional year, but in no case for more than three additional one-year periods. If the building is not at least 75 percent occupied after three additional one-year periods, the *code official* shall evaluate compliance with Section C402.1.5.6 based on the most recent one-year period and adjusted for the actual occupancy rate during that period.

C402.1.5.7 Adjustment for Data Center Energy Usage. Where data center *IT energy* use

during the demonstration period, multiplied by a factor of 1.45, is higher than the total data center energy use as calculated according to Section C402.1.5.2.1, that additional energy shall be added to the total allowable energy use. Where data center *IT energy* use, multiplied by a factor of 1.45, is lower than the total data center energy use as calculated according to Section C402.1.5.2.1, that shortfall shall be subtracted from the total allowable energy use.

C402.1.5.8 Adjustment for Change in Occupancy. When the occupancy of the building or a portion of the building changes from that assumed in the permit submittal, the assigned energy performance target shall be adjusted to reflect the new occupancy. If the new occupancy is not listed in Section C402.1.5.2, either the *code official* shall assign it an energy use target based on the best-performing local examples of that occupancy type, or a metering system shall be provided that excludes the energy loads for the additional occupancy.

C402.1.5.9 Adjustment for Unusually Cold Years. If the heating degree days (HDD) recorded by the national weather service for the Seattle-Tacoma International Airport exceeds 4885 HDD for the 12-month demonstration period (4 percent above the average 4697 HDD at 65° F base), the assigned energy performance target is permitted to be increased by 1 percent for that period.

C402.1.5.10 Adjustment for Retail Operating Hours. If the annual number of hours that a retail occupancy is open to the public during the 12-month recording period exceeds the hours assumed in the energy model by more than 4 percent, the annual energy use target for the retail space use only is permitted to be increased by 1 percent for each 4 percent increase in such hours. This claim shall be documented by publicly-available published hours of operation.

C402.1.5.11 Financial Security. The applicant shall provide a financial security to be used as a penalty for failing to achieve an operating energy use lower than the building's energy use target according to Section C402.1.5.6. The penalty shall be administered as provided in Section C110, except that the amount of the penalty shall be determined using Table C402.1.5.11 and not the amounts in Building Code Section C103. The financial security shall be submitted to and approved by the *code official* prior to issuance of the building's Certificate of Occupancy. The financial security requirement shall be fulfilled by one of the following methods:

1. An irrevocable letter of credit from a financial institution authorized to do business in Seattle, in an amount equal to $4.00 per square foot of gross floor area.
2. A bond secured by the applicant to ensure compliance with this section, in an amount equal to $4.00 per square foot of gross floor area.
3. A binding pledge that within 3 years of receipt of the Certificate of Occupancy, adjusted as allowed under Section C402.1.5, the applicant will comply with the requirements of this section.

A binding pledge pursuant to item 3 of this subsection shall be recorded as a covenant in the land records of King County between the applicant and the City of Seattle in a form that is satisfactory to the Seattle City Attorney. The covenant shall bind the applicant and any successors in title to pay any fines levied pursuant to this section. A lien will be placed on the property in cases of non-payment.

If the owner provides evidence that the building has operated at or below its target energy performance level as provided in Section C402.1.5.6, the financial security provided by the applicant shall be returned to the applicant, or the pledge and covenant shall be released, and the applicant will have no further obligations under this section.

C402.1.5.12 Procedure for non-compliance. If the owner fails to provide evidence that the building has operated as required under Section C402.1.5.6, the *code official* shall, as applicable,

either:

1. Draw down on a financial security provided in the form of an irrevocable letter of credit or a bond, in whole, or in part, or
2. Levy a fine against an applicant that provided a financial security in the form of a binding pledge as set forth in Section C402.1.5.11(3). The fine shall be in the amount shown in Table C402.1.5.12 and shall be issued as a civil penalty.

The amount of the fine levied or the amount drawn down from a financial security shall be determined per Table C402.1.5.12.

Table C402.1.5.12 Financial Security and Energy Efficiency Reimbursements

Energy use exceeding target	Amount of fine or draw-down from financial security, per square foot	Maximum reimbursement per square foot for work approved under Section C402.1.5.12
Less than 10%	$1.00	$0.50
10% to less than 20%	$2.00	$1.00
20% to less than 30%	$3.00	$1.50
30% or greater	$4.00	$2.00

C402.1.5.13 Reimbursements. Where a financial security has been drawn down pursuant to item 1 in Section C402.4.12, or a fine has been levied pursuant to item 2 in Section C402.5.12, the *code official* shall reimburse the owner for documented expenses incurred to lower the operating energy use of the building, including commissioning, repairs or improvements to the existing energy-consuming systems, or provision of additional energy efficiency measures, up to the maximum reimbursement amounts listed in Table C402.1.5.12. Such expenditures shall be approved in advance by the *code official*, and the work shall be fully completed within one year of the date when a financial security has been drawn down pursuant to item 1 in Section C402.5.12, or a fine has been levied pursuant to item 2 in Section C402.5.12.

C402.2 Specific insulation requirements (Prescriptive). Opaque assemblies shall comply with Table C402.2. Where two or more layers of continuous insulation board are used in a construction assembly, the continuous insulation boards shall be installed in accordance with Section C303.2. If the continuous insulation board manufacturer's installation instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

Table C402.2
Opaque Thermal Envelope Requirements[a, f]

CLIMATE ZONE	5 AND MARINE 4 (SEATTLE)		6	
	All Other	Group R	All Other	Group R
Roofs				
Insulation entirely above deck	((~~R-30ci~~)) R-38ci	R-38ci	R-30ci	R-38ci

Metal buildings (with R-3.5 thermal blocks)[a, b]	((~~25 + R-11 LS~~)) 25 + R-22 LS	((~~25 + R-11 LS~~)) 25 + R-22 LS	R-25 + R-11 LS	R-30 + R-11 LS
Attic and other	R-49	R-49	R-49	R-49
Walls, Above Grade				
Mass	((~~R-9.5~~)) Exterior: R-16 c.i. Interior: R-13 + R-6 ci wood stud, or R-13 + R-10 ci metal stud	((~~R-13.3ci~~)) Exterior: R-16 c.i. Interior: R-13 + R-6 ci wood stud, or R-13 + R-10 ci metal stud	R-11.4ci	R-15.2ci
Metal building	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-19 + R-16ci
Steel framed	R-13 + R-10ci	R-19 + R-8.5ci	R-13 + R-12.5ci	R-19 + R-14ci
Wood framed and other	((~~R-21 int~~)) R-13 + R-7.5 ci	R-21 int	R-13 + R-7.5ci or R-20 + R-3.8ci	R-21 + R-5ci
Walls, Below Grade				
Below-grade wall[d]	((~~Same as above grade~~)) Exterior R-10 ci Interior: R-19 wood stud, or R-13 + R-6 ci metal stud	((~~Same as above grade~~)) Exterior R-10 ci Interior: R-19 wood stud, or R-13 + R-6 ci metal stud	Same as above grade	Same as above grade
Floors				
Mass	R-30ci	R-30ci	R-30ci	R-30ci
Joist/framing	((~~R-30[e]~~)) Steel frame: R-38 +R-4 ci Wood frame: R-38	((~~R-30[e]~~)) Steel frame: R-38 +R-4 ci Wood frame: R-38	R-38[e]	R-38[e]
Slab-on-Grade Floors				
Unheated slabs	R-10 for 24" below	R-10 for 24" below	R-10 for 48" below	R-15 for 48" below
Heated slabs[d]	R-10 perimeter & under entire slab	R-10 perimeter & under entire slab	R-10 perimeter & under entire slab	R-10 perimeter & under entire slab

Opaque Doors				
Swinging	U-0.37	U-0.37	U-0.37	U-0.37
Roll-up or sliding	((~~R-4.75~~)) U-0.390	((~~R-4.75~~)) U-0.390	R-4.75	R-4.75

For SI: 1 inch = 25.4 mm.
ci = Continuous insulation.
NR = No requirement.
LS = Liner system--A continuous membrane installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins.
a Assembly descriptions can be found in Chapter 2 and Appendix A.
b Where using R-value compliance method, a thermal spacer block shall be provided, otherwise use the U-factor compliance method in Table C402.1.2.
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 C402.2 or U-factor from Table C402.1.2.~~))
d Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
e Steel floor joist systems shall be insulated to R-38 .+ R-10ci.
f For roof, wall or floor assemblies where the proposed assembly would not be continuous insulation, ((~~two~~)) an alternate nominal R-value compliance option((~~s~~)) for assemblies with isolated metal penetrations of otherwise continuous insulation ((~~are~~)) is shown in the right-hand column of the table below:

Assemblies with continuous insulation (see definition)	Alternate option for assemblies with metal penetrations, greater than 0.04% but less than 0.08%
R-11.4 ci	R-14.3 ci
R-13.3 ci	R-16.6 ci
R-15.2 ci	R-19.0 ci
R-30 ci	R-38 ci
R-38 ci	R-48 ci

R-13 + R-7.5 ci	R-13 + R-9.4 ci
R-13 + R-10 ci	R-13 + R-12.5 ci
R-13 + R-12.5 ci	R-13 + R-15.6 ci
R-13 + R-13 ci	R-13 + R-16.3 ci
R-19 + R-8.5 ci	R-19 + R-10.6 ci
R-19 + R-14 ci	R-19 + R-17.5 ci
R-19 + R-16 ci	R-19 + R-20 ci
R-20 + R-3.8 ci	R-20 + R-4.8 ci
R-21 + R-5 ci	R-21 + R-6.3 ci

These alternate nominal R-value compliance 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%).
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 C402.1.2 for determination of U-factors for assemblies that include metal other than screws and nails.

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 C402.2, based on construction materials used in the roof assembly. Skylight curbs shall be insulated to the level of roofs with insulation entirely above deck or R-5, whichever is less.

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 C402.2.
2. Unit skylight curbs included as a component of an NFRC 100 rated assembly shall not be required to be insulated.

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

Informative Note: The section below regarding roof solar reflectance does not apply to Washington State, as it refers only to Climate Zones 1, 2 and 3. Seattle is in Zone 4.

C402.2.1.1 Roof solar reflectance and thermal emittance. Low-sloped roofs with a slope less than 2 units vertical in 12 horizontal, directly above cooled conditioned spaces in Climate Zones 1, 2, and 3 shall comply with one or more of the options in Table C402.2.1.1.

EXCEPTIONS: The following roofs and portions of roofs are exempt from the requirements in Table C402.2.1.1:

1. Portions of roofs that include or are covered by:
1.1. Photovoltaic systems or components.
1.2. Solar air or water heating systems or components.
1.3. Roof gardens or landscaped roofs.
1.4. Above-roof decks or walkways.
1.5. Skylights.
1.6. HVAC systems, components, and other opaque objects mounted above the roof.
2. Portions of roofs shaded during the peak sun angle on the summer solstice by permanent features of the building, or by permanent features of adjacent buildings.
3. Portions of roofs that are ballasted with a minimum stone ballast of 17 pounds per square foot (psf) (74 kg/m^2) or 23 psf (117 kg/m^2) pavers.
4. Roofs where a minimum of 75 percent of the roof area meets a minimum of one of the exceptions above.

Table C402.2.1.1
Reflectance and Emittance Options[a]

Three-year aged solar reflectance[b] of 0.55 and three-year aged thermal emittance[c] of 0.75
Initial solar reflectance[b] of 0.70 and initial thermal emittance[c] of 0.75
Three-year-aged solar reflectance index[d] of 64 initial solar reflectance index[d] of 82

a The use of area-weighted averages to meet these requirements shall be permitted. Materials lacking initial tested values for either solar reflectance or thermal emittance, shall be assigned both an initial solar reflectance of 0.10 and an initial thermal emittance of 0.90. Materials lacking three-year aged tested values for either solar reflectance or thermal emittance shall be assigned both a three-year aged solar reflectance of 0.10 and a three-year aged thermal emittance of 0.90.

b Solar reflectance tested in accordance with ASTM C 1549, ASTM E 903 or ASTM E 1918.

c Thermal emittance tested in accordance with ASTM C 1371 or ASTM E 408.

d Solar reflectance index (SRI) shall be determined in accordance with ASTM E 1980 using a convection coefficient of 2.1 Btu/h x ft^2 x °F (12W/m2 x K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Calculation of initial SRI shall be based on initial tested values of solar

reflectance and thermal emittance.

C402.2.2 Classification of walls. Walls associated with the building envelope shall be classified in accordance with Section C202.

C402.2.3 Thermal resistance of above-grade walls. The minimum thermal resistance (*R*-value) of the insulating materials installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table C402.2, based on framing type and construction materials used in the wall assembly. The *R*-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table C402.2.

"Mass walls" shall include walls weighing not less than:

1. 35 psf (170 kg/m^2) of wall surface area; or
2. 25 psf (120 kg/m^2) of wall surface area if the material weight is not more than 120 pounds per cubic foot (pcf) (1,900 kg/m^3).

C402.2.4 Thermal resistance of below-grade walls. The minimum thermal resistance (*R*-value) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table C402.2.

C402.2.5 Floors over outdoor air or unconditioned space. The minimum thermal resistance (*R*-value) of the insulating material installed either between the floor framing or continuously on the floor assembly shall be as specified in Table C402.2, based on construction materials used in the floor assembly.

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

1. 35 psf (170 kg/m^2) of floor surface area; or
2. 25 psf (120 kg/m^2) of floor surface area if the material weight is not more than 120 pcf (1,900 kg/m^3).

C402.2.6 Slabs on grade. Where the slab on grade is in contact with the ground, the minimum thermal resistance (R-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors and under the entire slab of heated slab-on-grade floors shall be as specified in Table C402.2. The insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. Insulation extending away from the building shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil.

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

C402.2.7 Opaque doors. Opaque doors (doors having less than 50 percent glass area) shall meet the applicable requirements for doors as specified in Table C402.2 and be considered as part of the gross area of above-grade walls that are part of the building envelope.

C402.2.8 Insulation of radiant heating systems. Radiant panels, and associated U-bends and headers, designed for sensible heating of an indoor space through heat transfer from the

thermally effective panel surfaces to the occupants or indoor space by thermal radiation and natural convection and the bottom surfaces of floor structures incorporating radiant heating shall be insulated with a minimum of R-3.5 (0.62 $m^2/K \times W$). Adjacent envelope insulation counts towards this requirement.

C402.3 *Fenestration* (Prescriptive). *Fenestration* shall comply with Table C402.3. Automatic daylighting controls specified by this section shall comply with Section C405.2.2.3.2.

EXCEPTION. Single glazing is permitted for security purposes and for revolving doors, provided that the total area of single glazing does not exceed 1 percent of the gross exterior wall area, and such glazing is included in the percentage of the total glazing area, U-factor and SHGC requirements in Section C402.3.

Table C402.3
Building Envelope Requirements--*Fenestration*

CLIMATE ZONE	5 AND MARINE 4	6
Vertical *Fenestration*		
***U*-factor**		
Nonmetal framing (all)[a]	0.30	0.30
Metal framing (fixed)[b]	0.38	0.36
Metal framing (operable)[c]	0.40	0.40
Metal framing (entrance doors)[d]	0.60	0.60
SHGC		
SHGC	((~~0.40~~)) 0.35	0.40
Skylights		
***U*-factor**	((~~0.50~~)) 0.45	0.50
SHGC	((~~0.35~~)) 0.32	0.35

NR = No requirement.

a "Nonmetal framing" includes framing materials other than metal, with or without metal reinforcing or cladding.

b "Metal framing" includes metal framing, with or without thermal break. "Fixed" includes curtain wall, storefront, picture windows, and other fixed windows.

c "Metal framing" includes metal framing, with or without thermal break. "Operable" includes openable *fenestration* products other than "entrance doors."

d "Metal framing" includes metal framing, with or without thermal break. "Entrance door" includes glazed swinging entrance doors. Other doors which are not entrance

doors, including sliding glass doors, are considered "operable."

C402.3.1 Maximum area. The vertical *fenestration* area (not including opaque doors and opaque spandrel panels) shall not exceed 30 percent of the gross above-grade wall area. The skylight area shall not exceed ((~~3~~)) 5 percent of the gross roof area.

EXCEPTION: For vertical *fenestration* at street level retail or for other occupancies where the Seattle Land Use Code requires street-level transparency, the *fenestration* area shall not exceed 75 percent of the area of the street-level wall that faces the street or that adjoins other pedestrian areas used for retail access. For the purposes of this exception, the street-level wall shall be measured from the street-level floor to the interior ceiling level or to 20 feet above floor level, whichever is lowest. When this exception is utilized, separate calculations shall be performed for these sections of the building envelope, and these values shall not be averaged with any others for compliance purposes. On the street level the 75 percent *fenestration* area is permitted to be exceeded, if the additional *fenestration* area is deducted from *fenestration* allowances from other areas of the building.

C402.3.1.1 Increased vertical *fenestration* area with daylighting controls. In Climate Zones 1 through 6, a maximum of 40 percent of the gross above-grade wall area shall be permitted to be vertical *fenestration*, provided:

1. No less than 50 percent of the conditioned floor area is within a daylight zone;
2. Automatic daylighting controls are installed in daylight zones; and
3. Visible transmittance (VT) of vertical *fenestration* is greater than or equal to 1.1 times solar heat gain coefficient (SHGC).

EXCEPTION: *Fenestration* that is outside the scope of NFRC 200 is not required to comply with Item 3.

Informative Note: NFRC 200 covers almost all commonly-used glazing products. *Fenestration* products *not* within NFRC 200's scope include glass block, translucent fiberglass, curved glass, corrugated or patterned glazing, double-pane glass with shading devices between the panes, and glazing with translucent or patterned films.

C402.3.1.2 Increased vertical *fenestration* area with high-performance *fenestration*. The vertical *fenestration* area (not including opaque doors and opaque spandrel panels) is permitted to exceed 30 percent but shall not exceed 40 percent of the gross above grade wall area, for the purpose of prescriptive compliance with Section C402.1.2 or for the Target UA calculation in Equations C402-1 or C402-5, provided that each of the following conditions are met:

1. The vertical *fenestration* shall have the following maximum U-factors:
    a. Non-metal framing (all) = 0.28
    b. Metal framing (fixed) = 0.34
    c. Metal framing (operable) = 0.36
    d. Metal framing (entrance doors) = 0.60

An area-weighted average shall be permitted to satisfy the U-factor requirements for each fenestration product category listed above. Individual fenestration products from different fenestration product categories shall not be combined in calculating the

area-weighted average U-factor.

2. The SHGC of the vertical fenestration shall be less than or equal to 0.35, adjusted for projection factor in compliance with Section C402.3.3.1.

The compliance path described in this Section C402.3.1.2 is not permitted to be used for the Total Building Performance compliance path as set out in Section C407.

~~((**C402.3.1. Increased skylight area with daylighting controls.** The skylight area shall be permitted to be a maximum of 5 percent of the roof area provided automatic daylighting controls are installed in daylight zones under skylights.~~))

C402.3.2 Minimum skylight *fenestration* area. For single story buildings only, in an enclosed space greater than 10,000 square feet (929 m^2), directly under a roof with ceiling heights greater than 15 feet (4572 mm), and used as an office, lobby, atrium, concourse, corridor, gymnasium/exercise center, convention center, automotive service, manufacturing, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation, or workshop, the total daylight zone under skylights shall be not less than half the floor area and shall provide a minimum skylight area to daylight zone under skylights of either:

1. Not less than 3 percent with a skylight VT of at least 0.40; or
2. Provide a minimum skylight effective aperture of at least 1 percent determined in accordance with Equation C4-1.

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

(Equation C4-1)

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.

Light well depth = Measure vertically from the underside of the lowest point of the skylight glazing to the ceiling plane under the skylight.

EXCEPTION: Skylights above daylight zones of enclosed spaces are not required in:

1. Buildings in Climate Zones 6 through 8.
2. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft^2 (5.4 W/m^2).
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.

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

C402.3.2.1 Lighting controls in daylight zones under skylights. All lighting in the daylight zone shall be controlled by automatic daylighting controls that comply with Section C405.2.2.3.2.

~~((**EXCEPTION**: Skylights above daylight zones of enclosed spaces are not required in:~~

~~1. Buildings in Climate Zones 6 through 8.~~

~~2. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft^2 (5.4 W/m^2).~~

~~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.~~

~~4. Spaces where the daylight zone under rooftop monitors is greater than 50 percent of the enclosed space floor area.~~))

C402.3.2.2 Haze factor. Skylights in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store, and distribution/sorting area spaces shall have a glazing material or diffuser with a measured haze factor greater than 90 percent when tested in accordance with ASTM D 1003.

EXCEPTION: Skylights designed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles, or the geometry of skylight and light well need not comply with Section C402.3.2.2.

C402.3.3 Maximum *U*-factor and SHGC. For vertical *fenestration*, the maximum *U*-factor and solar heat gain coefficient (SHGC) shall be as specified in Table C402.3, based on the window projection factor. For skylights, the maximum *U*-factor and solar heat gain coefficient (SHGC) shall be as specified in Table C402.3.

The window projection factor shall be determined in accordance with Equation C4-2.

$$PF = A/B \qquad \textbf{(Equation C4-2)}$$

where:

PF = Projection factor (decimal).

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

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

Where different windows or glass doors have different *PF* values, they shall each be evaluated separately.

C402.3.3.1 SHGC adjustment. Where the *fenestration* projection factor for a specific vertical

fenestration product is greater than or equal to 0.2, the required maximum SHGC from Table C402.3 shall be adjusted by multiplying the required maximum SHGC by the multiplier specified in Table C402.3.3.1 corresponding with the orientation of the *fenestration* product and the projection factor.

Table C402.3.3.1
SHGC Adjustment Multipliers

PROJECTION FACTOR	ORIENTED WITHIN 45 DEGREES OF TRUE NORTH	ALL OTHER ORIENTATION
$0.2 \leq PF < 0.5$	1.1	1.2
$PF \geq 0.5$	1.2	1.6

C402.3.3.2 Increased vertical *fenestration* SHGC. In Climate Zones 1, 2 and 3, vertical *fenestration* entirely located not less than 6 feet (1729 mm) above the finished floor shall be permitted a maximum SHGC of 0.40.

C402.3.3.3 Reserved.

C402.3.3.4 Reserved.

C402.3.3.5 Dynamic glazing. For compliance with Section C402.3.3, the SHGC for dynamic glazing shall be determined using the manufacturer's lowest-rated SHGC, and the VT/SHGC ratio shall be determined using the maximum VT and maximum SHGC. Dynamic glazing shall be considered separately from other *fenestration*, and area-weighted averaging with other *fenestration* that is not dynamic glazing shall not be permitted.

C402.3.4 Area-weighted *U*-factor. An area-weighted average shall be permitted to satisfy the *U*-factor requirements for each *fenestration* product category listed in Table C402.3. Individual *fenestration* products from different *fenestration* product categories listed in Table C402.3 shall not be combined in calculating area-weighted average *U*-factor.

C402.4 Air leakage (Mandatory). The thermal envelope of buildings shall comply with Sections C402.4.1 through C402.4.8.

C402.4.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections C402.4.1.1 and C402.4.1.2.

EXCEPTION: Air barriers are not required in buildings located in Climate Zones 1, 2 and 3.

C402.4.1.1 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. Air barrier penetrations shall be sealed in accordance with Section C402.4.2. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.

3. Recessed lighting fixtures shall comply with Section C404.2.8. Where similar objects are installed which penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

4. 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.

EXCEPTION: Buildings that comply with Section C402.4.1.2.3 are not required to comply with Items 1 and 3.

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 semiheated 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.

C402.4.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall comply with Section C402.4.1.2.3.

C402.4.1.2.1 Materials. Materials with an air permeability no greater than 0.004 cfm/ft^2 (0.02 L/s · m^2) under a pressure differential of 0.3 inches water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 15 shall be deemed to comply with this section provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than 3/8 inch (10 mm).
2. Oriented strand board having a thickness of not less than 3/8 inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch (12 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch (12 mm).
5. Closed cell spray foam a minimum density of 1.5 pcf (2.4 kg/m^3) having a thickness of not less than 1 1/2 inches (36 mm).
6. Open cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m^3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch (12 mm).
8. Cement board having a thickness of not less than 1/2 inch (12 mm).
9. Built up roofing membrane.
10. Modified bituminous roof membrane.

11. Fully adhered single-ply roof membrane.

12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch (16 mm).

13. Cast-in-place and precast concrete.

14. Fully grouted concrete block masonry.

15. Sheet steel or aluminum.

C402.4.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not to exceed 0.04 cfm/ft^2 (0.2 L/s · m^2) under a pressure differential of 0.3 inches of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E 2357, ASTM E 1677 or ASTM E 283 shall comply with this section. Assemblies listed in Items 1 and 2 shall be deemed to comply provided joints are sealed and requirements of Section C402.4.1.1 are met.

1. Concrete masonry walls coated with one application either of block filler and two applications of a paint or sealer coating;

2. A Portland cement/sand parge, stucco or plaster minimum 1/2 inch (12 mm) in thickness.

C402.4.1.2.3 Building test. The completed building shall be tested and the air leakage rate of the *building envelope* shall not exceed 0.40 cfm/ft^2 at a pressure differential of 0.3 inches water gauge (2.0 L/s · m^2 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*. The following modifications shall be made to ASTM E 779:

1. Tests shall be accomplished using either (1) both pressurization and depressurization or (2) pressurization alone, but not depressurization alone. If both pressurization and depressurization are not tested, the air leakage shall be plotted against the corrected P for pressurization in accordance with Section 9.4.

2. The test pressure range shall be from 10 Pa to 60 Pa per Section 8.10, 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, the test shall be rerun with additional readings over a longer time interval.

If the tested rate exceeds that defined here, 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.

C402.4.2 Air barrier penetrations. Penetrations of the air barrier and paths of air leakage shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Joints and seals shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials shall be appropriate to the construction materials being sealed. 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.

C402.4.3 Air leakage of *fenestration*. The air leakage of *fenestration* assemblies shall meet the provisions of Table C402.4.3. Testing shall be in accordance with the applicable reference test standard in Table C402.4.3 by an accredited, independent testing laboratory and *labeled* by the manufacturer.

EXCEPTIONS:

1. Field-fabricated *fenestration* assemblies that are sealed in accordance with Section C402.4.1. A field-fabricated *fenestration* product is a *fenestration* product (including glazed exterior doors) whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a *fenestration* product or exterior door. Field-fabricated does not include curtain walls.
2. *Fenestration* in buildings that comply with Section C402.4.1.2.3 are not required to meet the air leakage requirements in Table C402.4.3.
3. Custom exterior windows and doors manufactured by a *small business* provided they meet the applicable provisions of Chapter 24 of the *International Building Code*. Once visual inspection has confirmed the presence of a gasket, operable windows and doors manufactured by *small business* shall be permitted to be sealed off at the frame prior to the test.

Table C402.4.3
Maximum Air Infiltration Rate
for *Fenestration* Assemblies

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

For SI:
1 cubic foot per minute = 0.47 L/s

1 square foot = 0.093 m^2.

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

C402.4.4 Doors and access openings to shafts, chutes, stairways, and elevator lobbies. Doors and access openings from conditioned space to shafts, chutes, stairways and elevator lobbies shall either meet the requirements of Section C402.4.3 or shall be gasketed, weatherstripped or sealed.

EXCEPTION: Door openings required to comply with Section 715 or 715.4 of the *International Building Code*; or doors and door openings required by the *International Building Code* to comply with UL 1784 shall not be required to comply with Section C402.4.4.

C402.4.5 Air intakes, exhaust openings, stairways and shafts. Stairway enclosures and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be provided with dampers in accordance with Sections C402.4.5.1 and C402.4.5.2.

C402.4.5.1 Stairway and shaft vents. Stairway and shaft vents shall be provided with Class I motorized dampers with a maximum leakage rate of 4 cfm/ft^2 (20.3 L/s · m^2) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with AMCA 500D.

Stairway and shaft vent dampers shall be installed with controls so that they are capable of automatically opening upon:

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

C402.4.5.2 Outdoor air intakes and exhausts. *Outdoor air* supply, exhaust openings and relief outlets shall be provided with Class IA motorized dampers which close automatically when the system is off. Return air dampers shall be equipped with motorized dampers. Dampers shall have a maximum leakage rate of 4 cfm/ft^2 (20.3 L/s · m^2) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with AMCA 500D. Gravity (nonmotorized) dampers for ventilation air intakes shall be protected from direct exposure to wind.

EXCEPTIONS:

1. Gravity (nonmotorized) dampers having a maximum leakage rate of 20 cfm/ft^2 (101.6 L/s · m^2) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with AMCA 500D are permitted to be used for relief, outside air and exhaust openings in buildings ((~~less than three stories in height above grade~~)) if equipment has less than ((~~5,000~~)) 300 cfm total supply flow.
2. (Reserved) ((~~Gravity (nonmotorized) dampers for ventilation air intakes shall be protected from direct exposure to wind.~~))
3. Gravity dampers smaller than 24 inches (610 mm) in either dimension shall be permitted to have a leakage of 40 cfm/ft^2 (203.2 L/s · m^2) at 1.0 inch water gauge (w.g.) (249 Pa) when tested in accordance with AMCA 500D.
4. Gravity (nonmotorized) dampers in Group R occupancies where the design outdoor air intake, relief or exhaust capacity does not exceed ((~~400~~)) 300 cfm (189 L/s).
5. Systems serving areas which require continuous operation.

6. Combustion air intakes.
7. Type I kitchen exhaust hoods.

C402.4.6 Loading dock weatherseals. Cargo doors and loading dock doors shall be equipped with weatherseals to restrict infiltration when vehicles are parked in the doorway.

C402.4.7 Vestibules. All building entrances shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. 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.

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.

EXCEPTIONS:
1. Buildings in Climate Zones 1 and 2.
2. Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use.
3. Doors opening directly from a *sleeping unit* or dwelling unit.
4. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area and are separate from the building entrance.
5. Revolving doors.
6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
7. Building entrances in buildings that are less than four stories above grade and less than 10,000 ft^2 in area.
8. Elevator doors in parking garages provided that the elevators have an enclosed lobby at each level of the garage.
9. Entrances to semi-heated spaces.

Informative Note: Building entrances are defined as the means ordinarily used to gain access to the building. Doors other than for building entrances, such as those leading to service areas, mechanical rooms, electrical equipment rooms, 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.

C402.4.8 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and *labeled* as having an air leakage rate of not more than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E 283 at a 1.57 psf (75 Pa) pressure

differential. All recessed luminaires shall be sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

C402.5 Walk-in coolers and walk-in freezers. Walk-in coolers and walk-in freezers shall comply with all of the following:

1. Shall be equipped with automatic door closers that firmly close walk-in doors that have been closed to within 1 inch of full closure.

EXCEPTION: Doors wider than 3 feet 9 inches or taller than 7 feet.

2. Doorways shall have strip doors (curtains), spring-hinged doors, or other method of minimizing infiltration when doors are open.

3. *Walk-in coolers* shall contain wall, ceiling, and door insulation of at least R-25 and *walk-in freezers* at least R-32.

EXCEPTION: Glazed portions of doors or structural members.

4. *Walk-in freezers* shall contain floor insulation of at least R-28.

5. Transparent reach-in doors for *walk-in freezers* and windows in *walk-in freezer* doors shall be of triple-pane glass, either filled with inert gas or with heat-reflective treated glass.

6. Transparent reach-in doors for *walk-in coolers* and windows in *walk-in cooler* doors shall be double-pane glass with heat-reflective treated glass and gas filled; or triple-pane glass, either filled with inert gas or with heat-reflective treated glass.

C402.6 Refrigerated warehouse coolers and refrigerated warehouse freezers. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with all of the following:

1. Shall be equipped with automatic door closers that firmly close walk-in doors that have been closed to within 1 inch of full closure.

EXCEPTION: Doors wider than 3 feet 9 inches or taller than 7 feet.

2. Doorways shall have strip doors (curtains), spring-hinged doors, or other method of minimizing infiltration when doors are open.

3. *Refrigerated warehouse coolers* shall contain wall, ceiling, and door insulation of at least R-((~~25~~)) 38 and *refrigerated warehouse freezers* at least R-((~~32~~)) 38.

EXCEPTION: Glazed portions of doors or structural members.

4. *Refrigerated warehouse* freezers shall contain floor insulation of at least R-((~~28~~)) 38.

5. Transparent reach-in doors for *refrigerated warehouse freezers* and windows in *refrigerated warehouse freezer* doors shall be of triple-pane glass, either filled with inert gas or with heat-reflective treated glass.

6. Transparent reach-in doors for *refrigerated warehouse coolers* and windows in *refrigerated warehouse cooler* doors shall be double-pane glass with heat-reflective treated glass and gas filled; or triple-pane glass, either filled with inert gas or with heat-reflective treated glass.

Section C403--Mechanical systems.

C403.1 General. Mechanical systems and equipment serving heating, cooling, ventilating, and other needs shall comply with Section C403.2 (referred to as the mandatory provisions) and

either:

1. Section C403.3 (Simple systems); or
2. Section C403.4 (Complex systems).

EXCEPTION: Energy using equipment used by a manufacturing, industrial or commercial process other than for conditioning spaces or maintaining comfort and amenities for the occupants and not otherwise regulated by C403.2.3, Tables C403.2.1 (1) through (9) inclusive, C403.2.4.5, C403.2.5.4, C403.2.8, C403.2.13, C403.4.6, C403.5, C403.6, C404.2, or Table C404.2. Data center HVAC equipment is not covered by this exception.

Walk-in coolers and walk-in freezers shall comply with Section C403.5. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.6.

C403.2 Provisions applicable to all mechanical systems (Mandatory). Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Sections C403.2.1 through C403.2.11.

C403.2.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with the procedures described in ANSI/ASHRAE/ACCA Standard 183. The design loads shall account for the building envelope, lighting, ventilation and occupancy loads based on the project design. Heating and cooling loads shall be adjusted to account for load reductions that are achieved where energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook*. Alternatively, design loads shall be determined by an *approved* equivalent computation procedure, using the design parameters specified in Chapter 3.

C403.2.2 Equipment and system sizing. The output capacity of heating and cooling equipment and systems shall not exceed the loads calculated in accordance with Section C403.2.1. A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

EXCEPTIONS:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.
3. The output capacity of heating and cooling equipment and systems may exceed the loads calculated in accordance with Section C403.2.1, provided that the smallest-capacity equipment available from a selected manufacturer that is capable of serving the heating and cooling loads is utilized and that the equipment capacity does not exceed 150 percent of the calculated loads.

C403.2.3 HVAC equipment performance requirements. Equipment shall meet the

minimum efficiency requirements of Tables C403.2.3(1), C403.2.3(2), C403.2.3(3), C403.2.3(4), C403.2.3(5), C403.2.3(6), C403.2.3(7) and C403.2.3(8) 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 C403.2.3(9). 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 ≥ 225,000 Btu/h (65 kW) 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 ≥225,000 Btu/h (65 kW), including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating.

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 C403.2.3(7).
3. Replacement of existing equipment.

C403.2.3.1 Water-cooled centrifugal chilling packages. Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44°F (7°C) leaving chilled-water temperature and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 I/s · kW) condenser water flow shall have maximum full-load kW/ton and *NPLV* ratings adjusted using Equations C4-3 and C4-4.

$$\text{Adjusted minimum full-load COP ratings} = (\text{Full-load COP from Table 6.8.1C of AHRI Standard 550/590}) \times K_{adj} \quad \textbf{(Equation C4-3)}$$

$$\text{Adjusted minimum NPLV rating} = (\text{IPLV from Table 6.8.1C of AHRI Standard 550/590}) \times K_{adj} \quad \textbf{(Equation C4-4)}$$

Where:

$$K_{adj} = A \times B$$

$$A = 0.0000015318 \times (LIFT)^4 - 0.000202076 \times (LIFT)^3 .+ 0.01\ 01800 \times (LIFT)^2 - 0.264958 \times LIFT .+ 3.930196$$

$$B = 0.0027 \times L_{vg}{}^{Evap}\ (°C) .+ 0.982$$

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

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

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

SI units shall be used in the K_{adj} equation.

The adjusted full-load and *NPLV* values shall only be applicable for centrifugal chillers meeting all of the following full-load design ranges:

1. The leaving evaporator fluid temperature is not less than 36°F (2.2°C).
2. The leaving condenser fluid temperature is not greater than 115°F (46.1°C).
3. LIFT is not less than 20°F (11.1°C) and not greater than 80°F (44.4°C).

EXCEPTION: Centrifugal chillers designed to operate outside of these ranges need not comply with this code.

C403.2.3.2 Positive displacement (air- and water-cooled) chilling packages. Equipment with a leaving fluid temperature higher than 32°F (0°C), shall meet the requirements of Table C403.2.3(7) when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

C403.2.3.3 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 20,000 Btu/h shall be a heat pump.

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

C403.2.3.4 Humidification. If an air economizer is required on a cooling system for which humidification equipment is to be provided to maintain minimum indoor humidity levels, then the humidifier shall be of the adiabatic type (direct evaporative media or fog atomization type).

EXCEPTIONS:

1. Health care facilities where WAC 246-320-525 allows only steam injection humidifiers in duct work downstream of final filters.
2. Systems with water economizer.
3. 100% outside air systems with no provisions for air recirculation to the central supply fan.
4. Nonadiabatic humidifiers cumulatively serving no more than 10% of a building's air economizer capacity as measured in cfm. This refers to the system cfm serving rooms with stand alone or duct mounted humidifiers.

Table C403.2.3(1)A
Minimum Efficiency Requirements--Electrically Operated Unitary Air Conditioners and Condensing Units

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency		Test Procedure[a]
				Before 6/1/2011	As of 6/1/2011	

Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	13.0 SEER	
			Single Package	13.0 SEER	13.0 SEER	
Through-the-wall (air cooled)	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	12.0 SEER	AHRI 210/240
			Single Package	12.0 SEER	12.0 SEER	
Air conditioners, air cooled	≥65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER 11.4 IEER	11.2 EER 11.4 IEER	AHRI 340/360
		All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
	≥135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.0 IEER	
	≥240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 10.1 IEER	10.0 EER 10.1 IEER	
		All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 9.9 IEER	
	≥,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 9.8 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 9.6 IEER	
Air conditioners, water cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	12.5 EER 12.7 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	12.3 EER 12.5 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.4 EER 12.6 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 12.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.2 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.0 EER 12.2 IEER	
Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 EER	11.7 EER 11.9 EER	
		All other	Split System and Single Package	10.8 EER 10.9 EER	11.5 EER 11.7 EER	
Condensing units, air cooled	≥ 135,000 Btu/h			10.1 EER 11.4 IEER	10.5 EER 11.8 IEER	

Condensing units, water cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	AHRI 365
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	

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

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

[b]Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

Table C403.2.3(1)B
Minimum Efficiency Requirements--Air Conditioners and Condensing Units Serving Computer Rooms

Equipment Type	Net Sensible Cooling Capacity[a]	Minimum Scop-127[b] Efficiency Downflow Units/upflow Units	Test Procedure
Air conditioners, air cooled	< 65,000 Btu/h (< 19 kW)	2.20/2.09	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.10/1.99	
	≥ 240,000 Btu/h (≥ 70 kW)	1.90/1.79	
Air conditioners, water cooled	< 65,000 Btu/h (< 19 kW)	2.60/2.49	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.50/2.39	
	≥ 240,000 Btu/h (≥ 70 kW)	2.40/2.29	
Air conditioners, water cooled with fluid economizer	< 65,000 Btu/h (< 19 kW)	2.55/2.44	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.45/2.34	

	≥ 240,000 Btu/h (≥ 70 kW)	2.35/2.24	
Air conditioners, glycol cooled (rated at 40% propylene glycol)	< 65,000 Btu/h (< 19 kW)	2.50/2.39	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.15/2.04	
	≥ 240,000 Btu/h (≥ 70 kW)	2.10/1.99	
Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer	< 65,000 Btu/h (< 19 kW)	2.45/2.34	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.10/1.99	
	≥ 240,000 Btu/h (≥ 70 kW)	2.05/1.94	

[a]Net sensible cooling capacity: The total gross cooling capacity less the latent cooling less the energy to the air movement system (Total Gross - Latent - Fan Power).

[b] Sensible coefficient of performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheaters and humidifiers) at conditions defined in ASHRAE Standard 127. The net sensible cooling capacity is the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.

Table C403.2.3(1)C
Minimum Efficiency Requirements--Electrically Operated Variable Refrigerant Flow Air Conditioners

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF Air Conditioners, Air Cooled	< 65,000 Btu/h	All	VRF 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 13.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	11.0 EER 12.9 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	10.0 EER 11.6 IEER	

Table C403.2.3(1)D
Minimum Efficiency Requirements--Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF Air Cooled (cooling mode)	< 65,000 Btu/h	All	VRF 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	11.0 EER 12.9 IEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System with Heat Recovery	10.8 EER 12.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	10.6 EER 12.3 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System with Heat Recovery	10.4 EER 12.1 IEER	

	≥ 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	9.5 EER 11.0 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System with Heat Recovery	9.3 EER 10.8 IEER	
VRF Water Source (cooling mode)	< 65,000 Btu/h	All	VRF Multi-Split System *86ºF entering water*	12.0 EER	AHRI 1230
	< 65,000 Btu/h	All	VRF Multi-Split System with Heat Recovery *86ºF entering water*	11.8 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	VRF Multi-Split System *86ºF entering water*	12.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery *86ºF entering water*	11.8 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System *86ºF entering water*	10.0 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery *86ºF entering water*	9.8 EER	

VRF Groundwater Source (cooling mode)	< 135,000 Btu/h	All	VRF Multi-Split System *59ºF entering water*	16.2 EER	AHRI 1230
	< 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery *59ºF entering water*	16.0 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System *59ºF entering water*	13.8 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery *59ºF entering water*	13.6 EER	
VRF Ground Source (cooling mode)	< 135,000 Btu/h	All	VRF Multi-Split System *77ºF entering water*	13.4 EER	AHRI 1230
	< 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery *77ºF entering water*	13.2 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System *77ºF entering water*	11.0 EER	

	≥ 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery *77ºF entering water*	10.8 EER	
VRF Air Cooled (heating mode)	< 65,000 Btu/h (cooling capacity)	--	VRF Multi-Split System	7.7 HSPF	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *47ºF db/43ºF wb outdoor air 17ºF db/15ºF wb outdoor air*	3.3 COP 2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *47ºF db/43ºF wb outdoor air 17ºF db/15ºF wb outdoor air*	3.2 COP 2.05 COP	
VRF Water Source (heating mode)	< 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *68ºF entering water*	4.2 COP	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *68ºF entering water*	3.9 COP	
VRF Groundwater Source (heating mode)	< 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *50ºF entering water*	3.6 COP	AHRI 1230

	≥ 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *50ºF entering water*	3.3 COP	
VRF Ground Source (heating mode)	< 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *32ºF entering water*	3.1 COP	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)	--	VRF Multi-Split System *32ºF entering water*	2.8 COP	

Table C403.2.3(2)
Minimum Efficiency Requirements--Electrically Operated Unitary and Applied Heat Pumps

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	AHRI 210/240
			Single Packaged	13.0 SEER	
Through-the-wall, air cooled (cooling mode)	≤ 30,000 Btu/h[b]	All	Split System	12.0 SEER	
			Single Packaged	12.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	AHRI 340/360
		All Other	Split System and Single Package	10.8 EER 11.0 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 10.7 IEER	
		All Other	Split System and Single Package	10.4 EER 10.5 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	
		All Other	Split System and Single Package	9.3 EER 9.4 IEER	
Water source (cooling mode)	< 17,000 Btu/h	All	86°F entering water	11.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	12.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	12.0 EER	
Ground water source (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.2 EER	

Ground water source (cooling mode)	< 135,000 Btu/h	All	77°F entering water	13.4 EER	
Water-source water to water (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
			59°F entering water	16.3 EER	
Ground water source brine to water (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF	AHRI 210/240
		—	Single Package	7.7 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/hb (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43ºF wb Outdoor Air	3.3 COP	AHRI 340/360
			17ºF db/15ºF wb Outdoor Air	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43ºF wb Outdoor Air	3.2 COP	
			17ºF db/15ºF wb Outdoor Air	2.05 COP	
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.2 COP	ISO 13256-1
Ground water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.6 COP	
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.1 COP	
Water-source water to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	ISO 13256-2
		—	50°F entering water	3.1 COP	
Ground source brine to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	

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

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

[b]Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

Table C403.2.3(3) Minimum Efficiency Requirements--Electrically Operated Packaged

Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners and Room Air-Conditioner Heat Pumps

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency		Test Procedure[a]
			Before 10/08/2012	As of 10/08/2012	
PTAC (cooling mode) new construction	All Capacities	95°F db outdoor air	12.5 - (0.213 × Cap/1000) EER	13.8 - (0.300 × Cap/1000) EER	AHRI 310/380
PTAC (cooling mode) replacements[b]	All Capacities	95°F db outdoor air	10.9 - (0.213 × Cap/1000) EER	10.9 - (0.213 × Cap/1000) EER	
PTHP (cooling mode) new construction	All Capacities	95°F db outdoor air	12.3 - (0.213 × Cap/1000) EER	14.0 - (0.300 × Cap/1000) EER	
PTHP (cooling mode) replacements[b]	All Capacities	95°F db outdoor air	10.8 - (0.213 × Cap/1000) EER	10.8 - (0.213 × Cap/1000) EER	
PTHP (heating mode) new construction	All Capacities	—	3.2 - (0.026 × Cap/1000) COP	3.7 - (0.052 × Cap/1000) COP	
PTHP (heating mode) replacements[b]	All Capacities	—	2.9 - (0.026 × Cap/1000) COP	2.9 - (0.026 × Cap/1000) COP	
SPVAC (cooling mode)	< 65,000 Btu/h	95°F db/75°F wb outdoor air	9.0 EER	9.0 EER	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/75°F wb outdoor air	8.9 EER	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95°F db/75°F wb outdoor air	8.6 EER	8.6 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/75°F wb outdoor air	9.0 EER	9.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/75°F wb outdoor air	8.9 EER	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95 °F db/75°F wb outdoor air	8.6 EER	8.6 EER	
SPVHP (heating mode)	<65,000 Btu/h	47°F db/43°F wb outdoor air	3.0 COP	3.0 COP	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	47°F db/43°F wb outdoor air	3.0 COP	3.0 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	47°F db/43°F wb outdoor air	2.9 COP	2.9 COP	
Room air conditioners, with louvered sides	< 6,000 Btu/h	—	9.7 SEER	9.7 SEER	ANSI/AHA-MRAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	9.7 EER	9.7 EER	
	≥ 8,000 Btu/h and < 14,000 Btu/h	—	9.8 EER	9.8 EER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	—	9.7 SEER	9.7 SEER	
	≥ 20,000 Btu/h	—	8.5 EER	8.5 EER	
Room air conditioners, without louvered sides	< 8,000 Btu/h	—	9.0 EER	9.0 EER	
	≥ 8,000 Btu/h and < 20,000 Btu/h	—	8.5 EER	8.5 EER	
	≥ 20,000 Btu/h	—	8.5 EER	8.5 EER	
Room air-conditioner heat pumps with louvered sides	< 20,000 Btu/h	—	9.0 EER	9.0 EER	

	≥ 20,000 Btu/h	—	8.5 EER	8.5 EER	
Room air-conditioner heat pumps without louvered sides	< 14,000 Btu/h	—	8.5 EER	8.5 EER	
	≥ 14,000 Btu/h	—	8.0 EER	8.0 EER	
Room air conditioner casement only	All capacities	—	8.7 EER	8.7 EER	
Room air conditioner casement-slider	All capacities	—	9.5 EER	9.5 EER	

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

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

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

[b]Replacement unit shall be factory labeled as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW STANDARD PROJECTS" or "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) in height and less than 42 inches (1067 mm) in width.

Table 403.2.3(4)
Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters, Minimum Efficiency Requirements

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency[d, e]	Test Procedure[a]
Warm air furnaces, gas fired	< 225,000 Btu/h	--	78% AFUE or 80% E_t[c]	DOE 10 C.F.R. Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80% E_t[f]	ANSI Z21.47
Warm air furnaces, oil fired	< 225,000 Btu/h	--	78% AFUE or 80% E_t[c]	DOE 10 C.F.R. Part 430 or UL 727
	≥ 225,000 Btu/h	Maximum capacity[b]	81% E_t[g]	UL 727
Warm air duct furnaces, gas fired	All capacities	Maximum capacity[b]	80% E_c	ANSI Z83.8
Warm air unit heaters, gas fired	All capacities	Maximum capacity[b]	80% E_c	ANSI Z83.8
Warm air unit heaters, oil fired	All capacities	Maximum capacity[b]	80% E_c	UL 731

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

[a]Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year

version of the test procedure.

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

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

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

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

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

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

Table C403.2.3(5)
Minimum Efficiency Requirements--Gas- and Oil-Fired Boilers

Equipment Type[a]	Subcategory or Rating Condition	Size Category (Input)	Minimum Efficiency	Test Procedure
Boilers, hot water	Gas-fired	< 300,000 Btu/h	80% AFUE	10 C.F.R. Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	80% E_t	10 C.F.R. Part 431
		> 2,500,000 Btu/h[a]	82% E_c	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 C.F.R. Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t	10 C.F.R. Part 431
		> 2,500,000 Btu/h[a]	84% E_c	
Boilers, steam	Gas-fired	< 300,000 Btu/h	75% AFUE	10 C.F.R. Part 430
	Gas-fired - All, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	79% E_t	10 C.F.R. Part 431
		> 2,500,000 Btu/h[a]	79% E_t	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	77% E_t	
		> 2,500,000 Btu/h[a]	77% E_t	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 C.F.R. Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	81% E_t	10 C.F.R. Part 431
		> 2,500,000 Btu/h[a]	81% E_t	

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

E_c = Combustion efficiency (100 percent less flue losses).

E_t = Thermal efficiency. See referenced standard document for detailed information.

[a]These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

[b]Maximum capacity minimum and maximum ratings as provided for and allowed by the unit's controls.

[c]Includes oil-fired (residual).

Table C403.2.3(6)
(Reserved)

Table C403.2.3(7)
Minimum Efficiency Requirements--Water Chilling Packages[a]

Equipment Type	Size Category	Units	Before 1/1/2010		As of 1/1/2010[b]				Test Procedure[c]
					Path A		Path B		
			Full Load	IPLV	Full Load	IPLV	Full Load	IPLV	
Air cooled chillers	< 150 tons	EER	≥ 9.562	≥ 10.416	❖ 9.562	≥ 12.500	NA	NA	AHRI 550/590
	≥ 150 tons	EER			≥ 9.562	≥ 12.750	NA	NA	
Air cooled without condenser, electrical operated	All capacities	EER	≥ 10.586	≥ 11.782	Air cooled chillers without condensers shall be rated with matching condensers and comply with the air cooled chiller efficiency requirements				
Water cooled, electrically operated, reciprocating	All capacities	kW/ton	≤ 0.837	≤ 0.696	Reciprocating units shall comply with water cooled positive displacement efficiency requirements				
Water cooled, electrically operated, positive displacement	< 75 tons	kW/ton	≤ 0.790	≤ 0.676	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	
	≥ 75 tons and < 150 tons	kW/ton			≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.717	≤ 0.627	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	≥ 300 tons	kW/ton	≤ 0.639	≤ 0.571	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	
Water cooled, electrically operated, centrifugal	< 150 tons	kW/ton	≤ 0.703	≤ 0.669	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.634	≤ 0.596					
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	❖600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR	≥ 0.600	NR	NA	NA	AHRI 560
Water cooled, absorption single effect	All capacities	COP	≥ 0.700	NR	≥ 0.700	NR	NA	NA	

Absorption double effect, indirect fired	All capacities	COP	≥ 1.000	≥ 1.050	≥ 1.000	≥ 1.050	NA	NA	
Absorption double effect, direct fired	All capacities	COP	≥ 1.000	≥ 1.000	≥ 1.000	≥ 1.000	NA	NA	

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.

[a] The centrifugal chiller equipment requirements, after adjustment in accordance with Section C403.2.3.1 or Section C403.2.3.2, do not apply to chillers used in low-temperature applications where the design leaving fluid temperature is less than 36ºF. The requirements do not apply to positive displacement chillers with leaving fluid temperatures less than or equal to 32ºF. The requirements do not apply to absorption chillers with design leaving fluid temperatures less than 40ºF.

[b] 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.

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

Table C403.2.3(8)
Minimum Efficiency Requirements--Heat Rejection Equipment

Equipment Type[a]	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition	Performance Required[b, c, d]	Test Procedure[e, f]
Propeller or axial fan open circuit cooling towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal fan open circuit cooling towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Propeller or axial fan closed circuit cooling towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ 14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal closed circuit cooling towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201
Air cooled condensers	All	125°F Condensing Temperature R-22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering db	≥ 176,000 Btu/h · hp	AHRI 460

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

wb = wet bulb temperature, °F.

[a] The efficiencies and test procedures for both open and closed circuit cooling towers are not applicable to hybrid cooling towers

that contain a combination of wet and dry heat exchange sections.

[b] For purposes of this table, open circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the fan nameplate rated motor power.

[c] For purposes of this table, closed circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the sum of the fan nameplate rated motor power and the spray pump nameplate rated motor power.

[d]For purposes of this table, air cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

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

[f]If a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program, or, if a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.

Table C403.2.3(9)
Heat Transfer Equipment

Equipment Type	Subcategory	Minimum Efficiency	Test Procedure[a]
Liquid-to-liquid heat exchangers	Plate type	NR	AHRI 400

NR = No requirement.

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

C403.2.4 HVAC system controls. Each heating and cooling system shall be provided with thermostatic controls as specified in Section C403.2.4.1, C403.2.4.2, C403.2.4.3, C403.2.4.4, C403.4.1, C403.4.2, C403.4.3, C403.4.4, C403.4.5, C403.4.6, C403.4.7, C403.4.8, C403.4.9, or C403.4.10.

C403.2.4.1 Thermostatic controls. The supply of heating and cooling energy to each *zone*

shall be controlled by individual thermostatic controls capable of responding to temperature within the *zone*. 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 C403.3.1 or C403.4.1 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.

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

1. The perimeter system includes at least one thermostatic control *zone* for each building exposure having exterior walls facing only one orientation (within +/-45 degrees) (0.8 rad) for more than 50 contiguous feet (15,240 mm); and
2. The perimeter system heating and cooling supply is controlled by a thermostat located within the *zones* served by the system.

C403.2.4.1.1 Heat pump supplementary heat. 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. <u>At final inspection, the lock out control shall be set to 32° F (0°C) or less.</u>

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.

C403.2.4.2 Setpoint overlap restriction. Where used to control both heating and cooling, *zone* thermostatic controls shall provide a temperature range or deadband of at least 5°F (2.8°C) within which the supply of heating and cooling energy to the *zone* is capable of being shut off or reduced to a minimum.

EXCEPTION: Thermostats requiring manual changeover between heating and cooling modes.

C403.2.4.3 Off-hour controls. For all occupancies other than Group R, each *zone* shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

EXCEPTIONS:

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

C403.2.4.3.1 Thermostatic setback capabilities. Thermostatic setback controls shall have the capability to set back or temporarily operate the system to maintain *zone* temperatures down to 55°F (13°C) or up to 85°F (29°C).

C403.2.4.3.2 Automatic setback and shutdown capabilities. Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours. Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer capable of being adjusted to operate the system for up to 2 hours; or an occupancy sensor.

C403.2.4.3.3 Automatic start capabilities. Automatic start controls shall be provided for each HVAC system. The controls shall be capable of automatically adjusting the daily start time of the HVAC system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy.

C403.2.4.4 Shutoff damper controls. ((~~Both o~~)) Outdoor air supply, relief and exhaust ducts shall be equipped with motorized dampers complying with Section C402.4.5.2 that will automatically shut when the systems or spaces served are not in use or during building warm-up, cooldown, and setback.

EXCEPTIONS:

1. Gravity relief dampers complying with exception 1 to Section C402.4.5.2 serving systems with a design outdoor air intake, relief or exhaust capacity of less than ((~~5,000~~)) 300 cfm total supply shall be permitted ((~~in buildings less than three stories in height~~)).
2. Gravity dampers shall be permitted for buildings of any height located in Climate Zones 1, 2 and 3.
3. Gravity (nonmotorized) dampers in Group R occupancies where the design outdoor air intake or exhaust capacity does not exceed ((~~400~~)) 300 cfm (189 L/s).
4. Systems serving areas which require continuous operation.
5. Combustion air intakes.
6. Operation of dampers shall be allowed during ventilation prepurge one hour before expected occupancy and for unoccupied period precooling during the cooling season.
7. Dampers are not required in systems where specifically prohibited by the *International Mechanical Code*.

C403.2.4.5 Snow melt system controls. Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F (10°C) and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible.

C403.2.4.6 Combustion heating equipment controls. Combustion heating equipment with a capacity over 225,000 Btu/h shall have modulating or staged combustion control.

EXCEPTIONS:

1. Boilers.
2. Radiant heaters.

C403.2.4.7 Group R-1 hotel/motel guest rooms. For hotel and motel guest rooms, a minimum of one of the following control technologies shall be required in hotels/motels with over 50 guest rooms such that the space temperature would automatically setback (winter) or set up (summer) by no less than 5°F (3°C) ~~or hotel and motel guest rooms, a minimum of~~ when the

occupant is not in the room:

1. Controls that are activated by the room occupant via the primary room access method - Key, card, deadbolt, etc.

2. Occupancy sensor controls that are activated by the occupant's presence in the room.

C403.2.4.8 Group R-2 and R-3 dwelling units. The primary space conditioning system within each dwelling unit shall be provided with at least one programmable thermostat for the regulation of space temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback periods per day.

Each additional system provided within the dwelling unit shall be provided with at least one adjustable thermostat for the regulation of temperature.

EXCEPTIONS:

1. Systems controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.
2. Systems controlled solely by a manually operated timer capable of operating the system for no more than two hours.
3. Ductless heat pumps.

Each thermostat shall be capable of being set by adjustment or selection of sensors as follows: When used to control heating only: 55°F to 75°F; when used to control cooling only: 70°F to 85°F; all other: 55°F to 85°F with an adjustable deadband of not less than 10°F.

C403.2.4.9 Group R-2 sleeping units. The primary space conditioning system within each sleeping unit shall be provided with at least one programmable thermostat for the regulation of space temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback periods per day.

Each additional system provided within the sleeping unit shall be provided with at least one adjustable thermostat for the regulation of temperature.

EXCEPTIONS:

1. Systems controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.
2. Systems controlled solely by a manually operated timer capable of operating the system for no more than two hours.
3. *Zones* with a full HVAC load demand not exceeding 3,400 Btu/h (1 kW) and having a readily accessible manual shutoff switch.
4. Ductless heat pumps.

Each thermostat shall be capable of being set by adjustment or selection of sensors as follows: When used to control heating only: 55°F to 75°F; when used to control cooling only: 70°F to 85°F.

C403.2.4.10 Direct digital control system capabilities. All complex systems equipped with direct digital control (DDC) systems and all buildings with total cooling capacity exceeding 780,000 Btu/h (2,662 kW) shall have the following capability:

1. Trending: All control system input and output points shall be accessible and

programmed for trending, and a graphic trending package shall be provided with the control system.

2. Demand Response Setpoint Adjustment: Control logic shall increase the cooling zone set points by at least 2°F (1°C) and reduce the heating zone set points by at least 2°F (1°C) when activated by a demand response signal. The demand response signal shall be a binary input to the control system or other interface approved by the serving electric utility.

C403.2.5 Ventilation. Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *International Mechanical Code*. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 4 of the *International Mechanical Code*.

C403.2.5.1 Demand controlled ventilation. Demand control ventilation (DCV) shall be provided for spaces larger than 500 square feet (50 m^2) and with an occupant load greater than 25 people per 1000 square feet (93 m^2) of floor area (as established in Table 403.3 of the *International Mechanical Code*) and served by systems with one or more of the following:

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

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

1. Systems with energy recovery complying with Section C403.2.6.
2. Multiple-*zone* systems without direct digital control of individual *zones* communicating with a central control panel.
3. System with a design outdoor airflow less than 1,000 cfm (472 L/s).
4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (600 L/s).
5. Ventilation provided for process loads only.

C403.2.5.2 Occupancy sensors. Classrooms, gyms, auditoriums and conference rooms larger than 500 square feet of floor area shall have occupancy sensor control that will either close outside air dampers or turn off serving equipment when the space is unoccupied except where equipped with another means to automatically reduce outside air intake below design rates when spaces are partially occupied.

C403.2.5.3 Enclosed loading dock, motor vehicle repair garage and parking garage exhaust ventilation system control. 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 upon detection of vehicle operation or the presence of occupants by approved automatic detection devices. Each of the following types of controllers shall be capable of shutting off fans or modulating fan speed. Control devices shall not reduce airflow rates below the minimum requirement in accordance with the *International Mechanical Code* during scheduled periods of occupied operation.

1. 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. Garages, repair garages and enclosed 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.

2. Occupant detection sensors used to activate the system shall detect entry ((~~into the parking garage~~)) along both the vehicle and pedestrian pathways.

C403.2.5.3.1 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 404.2 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.

C403.2.5.3.2 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.

C403.2.5.4 Exhaust systems.

C403.2.5.4.1 Kitchen hoods. Each kitchen area with total exhaust capacity larger than 2,000 cfm shall be provided with make-up air sized so that at least 50% of exhaust air volume be (a) unheated or heated to no more than 60°F and (b) uncooled or cooled without the use of mechanical cooling.

EXCEPTIONS:

1. Where hoods are used to exhaust ventilation air which would otherwise exfiltrate or be exhausted by other fan systems. A detailed accounting of exhaust airflows shall be provided on the plans that accounts for the impact of any required demand controlled ventilation.
2. Certified grease extractor hoods that require a face velocity no greater than 60 fpm.

C403.2.5.4.2 Laboratory exhaust systems. Buildings with laboratory exhaust systems having a total exhaust rate greater than 5,000 cfm (2,360 L/s) shall include heat recovery systems to precondition~~ed~~ makeup air from laboratory exhaust. The heat recovery system shall be capable of increasing the outside air supply temperature at design heating conditions by 25°F (13.9°C) in Climate Zones 4C/5B and 35°F (19.4°C) in Climate Zone 6B. A provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by Section C403.4.

EXCEPTIONS:

1. Variable air volume laboratory exhaust and room supply systems capable of reducing

exhaust and make-up air volume to 50% or less of design values; or

2. Direct make-up (auxiliary) air supply equal to at least 75% of the exhaust rate, heated no warmer than 2°F (1.1°C) below room set point, cooled to no cooler than 3°F (1.7°C) above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control; or
3. Combined Energy Reduction Method: VAV exhaust and room supply system capable of reducing exhaust and makeup air volumes and a heat recovery system to precondition makeup air from laboratory exhaust that when combined will produce the same energy reduction as achieved by a heat recovery system with a 50% sensible recovery effectiveness as required above. For calculation purposes, the heat recovery component can be assumed to include the maximum design supply airflow rate at design conditions. The combined energy reduction (Q_{ER}) shall meet the following:

$$Q_{ER} \geq Q_{MIN}$$

$$Q_{MIN} = CFM_S \cdot (T_R - T_O) \cdot 1.1 \cdot 0.6$$

$$Q_{ER} = CFM_S \cdot (T_R - T_O) \cdot 1.1(A + B)/100$$

Where:

Q_{MIN} = Energy recovery at 60% sensible effectiveness (Btu/h)

Q_{ER} = Combined energy reduction (Btu/h)

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

T_R = Space return air dry bulb at winter design conditions

T_O = Outdoor air dry bulb at winter design conditions

A = Percentage that the exhaust and makeup air volumes can be reduced from design conditions

B = Percentage sensible heat recovery effectiveness

C403.2.6 Energy recovery.

C403.2.6.1 Energy recovery ventilation systems. Any system with minimum outside air requirements at design conditions greater than 5,000 CFM or any system required by Table C403.2.6 shall include an energy recovery system. The energy recovery system shall have the capability to provide a change in the enthalpy of the outdoor air supply of not less than 50 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 or controls which permit operation of the economizer as required by Section C403.4. 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).

Informative Note: In Seattle, the outdoor design air temperature is 24°F as specified in Appendix C. The difference between 24°F and 65°F is 41 degrees. One-half of 41 degrees is 20.5 degrees. Therefore, to provide 50 percent heat recovery effectiveness in Seattle, the heat recovery system shall raise the outside supply air temperature to a minimum of 44.5°F (24°F + 20.5°F) at the outdoor design conditions.

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

1. Where energy recovery systems are prohibited by the *International Mechanical Code*.
2. Laboratory fume hood systems that include at least one of the following features, and also comply with Section 403.2.5.4.2:

2.1. Variable-air-volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.

2.2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (1.1°C) above room setpoint, cooled to no cooler than 3°F (1.7°C) below room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.

3. Systems serving spaces that are heated to less than 60°F (15.5°C) and are not cooled.
4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
5. Heating energy recovery in Climate Zones 1 and 2.
6. Cooling energy recovery in Climate Zones 3C, 4C, 5B, 5C, 6B, 7 and 8.
7. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
8. Multi-zone systems with cold deck supply air and zone reheat where the minimum outdoor air is less than 70 percent of total supply air.
9. Systems serving residential multifamily spaces 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.
10. Type I kitchen exhaust hoods

C403.2.6.2 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.

C403.2.6.3 Condenser heat recovery. Facilities having food service, meat or deli departments

and having 500,000 Btu/h or greater of remote refrigeration condensers shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, space heating or for dehumidification reheat. Facilities having a gross conditioned floor area of 40,000 ft^2 or greater and 1,000,000 Btu/h or greater of remote refrigeration shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, and either for space heating or for dehumidification reheat for maintaining low space humidity. 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.

Table C403.2.6
Energy Recovery Requirement

Climate Zone	Percent (%) Outdoor Air at Full Design Airflow Rate					
	≥ 30% and < 40%	**≥ 40% and < 50%**	**≥ 50% and < 60%**	**≥ 60% and < 70%**	**≥ 70% and < 80%**	**≥ 80%**
	Design Supply Fan Airflow Rate (cfm)					
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	≥ 5000	≥ 5000
1B, 2B, 5C	NR	NR	≥ 26000	≥ 12000	≥ 5000	≥ 4000
6B	≥ 11000	≥ 5500	≥ 4500	≥ 3500	≥ 2500	≥ 1500
1A, 2A, 3A, 4A, 5A, 6A	≥ 5500	≥ 4500	≥ 3500	≥ 2000	≥ 1000	> 0
7, 8	≥ 2500	≥ 1000	> 0	> 0	> 0	> 0

NR .= Not required.

Informative Note: For Climate Zone 4C (Seattle), Table C403.2.6 requires energy recovery for HVAC systems that have a design supply fan airflow rate greater than 5000 CFM and have a minimum requirement for 70% or more outside air. Thus a system with a 5000 CFM fan and an 80% outside air requirement for ventilation, providing just 4000 CFM of outside air, would require energy recovery.

In addition, the first sentence of Section C403.2.6.1 states that any system requiring more than 5000 CFM of outside air, no matter what percentage of the total supply air that represents, also requires energy recovery. Thus a 12,000 CFM fan with a 50% outside air requirement would require energy recovery.

C403.2.7 Duct and plenum insulation and sealing.

C403.2.7.1 Ducts, shafts and plenums conveying outside air from the exterior of the building to the mechanical system shall meet all air leakage and building envelope insulation requirements of Section C402, plus building envelope vapor control requirements from the *International*

Building Code, extending continuously from the building exterior to an automatic shutoff damper or heating or cooling equipment. For the purposes of building envelope insulation requirements, such duct surfaces shall meet the requirements for metal framed walls per Table C402.1.2. Duct surfaces included as part of the building envelope shall not be used in the calculation of maximum glazing area as described in Section 402.3.1.

EXCEPTIONS:
1. Outside air ducts serving individual supply air units with less than 2,800 cfm of total supply air capacity, provided these are insulated to R-7.
2. Unheated equipment rooms with combustion air louvers, provided they are isolated from conditioned space at sides, top and bottom of the room with R-11 nominal insulation.

C403.2.7.2 All other supply and return air ducts and plenums shall be insulated with a minimum of R-6 insulation where located in unconditioned spaces and a minimum of R-8 insulation where located outside the building. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by minimum insulation value as required for exterior walls by Section C402.2.3.

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

Supply ducts which convey supply air at temperatures less than 55°F or greater than 105°F shall be insulated with a minimum of R-3.3 insulation where located within conditioned space.

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

C403.2.7.3 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.

C403.2.7.3.1 Low-pressure duct systems. All longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (w.g.) (500 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus embedded-fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

EXCEPTION: Continuously welded and locking-type longitudinal joints and seams on ducts operating at static pressures less than 2 inches water gauge (w.g.) (500 Pa) pressure classification.

C403.2.7.3.2 Medium-pressure duct systems. All 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 C403.2.7. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

C403.2.7.3.3 High-pressure and exterior duct systems. Ducts designed to operate at static pressures in excess of 3 inches water gauge (w.g.) (750 Pa) and all ductwork located outside the building envelope shall be insulated and sealed in accordance with Section C403.2.7. In addition, ducts and plenums shall be leak-tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage (*CL*) less than or equal to 6.0 as determined in accordance with Equation C4-5.

(Equation C4-5)

$$CL = F/P0.65$$

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.

C403.2.8 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.2.8.

EXCEPTIONS:
1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 60°F (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).

C403.2.8.1 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 tape shall not be permitted.

Table C403.2.8
Minimum Pipe Insulation Thickness (thickness in inches)[a]

Fluid Operating Temperature Range and Usage (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (inches)				
	Conductivity Btu · in. /(h · ft^2 · °F)[b]	Mean Rating Temperature, °F	< 1	1 to < 1-1/2	1-1/2 to < 4	4 to < 8	≥ 8
> 350	0.32 - 0.34	250	4.5	5.0	5.0	5.0	5.0
251 - 350	0.29 - 0.32	200	3.0	4.0	4.5	4.5	4.5
201 - 250	0.27 - 0.30	150	2.5	2.5	2.5	3.0	3.0
141 - 200	0.25 - 0.29	125	1.5	1.5	2.0	2.0	2.0
105 - 140	0.21 - 0.28	100	1.0	1.0	1.5	1.5	1.5
40 - 60	0.21 - 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 - 0.26	75	0.5	1.0	1.0	1.0	1.5

[a] For piping smaller than 1-1/2 inch (38 mm) and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1 inch (25 mm) shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch (25 mm).

[b] For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

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

Where:

T = Minimum insulation thickness,

r = Actual outside radius of pipe,

t = Insulation thickness listed in the table for applicable fluid temperature and pipe size,

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

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

c For direct-buried heating and hot water system piping, reduction of these thicknesses by 1-1/2 inches (38 mm) shall be permitted (before thickness adjustment required in footnote b but not to thicknesses less than 1 inch (25 mm).

C403.2.9 Mechanical systems commissioning and completion requirements. Mechanical systems shall be commissioned and completed in accordance with Section C408.2.

C403.2.10 Air system design and control. Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) (3.7 kW) shall meet the provisions of Sections C403.2.10.1 through C403.2.10.((~~2~~))5. All motors less than 1 horsepower shall meet the provisions of Sections C403.2.10.3.

C403.2.10.1 Allowable fan floor horsepower. Each HVAC system at fan system design conditions shall not exceed the allowable *fan system motor nameplate hp* (Option 1) or *fan system bhp* (Option 2) as shown in Table C403.2.10.1(1). This includes supply fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability. Single *zone* variable-air-volume systems shall comply with the constant volume fan power limitation.

EXCEPTION: The following fan systems are exempt from allowable fan floor horsepower requirement.

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

C403.2.10.2 Motor nameplate horsepower. For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp). The fan brake horsepower (bhp) shall be indicated on the design documents to allow for compliance verification by the *code official*.

EXCEPTIONS: 1. For fans less than 6 bhp (4413 W), where the first available motor larger than the brake horsepower has a nameplate rating within 50 percent of the bhp, selection of the next larger nameplate motor size is allowed.

2. For fans 6 bhp (4413 W) and larger, where the first available motor larger than the bhp has a nameplate rating within 30 percent of the bhp, selection of the next larger nameplate motor size is allowed.
3. For fans used only in *approved* life safety applications such as smoke evacuation.

C403.2.10.3 Fractional hp fan motors. Motors for fans that are 1/12 hp or greater and less than 1 hp shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent when rated in accordance with DOE 10 C.F.R. 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of a varying motor speed.

EXCEPTIONS:

1. Motors in the airstream within fan-coils and terminal units that operate only when providing heating to the space served.
2. Motors installed in space conditioning equipment certified under Section C403.2.3.

Table C403.2.10.1(1)
Fan Power Limitation

	Limit	Constant Volume	Variable Volume
Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	hp ≤ $CFM_S \times 0.0011$	hp ≤ $CFM_S \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	bhp ≤ $CFM_S \times 0.00094 + A$	bhp ≤ $CFM_S \times 0.0013 + A$

Where:

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

hp = The maximum combined motor nameplate horsepower.

bhp = The maximum combined fan brake horsepower.

A = Sum of [$PD \times CFM_D/4131$]

For SI: 1 cfm = 0.471 L/s.

Where:

PD = Each applicable pressure drop adjustment from Table C403.2.10.1(2) in. w.c.

CFM_D = The design airflow through each applicable device from Table C403.2.10.1(2) in cubic feet per minute.

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W.

Table C403.2.10.1(2)
Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment
Credits	
Fully ducted return and/or exhaust air systems	0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)
Return and/or exhaust air flow control devices	0.5 inch w.c.
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate filtration credit: MERV 9 - 12	0.5 inch w.c.
Particulate filtration credit: MERV 13 - 15	0.9 inch w.c.
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy recovery device, other than coil runaround loop	(2.2 × energy recovery effectiveness) – 0.5 inch w.c. for each airstream
Coil runaround loop	0.6 inch w.c. for each airstream

Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions
Sound attenuation section	0.15 inch w.c.
Exhaust system serving fume hoods	0.35 inch w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100 feet of vertical duct exceeding 75 feet

w.c. .= water column

For SI: 1 inch w.c..= 249 Pa, 1 inch.= 25.4 mm

C403.2.10.4. Multiple-zone Variable Air Volume (VAV) System Ventilation Optimization Control. Multiple-zone VAV systems with direct digital control (DDC) of individual zone boxes reporting to a central control panel shall include means to automatically reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency as set out in ASHRAE 62.1, Appendix A.

Exceptions. The following systems are exempt from this section:

1. VAV Systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air
2. Dual-duct dual-fan VAV systems
3. VAV systems with fan-powered terminal units
4. Systems where total design exhaust airflow is more than 70 percent of the total design outdoor air intake flow requirements

C403.2.10.5 Multiple-zone VAV System Outdoor Airflow Control. Multiple-zone VAV systems with a minimum outside air requirement of 5,000 CFM 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 zonal systems as required by Sections C403.2.10.4 and C403.2.5.1.

Exceptions

1. Systems that meet all of the following are exempt from this section:
   - 1.1 No spaces served by the system require demand control ventilation per Section C403.2.5.1.
   - 1.2 The system meets the one of the exceptions to Section C403.2.10.4.
   - 1.3 The system complies with Section 403.6 of the International Mechanical Code.
2. Systems where total design exhaust airflow is more than 70 percent of the total design outdoor air intake flow requirements are exempt from this section.

C403.2.11 Heating outside a building. Systems installed to provide heat outside a building shall be radiant systems.

Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically deenergized when no occupants are present.

C403.2.12 System criteria. For fan and pump motors ((~~7.5~~)) 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 boosting 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.).

See Seattle Building Code, Section 3016.15 for energy efficiency requirements for ventilation fan systems in elevators.

C403.2.12.1 Heat rejection equipment. The requirements of this section apply to heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers, and evaporative condensers.

EXCEPTION: Heat rejection devices included as an integral part of equipment listed in Tables C403.2.3(1) through C403.2.3(3).

Heat rejection equipment shall have a minimum efficiency performance not less than values specified in Table C403.2.3(8). These requirements apply to all propeller, axial fan and centrifugal fan cooling towers. Table C403.2.3(8) specifies requirements for air-cooled condensers that are within rating conditions specified within the table.

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.

Hydronic heat pump and other cooling and refrigeration equipment, including but not limited to icemakers and walk-in coolers, shall not use domestic water only one time before dumping it to waste (no single pass water cooling systems are allowed).

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.

C403.2.12.1.1 Variable flow controls. Cooling tower fans 7.5 hp and greater shall have control devices that vary flow by controlling the leaving fluid temperature or condenser temperature/pressure of the heat rejection device.

C403.2.12.1.2 Limitation on centrifugal fan cooling towers. Open cooling towers with a combined rated capacity of 1,100 gpm and greater at 95°F condenser water return, 85°F condenser water supply and 75°F outdoor wet-bulb temperature shall meet the energy efficiency requirement for axial fan open circuit cooling towers.

EXCEPTION: Open circuit cooling towers that are ducted (inlet or discharge) ((~~or have external sound attenuation that requires~~)) and require external static pressure capability or open circuit cooling towers that have external sound attenuation.

C403.2.12.2 Large volume fan systems. Single or multiple fan systems serving a zone or adjacent zones without separating walls with total air flow over 10,000 cfm (3,540 L/s) are required to reduce airflow based on space thermostat heating and cooling demand. A variable speed drive shall reduce airflow to a maximum 75 percent of peak airflow or minimum ventilation air requirement as required by Section 403 of the *International Mechanical Code*, whichever is greater.

EXCEPTIONS:

1. Systems where the function of the supply air is for purposes other than temperature control, such as maintaining specific humidity levels or supplying an exhaust system.
2. Dedicated outdoor air supply unit(s) with heat recovery where airflow is equal to the minimum ventilation requirements and other fans cycle off unless heating or cooling is required.
3. An area served by multiple units where designated ventilation units have 50 percent or less of total area airflow and nonventilation unit fans cycle off when heating or cooling is not required.

All air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at AHRI conditions greater than or equal to 110,000 Btu/h that serve single zones shall have their supply fans controlled by two-speed motors or variable speed drives. At cooling demands less than or equal to 50 percent, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

1. Two-thirds of the full fan speed; or
2. The volume of outdoor air required to meet the ventilation requirements of Section 403 of the *International Mechanical Code*.

C403.2.13 Electric motor efficiency. Design A and B squirrel-cage, T-frame induction permanently wired polyphase motors of 1 hp or more having synchronous speeds of 3,600, 1,800 and 1,200 rpm shall have a nominal full-load motor efficiency no less than the corresponding values for energy efficient motors provided in NEMA Standard MG-1.

EXCEPTIONS:

1. Motors used in systems designed to use more than one speed of a multi-speed motor.
2. Motors used as a component of the equipment meeting the minimum equipment efficiency requirements of Section C403.2.3 and Tables C403.2.3(1) through C403.2.3(9) provided that the motor input is included when determining the equipment efficiency.
3. Motors that are an integral part of specialized process equipment.
4. Where the motor is integral to a listed piece of equipment for which no complying

motor has been approved.

Fan motors less than 1 hp in series terminal units and in fan-coil units shall be electronically commutated motors, or shall have a minimum motor efficiency of ((~~65~~)) 70 percent when rated in accordance with NEMA Standard MG-1 at full load rating conditions.

C403.3 Simple HVAC systems and equipment (Prescriptive). This section applies to unitary or packaged HVAC systems listed in Tables C403.2.3(1) through C403.2.3(8), each serving one *zone* and controlled by a single thermostat in the *zone* served. It also applies to two-pipe heating systems serving one or more *zones*, where no cooling system is installed.

To qualify as a simple system, systems shall have no active humidification or simultaneous heating and cooling and shall be one of the following:

1. Air cooled, constant volume packaged equipment, which provide heating, cooling or both, and require only external connection to duct work and energy services with cooling capacity of 135,000 Btu/h or less.
2. Air cooled, constant volume split systems, which provide heating, cooling or both, with cooling capacity of 84,000 Btu/h or less.
3. Heating only systems which have a capacity of less than 1,000 cfm or which have a minimum outside air supply of less than 30 percent of the total air circulation.

The combined airflow rate of all simple systems serving single rooms must be less than 10,000 cfm or they do not qualify as simple systems.

C403.3.1 Economizers. Each cooling system that has a fan shall include an air economizer meeting the requirements of Sections C403.3.1.1 through C403.3.1.1.4.

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

1. (Reserved. See Table C101.4.3.2, footnote 17.) ((~~Qualifying small equipment: This exception shall not be used for unitary cooling equipment installed outdoors or in a mechanical room adjacent to the outdoors. This exception is allowed to be used for other cooling units and split systems with a total cooling capacity rated in accordance with Section C403.2.3 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 C403.2.3 (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 its air economizer capacity, whichever is greater. That portion of the equipment serving residential occupancies is not included in determining the total capacity of all units without economizers in a building. Redundant units are not counted in the capacity limitations. This exception shall not be used for the shell-and-core permit or for the initial tenant improvement or for Total Building Performance.~~))
2. Systems with dehumidification that affect other systems so as to increase the overall building energy consumption. New humidification equipment shall comply with Section C403.2.3.4.
3. For residential 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, SEER, and EER values more than 15 percent higher than minimum efficiencies listed in Tables C403.2.3 (1) through (10), 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 and VRF systems, compliance is based on the cooling capacity of individual fan coil units.

4. Where the cooling *efficiency* meets or exceeds the *efficiency* requirements in Table C403.3.1(2).

Table C403.3.1(2)
Equipment Efficiency Performance
Exception for Economizers

Climate Zones	Cooling Equipment Performance Improvement (EER OR IPLV)
2B	10% Efficiency Improvement
3B	15% Efficiency Improvement
4B	20% Efficiency Improvement
4C	64% Efficiency Improvement

C403.3.1.1 Air economizers. Air economizers shall comply with Sections C403.3.1.1.1 through C403.3.1.1.4.

C403.3.1.1.1 Design capacity. Air economizer systems shall be capable of modulating *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.

C403.3.1.1.2 Control signal. Economizer dampers shall be capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature. Air economizers on systems with cooling capacity greater than 65,000 Btu/h shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

EXCEPTION: The use of mixed air temperature limit control shall be permitted for systems that are both controlled from space temperature (such as single *zone* systems) and having cooling capacity less than 65,000 Btu/h.

C403.3.1.1.3 High-limit shutoff. Air economizers shall be capable of automatically reducing *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will no longer reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table C403.3.1.1.3(1). High-limit shutoff control settings for these control types shall be those specified in Table C403.3.1.1.3(2).

Table C403.3.1.1.3(1)
High-limit Shutoff Control Options for Air Economizers

Climate Zones	Allowed Control Types	Prohibited Control Types

1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	Fixed dry-bulb Differential dry-bulb Electronic enthalpy[a] Differential enthalpy Dew-point and dry-bulb temperatures	Fixed enthalpy
1A, 2A, 3A, 4A	Fixed dry-bulb Fixed enthalpy Electronic enthalpy[a] Differential enthalpy Dew-point and dry-bulb temperatures	Differential dry-bulb
All other climates	Fixed dry-bulb Differential dry-bulb Fixed enthalpy Electronic enthalpy[a] Differential enthalpy Dew-point and dry-bulb temperatures	--

[a]Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

Table C403.3.1.1.3(2)
High-limit Shutoff Control Setting for Air Economizers

Device Type	Climate Zone	Required High Limit (Economizer off When): Equation	Description
Fixed dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	T_{OA} > 75°F	Outdoor air temperature exceeds 75°F
	5A, 6A, 7A	T_{OA} > 70°F	Outdoor air temperature exceeds 70°F
	All other zones	T_{OA} > 65°F	Outdoor air temperature exceeds 65°F
Differential dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy	All	h_{OA} > 28 Btu/lb[a]	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[a]
Electronic enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outdoor air temperature/RH exceeds the "A" setpoint curve[b]
Differential enthalpy	All	$h_{OA} > H_{ra}$	Outdoor air enthalpy exceeds return air enthalpy
Dew-point and dry-bulb temperatures	All	DP_{OA} > 55°F or T_{OA} > 75°F	Outdoor air dry-bulb exceeds 75°F or outside dew-point exceeds 55°F (65 gr/lb)

For SI: °C = (°F - 32) × 5/9, 1 Btu/lb = 2.33 kJ/kg.

a At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50 percent relative humidity. As an example, at approximately 6,000 feet elevation the fixed enthalpy limit is approximately 30.7 Btu/lb.

b Setpoint "A" corresponds to a curve on the psychometric chart that goes through a point

at approximately 75°F and 40 percent relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

C403.3.1.1.4 Relief of excess outdoor air. Systems shall be capable of relieving excess *outdoor air* during air economizer operation to prevent over-pressurizing the building. The relief air outlet shall be located to avoid recirculation into the building.

C403.3.2 Hydronic system controls. Hydronic systems of at least 300,000 Btu/h (87,930 W) design output capacity supplying heated ~~and chilled water~~ to comfort conditioning systems shall include controls that meet the requirements of Section C403.4.3.

C403.3.3 Single Zone Variable-Air-Volume Controls. HVAC systems shall have variable airflow controls as follows:

1. Supply fans for air handling and fan coil units with chilled-water cooling coils and supply fans with motors greater than or equal to 5 hp shall be controlled by variable-speed drives or electronically-commutated motors. At cooling demands less than or equal to 50 percent, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:
    1.1. One half of the full fan speed; or
    1.2. The volume of outdoor air required to meet the ventilation requirements of the *International Mechanical Code*.

2. Supply fans for air conditioning equipment and air handling units with direct expansion cooling and a cooling capacity greater than or equal to 110,000 Btu/h that serve single zones shall be controlled by variable-speed drives or electronically-commutated motors. Cooling capacity shall be determined at the rating conditions in the AHRI standard appropriate to the equipment, At cooling demands less than or equal to 50 percent, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:
    2.1. Two-thirds of the full fan speed; or
    2.2. The volume of outdoor air required to meet the ventilation requirements of the *International Mechanical Code*.

C403.4 Complex HVAC systems and equipment (prescriptive). This section applies to HVAC equipment and systems not covered in Section C403.3.

For buildings with a total equipment cooling capacity of 300 tons and above, the equipment shall comply with one of the following:

1. No one unit shall have a cooling capacity of more than 2/3 of the total installed cooling equipment capacity;
2. The equipment shall have a variable speed drive; or
3. The equipment shall have multiple compressors.

C403.4.1 Economizers. Air economizers shall be provided on all new systems including those serving computer server rooms, electronic equipment, radio equipment, and telephone switchgear. Economizers shall comply with Sections C403.4.1.1 through C403.4.1.4.

EXCEPTIONS:

1. Water-cooled refrigeration equipment serving chilled beams and chilled ceiling space cooling systems only which are provided with a water economizer meeting the requirements of Sections C403.4.1.1 through C403.4.1.4. Water economizer capacity per building shall not exceed 500 tons. This exception shall not be used for Total Building Performance.
2. Systems complying with all of the following criteria:

2.1. Consist of multiple water source heat pumps connected to a common water loop;

2.2. Have a minimum of 60 percent air economizer;

2.3. Have water source heat pumps with an EER at least 15 percent higher for cooling and a COP at least 15 percent higher for heating than that specified in Section C403.2.3;

2.4. Where provided with a dedicated boiler or furnace for that building, have a central boiler or furnace efficiency of 90 percent minimum for units up to 199,000 Btu/h; and

2.5. Provide heat recovery with a minimum 50 percent heat recovery effectiveness as defined in Section C403.2.6 to preheat the outside air supply.

3. Chilled water terminal units connected to systems with chilled water generation equipment with IPLV values more than 25 percent higher than minimum part load efficiencies listed in Table C403.2.3(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 per building, or ((~~20~~)) 5 percent of its air economizer capacity, whichever is greater. That portion of the equipment serving Group R Occupancy is not included in determining the total capacity of all units without economizers in a building. This exception shall not be used for the initial permit (this includes any initial permit for the space including, but not limited to, the shell-and-core permit, built-to-suit permit, and tenant improvement permit) or for Total Building Performance Method.
4. 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 SEER and EER values more than 15 percent higher than minimum efficiencies listed in Tables C403.2.3 (1) through (3), in the appropriate size category, using the same test procedures. PTAC and PTHP units with capacities no greater than 8,300 Btu/h are permitted for the purposes of this exception if they have EER values a minimum of 4 percent higher the minimum efficiencies listed in Table C403.2.3(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.
5. Equipment used to cool any dedicated server room, electronic equipment room or telecom switch room provided that they completely comply with Option a, b, ((~~or~~)) c, d or e in the table below. The total capacity of all qualifying systems without economizers shall not exceed 240,000 Btu/h per building or 10 percent of its air economizer capacity, whichever is greater. This exception shall not be used for Total Building Performance.

	Equipment Type	Higher Equipment Efficiency	Part-Load Control	Economizer

Option a	Tables C403.2.3(1) and C403.2.3(2)[a]	+15%[b]	Required over 85,000 Btu/h[c]	None Required
Option b	Tables C403.2.3(1) and C403.2.3(2)[a]	+5%[d]	Required over 85,000 Btu/h[c]	Waterside Economizer
Option c	ASHRAE Standard 127[f]	+0%[g]	Required over 85,000 Btu/h[c]	Waterside Economizer
Option d	Table C403.2.3(7) [h]	+ 25% [i]	Required for all chillers [J]	None Required
Option e	Table C403.2.3(7) [h]	+ 10/15% [k]	Required over 85,000 Btu/h [c]	Dedicated waterside economizer

Notes for Exception 5:

a For a system where all of the cooling equipment is subject to the AHRI standards listed in Tables C403.2.3(1) and C403.2.3(2), the system shall comply with all of the following (note that if the system contains any cooling equipment that exceeds the capacity limits in Table C403.2.3(1) or C403.2.3(2), or if the system contains any cooling equipment that is not included in Table C403.2.3(1) or C403.2.3(2), then the system is not allowed to use this option).

b The cooling equipment shall have an SEER/EER value and an IEER/IPLV value that each is a minimum of 15 percent greater than the value listed in Tables C403.2.3(1) and C403.2.3(2) (1.15 x values in Tables C403.2.3(1) and C403.2.3(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 each is a minimum of 5 percent greater than the value listed in Tables C403.2.3(1) and C403.2.3(2) (1.05 x values in Tables C403.2.3(1) and C403.2.3(2)).

e The system shall include a water economizer in lieu of air economizer. Water economizers shall meet the requirements of Sections C403.4.1.2 through C403.4.1.4 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 nondedicated condenser water system exists that can provide appropriate water temperatures during hours when waterside economizer cooling is available.

f For a system where all cooling equipment is subject to ASHRAE Standard 127.

g The cooling equipment subject to the ASHRAE Standard 127 shall have EER value and an IPLV SCOP value that is ((~~equal or~~)) a minimum of 10 percent greater than the value listed in Tables C403.2.3(1) and C403.2.3(2) (1.10 x values in these tables) when determined in accordance with the rating conditions 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 C403.2.3(7)

(e.g. a chilled water system with fan coil units).

i The cooling equipment shall have an full-load EER value and an IPLV value that is a minimum of 25 percent greater than the value listed in Table C403.2.3(7) (1.25 x value in Table C403.2.3(7) or a full-load and IPLV kW/ton that is at least 25 percent lower than the value listed in Table C403.2.3(7) (0.75 x value in Table C403.2.3(7)).

j 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).

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 C403.2.3(7) (1.10 x values in Table C403.2.3(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 C403.2.3(7) (0.85 x values in Table C403.2.3(7)).

6. Variable refrigerant flow (VRF) systems, multiple-zone split-system heat pumps, consisting of multiple, individually metered indoor units with multi-speed fan motors, served on a single common refrigeration circuit with an exterior reverse-cycle heat pump with variable speed compressor(s) and variable speed condenser fan(s). These systems shall also be capable of providing simultaneous heating and cooling operation, where in all rooms with VRF units recovered energy from the indoor units operating in one mode can be transferred to one or more indoor units operating in the other mode, and shall serve at least 20 percent internal (no perimeter wall within 12') and 20 percent perimeter zones (as determined by conditioned floor area) and the outdoor unit shall be at least 65,000 Btu/h in total capacity. Systems utilizing this exception shall have 50 percent heat recovery effectiveness as defined by Section C403.2.6 on the outside air. For the purposes of this exception, dedicated server rooms, electronic equipment rooms or telecom switch rooms are not considered perimeter zones and shall not exceed 20 percent of the floor area served by the VRF system. This exception shall be limited to buildings of 60,000 square feet and less.

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

C403.4.1.1 Design capacity. Water economizer systems shall be capable of cooling supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at *outdoor air* temperatures of 50°F dry-bulb (10°C dry-bulb)/45°F wet-bulb (7.2°C wet-bulb) and below.

EXCEPTION: Systems in which a water economizer is used and where dehumidification requirements cannot be met using outdoor air temperatures of 50°F dry-bulb (10°C dry-bulb)/45°F wet-bulb (7.2°C wet-bulb) shall satisfy 100 percent of the expected system cooling load at 45°F dry-bulb (7.2°C dry-bulb)/40°F wet-bulb (4.5°C wet-bulb).

C403.4.1.2 Maximum pressure drop. Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a waterside pressure drop of less than 15 feet (4572 mm) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal

cooling (noneconomizer) mode.

C403.4.1.3 Integrated economizer control. Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even where additional mechanical cooling is required to meet the remainder of the cooling load.

EXCEPTIONS:

1. Direct expansion systems that include controls that reduce the quantity of *outdoor air* required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is no greater than 25 percent of the total system capacity.
2. Individual direct expansion units that have a rated cooling capacity less than 54,000 Btu/h (15,827 W) and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.

C403.4.1.4 Economizer heating system impact. HVAC system design and economizer controls shall be such that economizer operation does not increase the building heating energy use during normal operation.

EXCEPTION: Economizers on VAV systems that cause *zone* level heating to increase due to a reduction in supply air temperature.

C403.4.2 Variable air volume (VAV) fan control. Individual VAV fans with motors of 7.5 horsepower (5.6 kW) or greater shall be:

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

C403.4.2.1 Static pressure sensor location. Static pressure sensors used to control VAV fans shall be placed in a position such that the controller setpoint is no greater than one-third the total design fan static pressure, except for systems with *zone* reset control complying with Section C403.4.2.2. For sensors installed downstream of major duct splits, at least one sensor shall be located on each major branch to ensure that static pressure can be maintained in each branch.

C403.4.2.2 Set points for direct digital control. For systems with direct digital control of individual *zone* boxes reporting to the central control panel, the static pressure setpoint shall be reset based on the *zone* requiring the most pressure, i.e., the setpoint is reset lower until one *zone* damper is nearly wide open.

C403.4.3 Hydronic systems controls. The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections C403.4.3.1 through C403.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls capable of sequencing operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h (146,550 W) input design capacity shall include either a multi-staged or

modulating burner.

C403.4.3.1 Three-pipe system. Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

C403.4.3.2 Two-pipe changeover system. Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a dead band between changeover from one mode to the other of at least 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for at least 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F (16.7°C) apart.

C403.4.3.3 Hydronic (water loop) heat pump systems. Hydronic heat pump systems shall comply with Sections C403.4.3.3.1 through C403.4.3.3.3.

C403.4.3.3.1 Temperature dead band. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature dead band of at least 20°F (11.1°C) between initiation of heat rejection and heat addition by the central devices.

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

C403.4.3.3.2 Heat rejection. Heat rejection equipment shall comply with Sections C403.4.3.3.2.1 and C403.4.3.3.2.2.

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

C403.4.3.3.2.1 Climate Zones 3 and 4. For Climate Zones 3 and 4:

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

C403.4.3.3.2.2 Climate Zones 5 through 8. For Climate Zones 5 through 8, if an open- or closed-circuit cooling tower is used, then a separate heat exchanger shall be provided to isolate the cooling tower from the heat pump loop, and heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop and providing an automatic valve to stop the flow of fluid.

C403.4.3.3.3 Isolation valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 horsepower (hp) (7.5 kW) shall have a two-way (but not

three-way) valve. For the purposes of this section, pump system power is the sum of the nominal power demand (i.e., nameplate horsepower at nominal motor efficiency) of motors of all pumps that are required to operate at design conditions to supply fluid from the heating or cooling source to all heat transfer devices (e.g., coils, heat exchanger) and return it to the source. This converts the system into a variable flow system and, as such, the primary circulation pumps shall comply with the variable flow requirements in Section C403.4.3.6.

C403.4.3.4 Part load controls. Hydronic systems greater than or equal to 300,000 Btu/h (87,930 W) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability to:

1. Automatically reset the supply-water temperatures using zone-return water temperature, building-return water temperature, or outside air temperature as an indicator of building heating or cooling demand. The temperature shall be capable of being reset by at least 25 percent of the design supply-to-return water temperature difference; and

2. Reduce system pump flow by at least 50 percent of design flow rate utilizing adjustable speed drive(s) on pump(s), or multiple-staged pumps where at least one-half of the total pump horsepower is capable of being automatically turned off or control valves designed to modulate or step down, and close, as a function of load, or other *approved* means.

Hydronic systems serving hydronic heat pumps are exempt from item 1, and only those hydronic systems with a total pump system power greater than 3 hp (2.2 kw) shall have controls meeting the requirements of item 2, above.

C403.4.3.5 Pump isolation. Chilled water plants including more than one chiller shall have the capability to reduce flow automatically through the chiller plant when a chiller is shut down and automatically shut off flow to chillers that are shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

EXCEPTION: Chillers that are piped in series for the purpose of increased temperature differential.

Boiler plants including more than one boiler shall have the capability to reduce flow automatically through the boiler plant when a boiler is shut down and automatically shut off flow to <u>boilers</u> ~~chillers~~ that are shut down.

C403.4.3.6 Variable flow controls. Individual pumps requiring variable speed control per Section ((~~C403.4.9~~)) <u>C403.2.12</u> shall be controlled in one of the following manners:

1. For systems having a combined pump motor horsepower less than or equal to 20 hp (15 kW) and without direct digital control of individual coils, pump speed shall be a function of either:

1.1. Required differential pressure; or

1.2. Reset directly based on zone hydronic demand, or other zone load indicators; or

1.3. Reset directly based on pump power and pump differential pressure.

2. For systems having a combined pump motor horsepower that exceeds 20 hp (15 kW) or smaller systems with direct digital control, pump speed shall be a function of either:

2.1. The static pressure set point as reset based on the valve requiring the most pressure; or

2.2. Directly controlled based on zone hydronic demand.

C403.4.4 Heat rejection equipment fan speed control. Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

C403.4.5 Requirements for complex mechanical systems serving multiple zones. Sections C403.4.5.1 through C403.4.5.4 shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be VAV systems which, during periods of occupancy, are designed and capable of being controlled to reduce primary air supply to each *zone* to one of the following before reheating, recooling or mixing takes place:

1. Thirty percent of the maximum supply air to each *zone*.
2. Three hundred cfm (142 L/s) or less where the maximum flow rate is less than 10 percent of the total fan system supply airflow rate.
3. The minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.
4. Minimum flow rates required by applicable codes or standards for occupant health and safety.

EXCEPTION: The following define where individual *zones* or where entire air distribution systems are exempted from the requirement for VAV control:

1. Reserved.
2. *Zones* or supply air systems where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. *Zones* where special humidity levels are required to satisfy process needs.
4. *Zones* with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.
5. *Zones* where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.
6. *Zones* or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the *zones* and which are capable of preventing reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

C403.4.5.1 Single duct variable air volume (VAV) systems, terminal devices. Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place.

C403.4.5.2 Dual duct and mixing VAV systems, terminal devices. Systems that have one warm air duct and one cool air duct shall use terminal devices which are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.

C403.4.5.3 Reserved.

C403.4.5.4 Supply-air temperature reset controls. Multiple *zone* HVAC systems shall include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be capable of resetting the

supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

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

C403.4.6 Heat recovery for service water heating. Condenser heat recovery shall be installed for heating or reheating of service hot water provided the facility operates 24 hours a day, the total installed heat capacity of water cooled systems exceeds 1,500,000 Btu/hr of heat rejection, and the design service water heating load exceeds 250,000 Btu/hr.

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

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

C403.4.7 Hot gas bypass limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table C403.4.7.

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

Table C403.4.7
Maximum Hot Gas Bypass Capacity

Rated Capacity	Maximum Hot Gas Bypass Capacity (% of total capacity)
≤ 240,000 Btu/h	50
> 240,000 Btu/h	25

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

C403.4.8 Hydronic System Design: All 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 C403.4.8 for the appropriate total annual hours of operation. Pipe size selections for systems that operate under variable flow conditions (e.g. modulating 2- way control valves at coils) and that contain variable speed pump motors are allowed to be made from the "Variable Flow/ Variable Speed" columns. All others shall be made from the "Other" columns.

EXCEPTION: Design flow rates exceeding the values in Table C403.4.8 are allowed 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.

Informative Note: The flow rates listed here do not consider noise or erosion. (Lower flow rates are often recommended for noise sensitive locations.)

TABLE C403.4.8
PIPING SYSTEM DESIGN MAXIMUM FLOW RATE IN GPM[1]

	<=2000 hours/yr		>2000 and <=4400 hours/year		> 4400 hours/year	
Pipe Size (in)	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed
2 ½	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 shown in the table or larger than the maximum shown in the table.

C403.5 Walk-in coolers and walk-in freezers. Walk-in coolers and walk-in freezers shall comply with all of the following:

1. Anti-sweat heaters without anti-sweat heater controls shall have a total door rail, glass, and frame heater power draw of less than or equal to 7.1 watts per square foot of door opening for *walk-in freezers*, and 3.0 watts per square foot of door opening for *walk-in coolers*.
2. Anti-sweat heater controls shall reduce the energy use of the anti-sweat heater as a function of the relative humidity in the air outside the door or to the condensation on the inner glass pane.
3. Evaporator fan motors that are less than 1 horsepower and less than 460 volts shall use

electronically commutated motors (brushless direct current motors) or 3-phase motors.

4. Condenser fan motors that are less than 1 horsepower shall use electronically commutated motors, permanent split capacitor-type motors or 3-phase motors.

C403.6 Refrigerated warehouse coolers and refrigerated warehouse freezers. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with all of the following:

1. Evaporator fan motors that are less than 1 horsepower and less than 460 volts shall use electronically commutated motors (brushless direct current motors) or 3-phase motors.

2. Condenser fan motors that are less than 1 horsepower shall use electronically commutated motors, permanent split capacitor-type motors or 3-phase motors.

3. Evaporator fans 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.

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 be less than or equal to 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.

C403.7 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 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.

C403.8 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 (Mandatory).

C404.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

C404.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through certification and *listed* under an *approved* certification program, or if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer.

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	Resistance	0.97 - 0.00 132*V*, EF	DOE 10 C.F.R. Part 430
	> 12 kW	Resistance	1.73*V* + 155 SL, Btu/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00 132*V*, EF	DOE 10 C.F.R. Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019*V*, EF	DOE 10 C.F.R. Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t (Q/800 + 110• *V*) SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t (Q/800 + 110•*V*) SL, Btu/h	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.00 19*V*, EF	DOE 10 C.F.R. Part 430
	≥ 200,000 Btu/h[c]	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t (Q/800 + 110•*V*) SL, Btu/h	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal	0.59 - 0.0019*V*, EF	DOE 10 C.F.R. Part 430
	> 105,000 Btu/h	< 4,000 Btu/h/gal	78% E_t (Q/800 + 110//*V*) SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019*V*, EF	DOE 10 C.F.R. Part 430
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E_t (Q/800 + 110•*V*) SL, Btu/h	
Hot water supply boilers, gas and oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
Hot water supply boilers, gas	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t (Q/800 + 110•*V*) SL, Btu/h	

Hot water supply boilers, oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and > 10 gal	78% E_t (Q/800 + 110•V) SL, Btu/h	
Pool heaters, gas and oil	All	--	78% E_t	ASHRAE 146
Heat pump pool heaters	All	--	4.0 COP	AHRI 1160
Unfired storage tanks	All	--	Minimum insulation requirement R-12.5 (h •ft^2 •°F)/Btu	(none)

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

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

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

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

C404.3 Temperature controls. Service water-heating equipment shall be provided with controls to allow a setpoint of 110°F (43°C) for equipment serving dwelling units and 90°F (32°C) for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to 110°F (43°C).

C404.4 Heat traps. Water-heating equipment not supplied with integral heat traps and serving noncirculating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

C404.5 Water heater installation. Electric water heaters in unconditioned spaces or on concrete floors shall be placed on an incompressible, insulated surface with a minimum thermal resistance of R-10.

C404.6 Pipe insulation. For automatic-circulating hot water and heat-traced systems, piping shall be insulated with not less than 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h × ft^2 × °F (1.53 W per 25 mm/m^2 × K). The first 8 feet (2438 mm) of piping in nonhot-water-supply temperature maintenance systems served by equipment without integral heat traps shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h × ft^2 × °F (1.53 W per 25 mm/m^2 × K).

EXCEPTIONS:

1. Heat-traced piping systems shall meet the insulation thickness requirements per the manufacturer's installation instructions. Untraced piping within a heat traced system shall be insulated with not less than 1 inch (25 mm) of insulation having a conductivity

not exceeding 0.27 Btu per inch/h × ftv × °F (1.53 W per 25 mm/m² × K).

2. Hot water piping that is part of the final pipe run to the plumbing fixture and is not part of the automatic-circulating hot water recirculation path is not required to meet the minimum insulation requirements of C404.6.

C404.7 Hot water system controls. Circulating hot water system pumps or heat trace shall be arranged to be turned off either automatically or manually when there is limited hot water demand. Ready access shall be provided to the operating controls.

C404.8 Shut-off controls. Systems designed to maintain usage temperatures in hot water pipes, such as circulating hot water systems or heat traced pipes, shall be equipped with automatic time switches or other controls to turn off the system during periods of nonuse.

C404.9 Domestic hot water meters. Each individual dwelling unit in a Group R-2 multi-family residential occupancy with central service shall be provided with a domestic hot water meter to allow for domestic hot water billing based on actual domestic hot water usage.

C404.10 Pools and in-ground permanently installed spas (mandatory). Pools and in-ground permanently installed spas shall comply with Sections C404.10.1 through C404.10.4.

C404.10.1 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, Method of Testing for Rating Pool Heaters~~)) AHRI Standard 1160, Performance Rating of Heat Pump Pool Heaters. Other pool heating equipment shall comply with the applicable efficiencies in Section C404.2.3. All heaters shall be equipped with a readily *accessible* on-off switch that is mounted outside of the heater to allow shutting off the heater without adjusting the thermostat setting. Gas-fired heaters shall not be equipped with constant burning pilot lights.

C404.10.2 Time switches. Time switches or other control method that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on all heaters and pumps. Heaters, pumps and motors that have built in timers shall be deemed in compliance with this requirement.

EXCEPTIONS:

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

C404.10.3 Covers. Heated pools and in-ground permanently installed spas shall be provided with a vapor-retardant cover on or at the water surface. Pools heated to more than 90°F shall have a pool cover with a minimum insulation value of R-12, and the sides and bottom of the pool shall also have a minimum insulation value of R-12.

C404.10.4 Heat recovery. Heated indoor swimming pools, spas or hot tubs with water surface area greater than 200 square feet shall provide for energy conservation by an exhaust air heat recovery system that heats ventilation air, pool water or domestic hot water. The heat recovery system shall be capable of decreasing the exhaust air temperature at design heating conditions (80°F indoor) by 36°F (10°C) in Climate Zones 4C and 5B and 48°F (26.7°C) in Climate Zone 6B.

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

1. Renewable energy;
2. Dehumidification heat recovery;
3. Waste heat recovery; or
4. A combination of these system sources capable of providing at least 70 percent of the heating energy required over an operating season.

C404.11 Conservation of water pumping energy. Pumps for domestic water systems shall comply with Section C403.2.12. Water pressure booster systems shall comply with the following:

1. One or more pressure sensors shall be used to vary pump speed or to start and stop pumps, or for both purposes. Either the sensor(s) shall be located near the critical fixtures(s) that determine the pressure required, or logic shall be employed that adjusts the setpoint to simulate operation of remote sensors(s).
2. No device shall be installed for the purpose of reducing the pressure of all of the water supplied by any booster system pump or booster system, except for safety devices.
3. No booster system pumps shall operate when there is no service water flow.

Section C405--Electrical power and lighting systems.

C405.1 General (mandatory). This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior applications, electrical energy consumption, minimum acceptable lighting equipment for exterior applications, and minimum efficiencies for motors and transformers.

EXCEPTION: Dwelling units within commercial buildings shall not be required to comply with Sections C405.2 through C405.5 provided that a minimum of 75 percent of the lamps in permanently installed light fixtures shall be high efficacy lamps.

Walk-in coolers and walk-in freezers shall comply with C405.10. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with C405.11. Escalators and moving walks shall comply with Section C405.12. Lighting systems shall be commissioned according to Section C405.13. Receptacles shall be controlled according to Section C405.14.

C405.2 Lighting controls (mandatory). Lighting systems shall be provided with controls as specified in Sections C405.2.1, C405.2.2, C405.2.3, C405.2.4 and C405.2.5.

EXCEPTION: Industrial or manufacturing process areas, as may be required for production and safety.

C405.2.1 Manual lighting controls. All buildings shall include manual lighting controls that meet the requirements of Sections C405.2.1.1 and C405.2.1.2.

C405.2.1.1 Interior lighting controls. Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status.

EXCEPTIONS: 1. Areas designated as security or emergency areas that need to be continuously lighted.
2. Lighting in stairways or corridors that are elements of the means of egress.
3. Stairwells and parking garages are not permitted to have a wall-mounted manual switch.

C405.2.1.2 Light reduction controls. Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other *approved* method:

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

EXCEPTION: Light reduction controls need not be provided in the following areas and spaces:

1. Areas that have only one luminaire, with rated power less than 100 watts.
2. Areas that are controlled by an occupant-sensing device.
3. Corridors, equipment rooms, storerooms, restrooms, public lobbies, electrical or mechanical rooms.
4. *Sleeping unit* (see Section C405.2.3).
5. Spaces that use less than 0.6 watts per square foot (6.5 W/m^2).
6. Daylight spaces complying with Section C405.2.2.3.2.

C405.2.2 Additional lighting controls. Each area that is required to have a manual control shall also have controls that meet the requirements of Sections C405.2.2.1, C405.2.2.2 and C405.2.2.3.

EXCEPTION: Additional lighting controls need not be provided in the following spaces:

1. *Sleeping units*.
2. Spaces where patient care is directly provided.
3. Spaces where an automatic shutoff would endanger occupant safety or security.
4. Lighting intended for continuous operation.

C405.2.2.1 Automatic time switch control devices. Automatic time switch controls shall be installed to control lighting in all areas of the building. Automatic time switches shall have a minimum 7 day clock and be capable of being set for 7 different day types per week and incorporate an automatic holiday "shut-off" feature, which turns off all loads for at least 24 hours and then resumes normally scheduled operations. Automatic time switches shall also have program back-up capabilities, which prevent the loss of program and time settings for at least 10

hours, if power is interrupted.

EXCEPTIONS:

1. Emergency egress lighting does not need to be controlled by an automatic time switch, except as required by item 7 of Section C405.2.3.
2. Lighting in spaces controlled by occupancy sensors does not need to be controlled by automatic time switch controls.

The automatic time switch control device shall include an override switching device that complies with the following:

1. The override switch shall be in a readily accessible location;
2. The override switch shall be located where the lights controlled by the switch are visible; or the switch shall provide a mechanism which announces the area controlled by the switch;
3. The override switch shall permit manual operation;
4. The override switch, when initiated, shall permit the controlled lighting to remain on for a maximum of 2 hours; and
5. Any individual override switch shall control the lighting for a maximum area of 2,500 ~~5,000~~ square feet (465 m^2).

EXCEPTION: Within malls, arcades, auditoriums, single tenant retail spaces, industrial facilities, pools, gymnasiums, skating rinks and arenas:

1. The time limit shall be permitted to exceed 2 hours provided the override switch is a captive key device; and
2. The area controlled by the override switch is permitted to exceed 5,000 square feet (465 m^2), but shall not exceed 20,000 square feet (1860 m^2).

C405.2.2.2 Occupancy sensors. Occupancy sensors shall be installed in all classrooms, conference/meeting rooms, employee lunch and break rooms, private offices, restrooms, warehouse spaces, storage rooms and janitorial closets, and other spaces 300 square feet (28 m^2) or less enclosed by floor-to-ceiling height partitions. These automatic control devices shall be installed to automatically turn off lights within 30 minutes of all occupants leaving the space, and shall either be manual on or shall be controlled to automatically turn the lighting on to not more than 50 percent power. At initial installation, occupancy sensor controls shall be set to turn lights off after 15 minutes unless other thresholds required for safety, security or operational considerations are specifically set out in the approved permit.

EXCEPTION: Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, parking garages, and areas where manual-on operation would endanger the safety or security of the room or building occupants.

C405.2.2.3 Daylight zone control. Daylight zones shall be designed such that lights in the daylight zone are controlled independently of general area lighting and are controlled in accordance with Section C405.2.2.3.2. Each daylight control zone shall not exceed 2,500 square feet (232 m^2). Contiguous daylight zones adjacent to vertical *fenestration* are allowed to be controlled by a single controlling device serving no more than 60 lineal feet of façade, provided that they do not include zones facing more than two adjacent cardinal orientations (i.e., north, east, south, west). The primary daylight zone shall be controlled separately from the secondary daylight zone. Daylight zones under skylights more than 15 feet (4572 mm) from the perimeter

shall be controlled separately from daylight zones adjacent to vertical *fenestration*. Controls shall:

1. Control only luminaires within the daylit area.

2. Incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes.

3. Be set initially at 30 footcandles (323 lux) or not more than 110 percent of the illuminance level specified on the construction documents.

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

C405.2.2.3.1 Reserved.

C405.2.2.3.2 Automatic daylighting controls. Setpoint and other controls for calibrating the lighting control device shall be readily accessible.

Daylighting controls device shall be capable of automatically reducing the lighting power in response to available daylight by either one of the following methods:

1. Continuous dimming using dimming ballasts and daylight-sensing automatic controls that are capable of reducing the power of general lighting in the daylit zone continuously to less than 20 percent of rated power at maximum light output.

2. Stepped dimming using multi-level switching and daylight-sensing controls that are capable of reducing lighting power automatically. The system shall provide a minimum of two control channels per zone and be installed in a manner such that at least one control step is between 50 percent and 70 percent of design lighting power and another control step is no greater than 35 percent of design power, and the system is capable of automatically turning the system off.

Exception. In restaurant dining areas and retail sales areas, light fixtures located less than 10 feet horizontally from vertical *fenestration* are not required to be controlled by daylight sensors where the *fenestration* adjoins a sidewalk or other outdoor pedestrian area, provided that the light fixtures are controlled separately from the general area lighting.

C405.2.2.3.3 Reserved.

C405.2.3 Specific application controls. Specific application controls shall be provided for the following:

1. Display and accent light shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.

2. Lighting in cases used for display case purposes shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.

3. Hotel and motel sleeping units and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles. Where a hotel/motel includes more than 50 rooms, controls shall be automatic to ensure all power to the lights and switched outlets are turned off when the occupant is not in the room.

4. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting, shall be automatically shut off whenever that space is unoccupied and shall have a control device integral to the luminaires or be controlled by a wall-mounted control

device provided the control device is readily accessible.

5. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.

6. Lighting equipment that is for sale or for demonstrations in lighting education shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.

7. 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 0.05 watts per square foot of building area is exempt from this requirement.

8. Each stairway shall have one or more control devices to automatically reduce lighting power by not less than 50 percent when no occupants have been detected in the stairway for a period not exceeding 30 minutes, and restore lighting to full power when occupants enter the stairway. All portions of stairways shall remain illuminated to at least 1 footcandle (11 lux) at the walking surface when the lighting power is reduced.

9. Lighting in parking garages shall have one or more control devices to automatically reduce lighting power in any one controlled zone by not less than 50 percent when no occupants have been detected in that zone for a period not exceeding 30 minutes, and restore lighting to full power when occupants enter or approach the zone. Each lighting zone controlled by occupancy sensors shall be no larger than 7,200 square feet. Pedestrian occupancy sensors controlling any lighting zone are permitted to be configured to detect pedestrians no more than 30 feet outside of that zone. Vehicle occupancy sensors controlling any lighting zone are permitted to be configured to detect vehicles no more than 60 feet outside of that zone.

C405.2.4 Exterior lighting controls. Lighting not designated for dusk-to-dawn operation shall be controlled by either a combination of a photosensor and a time switch, or an astronomical time switch. Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least 10 hours. Building façade lighting shall be automatically shut off between midnight or business/facility closing, whichever is later, and 6 AM or business/facility opening, whichever is earlier. Other lighting, including advertising signage, shall be controlled by a device that automatically reduces the connected lighting power, on a system-wide basis, by at least 30 percent for at least one of the following conditions:

1. from midnight or business/facility closing, whichever is later, and 6 AM or business/facility opening, whichever is earlier; or
2. during any period when no activity has been detected on the site for a time of no longer than 15 minutes.

Exception: Lighting for covered vehicle entrances or exits from buildings or parking

structures where required for safety, security, or eye adaptation.

C405.2.5 Area controls. The maximum lighting power that may be controlled from a single switch or automatic control shall not exceed that which is provided by a 20 ampere circuit loaded to not more than 80 percent. A master control may be installed provided the individual switches retain their capability to function independently. Circuit breakers may not be used as the sole means of switching.

EXCEPTION: Areas less than 5 percent of the building footprint for footprints over 100,000 ft^2.

C405.3 Reserved.

C405.4 Exit signs (mandatory). Internally illuminated exit signs shall not exceed 5 watts per side.

C405.5 Interior lighting power requirements (prescriptive). A building complies with this section if its total connected lighting power calculated under Section C405.5.1 is no greater than the interior lighting power calculated under Section C405.5.2.

C405.5.1 Total connected interior lighting power. The total connected interior lighting power (watts) shall be the sum of the watts of all interior lighting equipment as determined in accordance with Sections C405.5.1.1 through C405.5.1.4. 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 limits of the applicable areas shall be clearly documented on the electrical construction documents.

EXCEPTIONS:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
   1.1. Professional sports arena playing field lighting.
   1.2. Emergency lighting automatically off during normal building operation.
   1.3. Lighting in spaces specifically designed for use by occupants with special lighting needs including the visually impaired and other medical and age-related issues.
   1.4. Casino gaming areas.
   1.5. General area lighting power in industrial and manufacturing occupancies dedicated to the inspection or quality control of goods and products.
2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:
   2.1. Task lighting for medical and dental purposes.
   2.2. Display lighting for exhibits in galleries, museums and monuments.
3. Lighting for theatrical purposes, including performance, stage, film production and video production.

4. Lighting for photographic processes.
5. Lighting integral to equipment or instrumentation and is installed by the manufacturer.
6. Task lighting for plant growth or maintenance.
7. Advertising signage or directional signage.
8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
9. Lighting equipment that is for sale.
10. Lighting demonstration equipment in lighting education facilities.
11. Lighting *approved* because of safety or emergency considerations, inclusive of exit lights.
12. Lighting integral to both open and glass enclosed refrigerator and freezer cases.
13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
14. Furniture mounted supplemental task lighting that is controlled by automatic shutoff.
15. Lighting used for aircraft painting.

C405.5.1.1 Screw lamp holders. The wattage shall be the maximum *labeled* wattage of the luminaire.

C405.5.1.2 Low-voltage lighting. The wattage shall be the specified wattage of the transformer supplying the system.

C405.5.1.3 Other luminaires. The wattage of all other lighting equipment shall be the wattage of the lighting equipment verified through data furnished by the manufacturer or other *approved* sources.

C405.5.1.4 Line-voltage lighting track and plug-in busway. The wattage shall be:

1. The specified wattage of the luminaires included in the system with a minimum of 50 W/lin ft. (162 W/lin. m);
2. The wattage limit of the system's circuit breaker; or
3. The wattage limit of other permanent current limiting device(s) on the system.

C405.5.2 Interior lighting power. The total interior lighting power allowance (watts) is determined according to Table C405.5.2(1) using the Building Area Method, or Table C405.5.2(2) using the Space-by-Space Method, for all areas of the building covered in this permit. For the Building Area Method, the interior lighting power allowance is the floor area for each building area type listed in Table C405.5.2(1) times the value from Table C405.5.2(1) for that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single building area type as listed in Table C405.5.2(1). Where this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area. 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 C405.5.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Tradeoffs among spaces are permitted, except that tradeoffs with covered parking areas are not permitted. See the Seattle Building Code, Section 3016.15, for energy efficiency requirements for lighting in elevators.

Table C405.5.2(1)
Interior Lighting Power Allowances--Building Area Method

Building Area Type	LPD (w/ft^2)
Automotive facility	0.82
Convention center	1.08
Court house	1.05
Dining: Bar lounge/leisure	0.99
Dining: Cafeteria/fast food	0.90
Dining: Family	0.89
Dormitory	0.61
Exercise center	0.88
Fire station	0.71
Gymnasium	0.95
Health care clinic	0.87
Hospital	1.20
Hotel	1.00
Library	1.18
Manufacturing facility	1.11
Motel	0.88
Motion picture theater	0.83
Multifamily	0.60
Museum	1.00
Office	0.90
Parking garage	0.20
Penitentiary	0.90
Performing arts theater	1.25
Police station	0.90
Post office	0.87
Religious building	1.05
Retail	1.33

School/university	0.99
Sports arena	0.78
Town hall	0.92
Transportation	0.77
Warehouse	0.50
Workshop	1.20

Table C405.5.2(2)
Interior Lighting Power Allowances--Space-by-Space Method

Common Space-by-Space Types	LPD (w/ft^2)
Atrium - First 40 feet in height	0.03 per ft. ht.
Atrium - Above 40 feet in height	0.02 per ft. ht.
Audience/seating area - Permanent	
For auditorium	0.79
For performing arts theater	2.43
For motion picture theater	1.14
Classroom/lecture/training	1.24
Conference/meeting/multipurpose	1.23
Corridor/transition	0.66
Dining area	
Bar/lounge/leisure dining	1.31
Family dining area	0.89
Dressing/fitting room performing arts theater	0.40
Electrical/mechanical	0.95
Food preparation	0.99
Laboratory for classrooms	1.28
Laboratory for medical/industrial/research	1.81

Lobby	0.90
Lobby for performing arts theater	2.00
Lobby for motion picture theater	0.52
Locker room	0.75
Lounge recreation	0.73
Office - Enclosed	1.11
Office - Open plan	0.98
Restroom	0.98
Sales area	1.68[a]
Stairway	0.69
Storage	0.63
Workshop	1.59
Building Specific Space-by-space Types	
Automotive - Service/repair	0.67
Bank/office - Banking activity area	1.38
Convention center	
Exhibit space	1.45
Audience/seating area	0.82
Courthouse/police station/penitentiary	
Courtroom	1.72
Confinement cells	1.10
Judge chambers	1.17
Penitentiary audience seating	0.43
Penitentiary classroom	1.34
Penitentiary dining	1.07
Dormitory living quarters	0.38
Fire stations	
Engine rooms	0.56
Sleeping quarters	0.25

Gymnasium/fitness center	
Fitness area	0.72
Gymnasium audience/seating	0.43
Playing area	1.20
Health care clinic/hospital	
Corridors/transition	0.89
Emergency	2.26
Exam/treatment	1.66
Medical supplies	1.27
Nursery	0.88
Nurse station	0.87
Operating room	1.89
Patient room	0.62
Pharmacy	1.14
Physical therapy	0.91
Radiology/imaging	1.32
Recovery	1.15
Hotel	
Dining area	0.82
Guest rooms	1.11
Hotel lobby	1.06
Highway lodging dining	0.88
Highway lodging guest rooms	0.75
Library	
Card file and cataloguing	0.72
Reading area	0.93
Stacks	1.71
Manufacturing	
Corridors/transition	0.41
Detailed manufacturing	1.29

Equipment room	0.95
Extra high bay (> 50-foot floor-ceiling height)	1.05
High bay (25 - 50-foot floor-ceiling height)	1.23
Low bay (< 25-foot floor-ceiling height)	1.19
Museum	
General exhibition	1.05
Restoration	1.02
Parking garage - Garage areas	0.19
Post office	
Sorting area	0.94
Religious building	
Audience seating	1.53
Fellowship hall	0.64
Worship pulpit/choir	1.53
Retail	
Dressing/fitting area	0.87
Mall concourse	1.10
Sales area	1.68[a]
Sports arena	
Audience seating	0.43
Court sports area - Class 4	0.72
Court sports area - Class 3	1.20
Court sports area - Class 2	1.92
Court sports area - Class 1	3.01
Ring sports area	2.68
Transportation	
Air/train/bus baggage area	0.76
Airport concourse	0.36

	Audience seating	0.54
	Terminal - Ticket counter	1.08
Warehouse		
	Fine material storage	0.95
	Medium/bulky material	0.58

For SI:
1 foot = 304.8 mm
1 watt per square foot = 11 W/m^2.

a Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

Calculate the additional lighting power as follows:

Additional Interior Lighting Power Allowance = 500 watts + (Retail Area 1 × 0.6 W/ft^2) + (Retail Area 2 × 0.6 W/ft^2) + (Retail Area 3 × 1.4 W/ft^2) + (Retail Area 4 × 2.5 W/ft^2).

Where:

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

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

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

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

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

C405.6 Exterior lighting (mandatory). Where the power for exterior lighting is supplied through the energy service to the building, all exterior lighting shall comply with Sections C405.6.1 and C405.6.2.

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

C405.6.1 Exterior building grounds lighting. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lumens per watt unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section C405.6.2.

C405.6.2 Exterior building lighting power. The total exterior lighting power allowance for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated and are permitted in Table C405.6.2(2) for the applicable lighting zone. Tradeoffs are allowed only among exterior lighting applications listed in Table C405.6.2(2), Tradable Surfaces section. Parking garage lighting cannot be traded with exterior lighting or with other interior lighting. The lighting zone for the building exterior is determined from Table C405.6.2(1) unless otherwise specified by the local jurisdiction. Exterior lighting for all applications (except those included in the exceptions to Section C405.6.2) shall comply with the requirements of Section C405.6.1.

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

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

Table C405.6.2(1)
Exterior Lighting Zones

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
~~4~~ (not used)	~~High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority~~

C405.6.3 Full cutoff luminaires. For open parking and outdoor areas and roadways, luminaires mounted more than 15 feet above the ground shall be full cutoff luminaires. Full cutoff means a

luminaire light distribution where zero candela intensity occurs at an angle of 90 degrees above nadir, and all greater angles from nadir.

Table C405.6.2(2)
Individual Lighting Power Allowances for Building Exteriors

		Lighting Zones			
		Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
Base Site Allowance (Base allowance is usable in tradable or nontradable surfaces.)		500 W	600 W	750 W	1300 W
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas are tradable.)	**Uncovered Parking Areas**				
	Parking areas and drives	0.04 W/ft^2	0.06 W/ ft^2	0.10 W/ ft^2	0.13 W/ ft^2
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas, special feature areas	0.14 W/v	0.14 W/ ft^2	0.16 W/ ft^2	0.2 W/ ft^2
	Stairways	0.75 W/ ft^2	1.0 W/ ft^2	1.0 W/ ft^2	1.0 W/ ft^2
	Pedestrian tunnels	0.15 W/ ft^2	0.15 W/ ft^2	0.2 W/ ft^2	0.3 W/ ft^2
	Building Entrances and Exits				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ ft^2	0.25 W/ ft^2	0.4 W/ ft^2	0.4 W/ ft^2
	Sales Canopies				
	Free standing and attached	0.6 W/ ft^2	0.6 W /ft^2	0.8 W/ ft^2	1.0 W/ ft^2
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ ft^2	0.25 W/ ft^2	0.5 W/ ft^2	0.7 W/ ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No Allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades and signs	No allowance	0.1 W/ ft^2 for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length	0.15 W/ ft^2 for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length	0.2 W/ ft^2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length

	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ ft^2 of covered and uncovered area	0.75 W/ ft^2 of covered and uncovered area	0.75 W/ ft^2 of covered and uncovered area	0.75 W/ ft^2 of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ ft^2 of covered and uncovered area	0.5 W/ ft^2 of covered and uncovered area	0.5 W/ ft^2 of covered and uncovered area	0.5 W/ ft^2 of covered and uncovered area
	Drive-up windows/doors	400 W per drive-through	400 W per drive-through	400 W per drive-through	400 W per drive-throug h
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

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

C405.7 Electrical energy consumption (mandatory). In buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units. A utility tenant meter meets this requirement.

C405.8 Electric motors. All permanently wired polyphase motors of 1 hp or more, which are not part of an HVAC system, shall comply with Section C403.2.13.

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.

C405.9 Transformers. The minimum efficiency of a low voltage dry-type distribution transformer shall be the Class I Efficiency Levels for distribution transformers specified in Table 4-2 of NEMA TP-1.

C405.10 Walk-in coolers and walk-in freezers. Walk-in coolers and walk-in freezers shall comply with all of the following:

1. Lights shall use light sources with an efficacy of 40 lumens per watt or more, including ballast losses (if any). Light sources with an efficacy of less than 40 lumens per watt, including ballast losses (if any), may be used in conjunction with a timer or device that turns off the lights within 15 minutes of when the *walk-in cooler* or *walk-in freezer* is not occupied by people.

C405.11 Refrigerated warehouse coolers and refrigerated warehouse freezers. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with all of the following:

1. Lights shall use light sources with an efficacy of 40 lumens per watt or more, including ballast losses (if any). Light sources with an efficacy of less than 40 lumens per watt, including ballast losses (if any), may be used in conjunction with a timer or device that turns off the lights

within 15 minutes of when the *refrigerated warehouse cooler* or *refrigerated warehouse freezer* is not occupied by people.

C405.12 Escalators and moving walks.

C405.12.1 Variable speed escalators. Where variable speed escalators and moving walks are permitted by the administrative authority, all escalators and moving walks shall reduce their operating speed to no more than 15 feet per minute when no passengers have been detected for a period of time not exceeding three times the amount of time required to transfer a passenger between landings. Such escalators and moving walks shall comply with the requirements of ANSI/ASME A17.1 for variable speed escalators and moving walks.

EXCEPTION: A power factor controller that reduces operating voltage in response to light loading conditions may be provided in place of the variable speed function.

C405.12.2 Regenerative drive. Escalators designed either for one-way down operation only or for reversible operation shall have variable frequency regenerative drives that supply electrical energy to the building electrical system when loaded with more than 5 passengers.

C405.13 Electrical power and lighting systems commissioning and completion requirements. Electrical power and lighting systems shall be commissioned and completed in accordance with Section C408.

C405.14 *Controlled receptacles*. At least 50 percent of all 125 volt 15- and 20-ampere receptacles installed in private offices, open offices, or classrooms, including those installed in modular partitions and modular office workstation systems, shall be *controlled receptacles*. In rooms larger than 200 square feet (19 M^2), a controlled receptacle shall be located within 72 inches (1.8 M) of each uncontrolled receptacle. *Controlled receptacles* shall be visibly differentiated from standard receptacles 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 30 minutes, or
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 capable of providing an independent schedule for each portion of the building not to exceed 25,000 square feet (2,323 M^2) 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 accessible to occupants. Any individual override switch shall control the *controlled receptacles* for a maximum area of 5,000 square feet (465 M^2). Override switches for *controlled receptacles* are permitted to control the lighting within the same area.

Exception: 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 inches (1.8 M) of a *controlled receptacle*.

Section C406--Additional efficiency package options.

(Section C406 is not adopted.)

Section C407--Total building performance.

C407.1 Scope. This section establishes criteria for compliance using total building performance. All systems and loads shall be included in determining the total building performance including, but not limited to: Heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads.

C407.2 Mandatory requirements. Compliance with this section requires that the criteria of Sections C402.4, C403.2, C404, ((~~and~~)) C405, C408, C409 and C410 be met.

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 based on total building performance requires that a proposed building (*proposed design*) be shown to have an annual energy consumption based on site energy expressed in Btu and Btu per square foot of *conditioned floor area* that is less than or equal to 93 percent of the annual energy consumption of the *standard reference design*.

C407.4 Documentation. Documentation verifying that the methods and accuracy of compliance software tools conform to the provisions of this section shall be provided to the *code official*.

C407.4.1 Compliance report. Building permit submittals shall include a report that documents that the *proposed design* has annual energy consumption less than or equal to the annual energy consumption of the *standard reference design*. The compliance documentation shall include the information listed in Appendix D ((~~following information:~~

~~1. Address of the building;~~

~~2. An inspection checklist documenting the building component characteristics of the proposed design as listed in Table C407.5.1(1). The inspection checklist shall show the estimated annual energy consumption for both the standard reference design and the proposed design;~~

~~3. Name of individual completing the compliance report; and~~

~~4. Name and version of the compliance software tool.~~

~~**C407.4.2 Additional documentation**. The *code official* shall be permitted to require the following documents:~~

~~1. Documentation of the building component characteristics of the standard reference design;~~

~~2. Thermal zoning diagrams consisting of floor plans showing the thermal zoning scheme for standard reference design and proposed design;~~

~~3. Input and output report(s) from the energy analysis simulation program containing the complete input and output files, as applicable. The output file shall include energy use totals and energy use by energy source and end-use served, total hours that space conditioning loads are not met and any errors or warning messages generated by the simulation tool as applicable;~~

~~4. An explanation of any error or warning messages appearing in the simulation tool output; and~~

~~5. A certification signed by the builder providing the building component characteristics of the proposed design as given in Table C407.5.1(1).~~))

C407.5 Calculation procedure. Except as specified by this section, the *standard reference design* and *proposed design* shall be configured and analyzed using identical methods and techniques.

C407.5.1 Building specifications. The *standard reference design* and *proposed design* shall be configured and analyzed as specified by Table C407.5.1(1). Table C407.5.1(1) shall include by reference all notes contained in Table C402.2.

C407.5.2 Thermal blocks. The *standard reference design* and *proposed design* shall be analyzed using identical thermal blocks as specified in Section C407.5.2.1, C407.5.2.2 or C407.5.2.3.

C407.5.2.1 HVAC zones designed. Where HVAC *zones* are defined on HVAC design drawings, each HVAC *zone* shall be modeled as a separate thermal block.

EXCEPTION: Different HVAC *zones* shall be allowed to be combined to create a single thermal block or identical thermal blocks to which multipliers are applied provided:

1. The space use classification is the same throughout the thermal block.
2. All HVAC *zones* in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees (0.79 rad) of each other.
3. All of the *zones* are served by the same HVAC system or by the same kind of HVAC system.

C407.5.2.2 HVAC zones not designed. Where HVAC *zones* have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and temperature schedules, and in combination with the following guidelines:

1. Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located more than 15 feet (4572 mm) from an exterior wall. Perimeter spaces shall be those located closer than 15 feet (4572 mm) from an *exterior wall*.

2. Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls: A separate *zone* shall be provided for each orientation, except orientations that differ by no more than 45 degrees (0.79 rad) shall be permitted to be considered to be the same orientation. Each *zone* shall include floor area that is 15 feet (4572 mm) or less from a glazed perimeter wall, except that floor area within 15 feet (4572 mm) of glazed perimeter walls having more than one orientation shall be divided proportionately between *zones*.

3. Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from *zones* that do not share these features.

4. Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from *zones* that do not share these features.

C407.5.2.3 Multifamily residential buildings. Residential spaces shall be modeled using one thermal block per space except that those facing the same orientations are permitted to be combined into one thermal block. Corner units and units with roof or floor loads shall only be

combined with units sharing these features.

Table C407.5.1(1)
Specifications for the Standard Reference and Proposed Designs

Building Component Characteristics	Standard Reference Design	Proposed Design
Space use classification	Same as proposed	The space use classification shall be chosen in accordance with Table C405.5.2 for all areas of the building covered by this permit. Where the space use classification for a building is not known, the building shall be categorized as an office building.
Roofs	Type: Insulation entirely above deck	As proposed
	Gross area: Same as proposed	As proposed
	U-factor: From Table C402.1.2	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, above-grade	Type: Mass wall if proposed wall is mass; otherwise steel-framed wall	As proposed
	Gross area: Same as proposed	As proposed
	U-factor: From Table C402.1.2	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, below-grade	Type: Mass wall	As proposed
	Gross area: Same as proposed	As proposed
	U-Factor: From Table C402.1.2 with insulation layer on interior side of walls	As proposed
Floors, above-grade	Type: Joist/framed floor	As proposed
	Gross area: Same as proposed	As proposed
	U-factor: From Table C402.1.2	As proposed
Floors, slab-on-grade	Type: Unheated	As proposed
	F-factor: From Table C402.1.2	As proposed
Doors	Type: Swinging	As proposed

	Area: Same as proposed	As proposed
	U-factor: From Table C402.2	As proposed
Vertical *Fenestration*	Area 1. The proposed vertical *fenestration* area; where the proposed vertical *fenestration* area is less than 30 percent of above-grade wall area. 2. 30 percent of above-grade wall area; where the proposed vertical *fenestration* area is 30 percent or more of the above-grade wall area.	As proposed
	U-factor: From Table C402.3 for the same framing material as proposed	As proposed
	SHGC: From Table C402.3 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
	External shading and PF: None	As proposed
Skylights	Area 1. The proposed skylight area; where the proposed skylight area is less than ((~~3~~)) 5 percent of gross area of roof assembly. 2. ((~~3~~)) 5 percent of gross area of roof assembly; where the proposed skylight area is ((~~3~~)) 5 percent or more of gross area of roof assembly.	As proposed
	U-factor: From Table C402.3	As proposed
	SHGC: From Table C402.3 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
Lighting, interior	The interior lighting power shall be determined in accordance with Table C405.5.2. Where the occupancy of the building is not known, the lighting power density shall be 1.0 watt per square foot (10.73 W/m^2) based on the categorization of buildings with unknown space classification as offices. Automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in *the standard reference design* as required by Section C405.	As proposed

Lighting, exterior	The lighting power shall be determined in accordance with Table C405.6.2(2). Areas and dimensions of tradable and nontradable surfaces shall be the same as proposed.	As proposed
Internal gains	Same as proposed	Receptacle, motor and process loads shall be modeled and estimated based on the space use classification. All end-use load components within and associated with the building shall be modeled to include, but not be limited to, the following: Exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators, escalators, refrigeration equipment and cooking equipment.
Schedules	Same as proposed	Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays and any seasonal operation. Schedules shall model the time-dependent variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads. The schedules shall be typical of the proposed building type as determined by the designer and approved by the jurisdiction.

Mechanical ventilation	Same as proposed, except when modeling demand-control ventilation in the proposed design when its use is not required by Section C403.2.5.1 or occupancy sensor ventilation controls when their use is not required by Section C403.2.5.2.	As proposed, in accordance with Section C403.2.5.
Heating systems	Fuel type: Same as proposed design Equipment type[a]: From Tables C407.5.1(2) and C407.5.1(3) Efficiency: From Tables C403.2.3(2), C403.2.3(3), C403.2.3(4) and C403.2.3(5) Preheat coils: If the HVAC system in the proposed design has a preheat coil and a preheat coil can be modeled in the *standard reference design*, the *standard reference design* shall be modeled with a preheat coil controlled in the same manner as the proposed design. Capacity[b]: Sized proportionally to the capacities in the proposed design based on sizing runs, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the proposed design and *standard reference design*, and shall be established such that no smaller number of unmet heating load hours and no larger heating capacity safety factors are provided than in the proposed design. Weather conditions used in sizing runs to determine *standard reference design* equipment capacities may be based either on hourly historical weather files containing typical peak conditions or on design days developed using 99.6% heating design temperatures and 1% dry-bulb and 1% wet-bulb cooling design temperatures.	As proposed As proposed As proposed As proposed
Cooling systems	Fuel type: Same as proposed design Equipment type[c]: From Tables C407.5.1(2) and C407.5.1(3) Efficiency: From Tables C403.2.3(1), C403.2.3(2) and C403.2.3(3)	As proposed As proposed As proposed

	Capacity[b]: Sized proportionally to the capacities in the proposed design based on sizing runs, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the proposed design and *standard reference design*, and shall be established such that no smaller number of unmet cooling load hours and no larger cooling capacity safety factors are provided than in the proposed design. Economizer[d]: Same as proposed, in accordance with Section C403.4.1. The high-limit shutoff shall be a dry-bulb switch with a setpoint as determined by Table C403.3.1.1.3(2).	As proposed As proposed
Energy recovery	*Standard reference design* systems shall be modeled where required in Section C403.2.6.	As proposed
Fan systems	Airflow rate: System design supply airflow rates for the *standard reference design* shall be based on a supply-air-to-room-air temperature difference of 20°F or the required ventilation air or makeup air, whichever is greater. If return or relief fans are specified in the proposed design, the *standard reference design* shall also be modeled with fans serving the same functions and sized for the *standard reference design* system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.	As proposed

	Motor brake horsepower: System fan electrical power for supply, return, exhaust, and relief (excluding power to fan-powered VAV boxes) shall be calculated using the following formulas: For systems 8 and 10, Pfan = CFMS × 0.3 For all other systems, Pfan = bhp × 746/Fan Motor Efficiency Where: Pfan = Electric power to fan motor (watts) bhp = Brake horsepower of *standard reference design* fan motor from Table C403.2.10.1(1) – Option 2 Fan motor = The efficiency from Table C403.2.13 for the efficiency next motor size greater than the bhp using the enclosed motor at 1800 rpm CFMS = The *standard reference design* system maximum design supply fan airflow rate in cfm	As proposed
On-site renewable energy	No on-site renewable energy shall be modeled in the *standard reference design*.	As proposed. On-site renewable energy sources energy shall not be considered to be consumed energy and shall not be included in the proposed building performance.
Shading from adjacent structures/terrain	Same as proposed.	For the *standard reference design* and the proposed building, shading by permanent structures and terrain shall be taken into account for computing energy consumption whether or not these features are located on the building site. A permanent fixture is one that is likely to remain for the life of the proposed design.
Service water heating	Fuel type: Same as proposed Efficiency: From Table C404.2 Capacity: Same as proposed	As proposed As proposed

	Same as proposed	Demand: Service hot-water energy consumption shall be calculated explicitly based upon the volume of service hot water required and the entering makeup water and the leaving service hot water temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements. Service water loads and usage shall be the same for both the *standard reference design* and the proposed design and shall be documented by the calculation procedures recommended by the manufacturer's specifications or generally accepted engineering methods.
	Where no service water hot water system exists or is specified in the proposed design, no service hot water heating shall be modeled.	As proposed

a Where no heating system exists or has been specified, the heating system shall be modeled as fossil fuel. The system characteristics shall be identical in both the standard reference design and proposed design.

b The ratio between the capacities used in the annual simulations and the capacities determined by sizing runs shall be the same for both the standard reference design and proposed design.

c Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per thermal zone. The system characteristics shall be identical in both the standard reference design and proposed design.

d Reserved.

Table C407.5.1(2)
HVAC Systems Map

Condenser Cooling Source[a]	Heating System Classification[b]	Standard Reference Design HVAC System Type[c]		
		Single-Zone Residential System	Single-Zone Nonresidential System	All Other
Water/ground	Electric resistance	System 5	System 5	System 1
	Heat pump	System 6	System 6	System 6
	Fossil fuel	System 7	System 7	System 2
	Electric resistance	System 8	System 9	System 3
Air/none	Heat pump	System 8	System 9	System 3
	Fossil fuel	System 10	System 11	System 4

[a]Select "water/ground" if the proposed design system condenser is water or evaporatively cooled; select "air/none" if the condenser is air cooled. Closed-circuit dry coolers shall be considered air cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is specified or the mechanical cooling system in the proposed design does not require heat rejection, the system shall be treated as if the condenser water type were "Air." For proposed designs with ground-source or groundwater-source heat pumps, the standard reference design HVAC system shall be water-source heat pump (System 6).

[b]Select the path that corresponds to the proposed design heat source: Electric resistance, heat pump (including air source and water source), or fuel fired. Systems utilizing district heating (steam or hot water) and systems with no heating capability shall be treated as if the heating system type were "fossil fuel." For systems with mixed fuel heating sources, the system or systems that use the secondary heating source type (the one with the smallest total installed output capacity for the spaces served by the system) shall be modeled identically in the standard reference design and the primary heating source type shall be used to determine *standard reference design* HVAC system type.

[c]Select the *standard reference design* HVAC system category: The system under "single-zone residential system" shall be selected if the HVAC system in the proposed design is a single-zone system and serves a residential space. The system under "single-zone nonresidential system" shall be selected if the HVAC system in the proposed design is a single-zone system and serves other than residential spaces. The system under "all other" shall be selected for all other cases.

Table C407.5.1(3)
Specifications for the Standard Reference Design HVAC System Descriptions

System No.	System Type	Fan Control	Cooling Type	Heating Type
1	Variable air volume with parallel fan-powered boxes[a]	VAV[d]	Chilled water[e]	Electric resistance
2	Variable air volume with reheat[b]	VAV[d]	Chilled water[e]	Hot water fossil fuel boiler[f]
3	Packaged variable air volume with parallel fan-powered boxes[a]	VAV[d]	Direct expansion[c]	Electric resistance
4	Packaged variable air volume with reheat[b]	VAV[d]	Direct expansion[c]	Hot water fossil fuel boiler[f]
5	Two-pipe fan coil	Constant volume[i]	Chilled water[e]	Electric resistance

6	Water-source heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump and boiler[g]
7	Four-pipe fan coil	Constant volume[i]	Chilled water[e]	Hot water fossil fuel boiler[f]
8	Packaged terminal heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump[h]
9	Packaged rooftop heat pump	Constant volume[i]	Direct expansion[c]	Electric heat pump[h]
10	Packaged terminal air conditioner	Constant volume[i]	Direct expansion	Hot water fossil fuel boiler[f]
11	Packaged rooftop air conditioner	Constant volume[i]	Direct expansion	Fossil fuel furnace

For SI: 1 foot = 304.8 mm, 1 cfm/ft^2 = 0.0004719, 1 Btu/h = 0.293/W, °C = [(°F) -32/1.8].

[a]**VAV with parallel boxes:** Fans in parallel VAV fan-powered boxes shall be sized for 50 percent of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume setpoints for fan-powered boxes shall be equal to the minimum rate for the space required for ventilation consistent with Section C403.4.5, Exception 5. Supply air temperature setpoint shall be constant at the design condition.

[b]**VAV with reheat:** Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft^2 of floor area. Supply air temperature shall be reset based on zone demand from the design temperature difference to a 10°F temperature difference under minimum load conditions. Design airflow rates shall be sized for the reset supply air temperature, i.e., a 10°F temperature difference.

[c]**Direct expansion:** The fuel type for the cooling system shall match that of the cooling system in the proposed design.

[d]**VAV:** When the proposed design system has a supply, return or relief fan motor horsepower (hp) requiring variable flow controls as required by Section C403.2.12, the corresponding fan in the VAV system of the standard reference design shall be modeled assuming a variable speed drive. For smaller fans, a forward-curved centrifugal fan with inlet vanes shall be modeled. If the proposed design's system has a direct digital control system at the zone level, static pressure setpoint reset based on zone requirements in accordance with Section C403.4.2 shall be modeled.

[e]**Chilled water:** For systems using purchased chilled water, the chillers are not explicitly modeled. Otherwise, the standard reference design's chiller plant shall be modeled with chillers having the number as indicated in Table C407.5.1(4) as a function of standard reference building chiller plant load and type as indicated in Table C407.5.1(5) as a function of individual chiller load. Where chiller fuel source is mixed, the system in the standard reference design shall have chillers

with the same fuel types and with capacities having the same proportional capacity as the proposed design's chillers for each fuel type. Chilled water supply temperature shall be modeled at 44°F design supply temperature and 56°F return temperature. Piping losses shall not be modeled in either building model. Chilled water supply water temperature shall be reset in accordance with Section C403.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no chilled water pumps, the standard reference design pump power shall be 22 W/gpm (equal to a pump operating against a 75-foot head, 65-percent combined impeller and motor efficiency). The chilled water system shall be modeled as primary-only variable flow with flow maintained at the design rate through each chiller using a bypass. Chilled water pumps shall be modeled as riding the pump curve or with variable-speed drives when required in Section C403.4.3.4. The heat rejection device shall be an axial fan cooling tower with variable speed fans if required in Section C403.4.4 or Section C403.2.12. Condenser water design supply temperature shall be 85°F or 10°F approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no condenser water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot head, 60-percent combined impeller and motor efficiency). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

[f]**Fossil fuel boiler:** For systems using purchased hot water or steam, the boilers are not explicitly modeled. Otherwise, the boiler plant shall use the same fuel as the proposed design and shall be natural draft. The standard reference design boiler plant shall be modeled with a single boiler if the standard reference design plant load is 600,000 Btu/h and less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Hot water supply temperature shall be modeled at 180°F design supply temperature and 130°F return temperature. Piping losses shall not be modeled in either building model. Hot water supply water temperature shall be reset in accordance with Section C403.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no hot water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot head, 60-percent combined impeller and motor efficiency). The hot water system shall be modeled as primary only with continuous variable flow. Hot water pumps shall be modeled as riding the pump curve or with variable speed drives when required by Section C403.4.3.4.

[g]**Electric heat pump and boiler:** Water-source heat pumps shall be connected to a common heat pump water loop controlled to maintain temperatures between 60°F and 90°F. Heat rejection from the loop shall be provided by an axial fan closed-circuit evaporative fluid cooler with variable speed fans if required in Section C403.4.2 or Section C403.2.12. Heat addition to the loop shall be provided by a boiler that uses the same fuel as the proposed design and shall be natural draft. If no boilers exist in the proposed design, the standard reference building boilers shall be fossil fuel. The standard reference design boiler plant shall be modeled with a single boiler if the standard reference design plant load is 600,000 Btu/h or less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Piping losses shall not be modeled in either building model. Pump system power shall be the same as the proposed design; if the proposed design has no pumps, the standard reference design pump power shall be 22 W/gpm, which is equal to a pump operating against a 75-foot head, with a 65-percent combined impeller and motor efficiency. Loop flow shall be variable with flow shutoff at each heat pump when its compressor cycles off as required by Section C403.4.3.3. Loop pumps shall be modeled as riding the pump curve or with variable speed drives when required by Section C403.4.3.4.

[h]**Electric heat pump:** Electric air-source heat pumps shall be modeled with electric auxiliary heat. The system shall be controlled with a multistage space thermostat and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outdoor air temperature is less than 40°F. In heating operation the system shall be controlled to operate the heat pump as the first stage of heating, before energizing the electric auxiliary heat, down to a minimum outdoor air temperature of 35°F for System No. 8 or 17°F for System No. 9. If the Proposed Design utilizes the same system type as the Standard Design (PTHP or PSZ-HP), the Proposed Design shall be modeled with the same minimum outdoor air temperature for heat pump operation as the Standard Design. For temperatures below the stated minimum outdoor air temperatures, the electric auxiliary heat shall be controlled to provide the full heating load.

[i]**Constant volume:** Fans shall be controlled in the same manner as in the proposed design; i.e., fan operation whenever the space is occupied or fan operation cycled on calls for heating and cooling. If the fan is modeled as cycling and the fan energy is included in the energy efficiency rating of the equipment, fan energy shall not be modeled explicitly.

Table C407.5.1(4)
Number of Chillers

Total Chiller Plant Capacity	Number of Chillers
≤ 300 tons	1
> 300 tons, < 600 tons	2, sized equally
≥ 600 tons	2 minimum, with chillers added so that no chiller is larger than 800 tons, all sized equally

For SI: 1 ton = 3517 W.

Table C407.5.1(5)
Water Chiller Types

Individual Chiller Plant Capacity	Electric-Chiller Type	Fossil Fuel Chiller Type
≤ 100 tons	Reciprocating	Single-effect absorption, direct fired
> 100 tons, < 300 tons	Screw	Double-effect absorption, direct fired
≥ 300 tons	Centrifugal	Double-effect absorption, direct fired

For SI: 1 ton = 3517 W.

C407.6 Calculation software tools. Calculation procedures used to comply with this section shall be software tools capable of calculating the annual energy consumption of all building elements that differ between the *standard reference design* and the *proposed design* and shall include the following capabilities.

1. Building operation for a full calendar year (8,760 hours).
2. Climate data for a full calendar year (8,760 hours) and shall reflect *approved* coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.
3. Ten or more thermal zones.
4. Thermal mass effects.
5. Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads.
6. Part-load performance curves for mechanical equipment.
7. Capacity and efficiency correction curves for mechanical heating and cooling equipment.

8. Printed *code official* inspection checklist listing each of the *proposed design* component characteristics from Table C407.5.1(1) determined by the analysis to provide compliance, along with their respective performance ratings (e.g., *R*-value, *U*-factor, SHGC, HSPF, AFUE, SEER, EF, etc.).

9. Air-side economizers with integrated control.

10. *Standard reference design* characteristics specified in Table C407.5.1(1).

C407.6.1 Specific approval. Performance analysis tools meeting the applicable subsections of Section C407 and tested according to ASHRAE Standard 140 shall be permitted to be *approved*. Tools are permitted to be *approved* based on meeting a specified threshold for a jurisdiction. The *code official* shall be permitted to approve tools for a specified application or limited scope.

C407.6.2 Input values. Where calculations require input values not specified by Sections C402, C403, C404 and C405, those input values shall be taken from an *approved* source.

C407.6.3 Exceptional calculation methods. When the *simulation program* does not model a design, material, or device of the *proposed design*, an Exceptional Calculation Method shall be used if approved by the *building official*. If there are multiple designs, materials, or devices that the *simulation program* does not model, each shall be calculated separately and Exceptional Savings determined for each. At no time shall the total Exceptional Savings constitute more than half of the difference between the *baseline building performance* and the *proposed building performance*. All applications for approval of an exceptional method shall include:

1. Step-by-step documentation of the Exceptional Calculation Method performed detailed enough to reproduce the results;

2. Copies of all spreadsheets used to perform the calculations;

3. A sensitivity analysis of *energy* consumption when each of the input parameters is varied from half to double the value assumed;

4. The calculations shall be performed on a time step basis consistent with the *simulation program* used; and

5. The *Performance Rating* calculated with and without the Exceptional Calculation Method.

Section C408--System commissioning.

C408.1 General. This section covers the commissioning of the building mechanical systems in Section C403, service water heating systems in Section C404, electrical power and lighting systems in Section C405 and energy metering in Section C409. Prior to passing the final mechanical and electrical inspections or obtaining a certificate of occupancy, the *registered design professional* or ((~~approved agency~~)) *qualified commissioning authority* shall provide evidence of systems *commissioning* and completion in accordance with the provisions of this section.

Copies of all documentation shall be given to the owner and made available to the *code official* upon request in accordance with Sections C408.1.2 and C408.1.3.

C408.1.1 Commissioning plan. A *commissioning plan* shall be developed by a *registered design professional* or *qualified commissioning authority* and shall include the items listed in this section. Items 1 – 4 shall be included with the construction documents, and items 5 – 8 shall be submitted prior to the first mechanical inspection. For projects where no mechanical inspection is

required, items 5 – 8 shall be submitted prior to the first electrical inspection. ((~~A commissioning plan shall be developed by a registered design professional or approved agency and shall include the following items:~~))

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.

2. Roles and responsibilities of the commissioning team, including statement of qualifications of the commissioning authority in accordance with Section C408.1.

3. A schedule of activities including systems testing and balancing, functional testing, and supporting documentation.

4. Where the *qualified commissioning authority* is an employee of one of the *registered design professionals* of record or an employee or subcontractor of the project contractor, an In-House Commissioning Disclosure and Conflict Management Plan shall be submitted with the commissioning plan. This Plan shall disclose the *qualified commissioning authority's* contractual relationship with other team members and provide a conflict management plan demonstrating that the *qualified commissioning authority* is free to identify any issues discovered and report directly to the owner.

((~~4~~)) 5. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.

((~~5~~)) 6. Functions to be tested.

((~~6~~)) 7. Conditions under which the test will be performed.

((~~7~~)) 8. Measurable criteria for performance.

~~**C408.1.2 Preliminary commissioning report.** A preliminary report of commissioning test procedures and results shall be completed and certified by the *registered design professional* or approved agency and provided to the building owner. The report shall be identified as "Preliminary Commissioning Report" and shall identify:~~

~~1. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.~~

~~2. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions, with anticipated date of completion.~~

~~3. Climatic conditions required for performance of the deferred tests.~~

~~4. Record of progress and completion of operator training.~~

~~**EXCEPTION:** The preliminary commissioning report is not required if all of the items listed above are included in the commissioning report described in Section C408.1.3.4.~~

C408.1.2.1 Acceptance of report. *Buildings*, or portions thereof, shall not pass the final mechanical and electrical inspections or obtain a certificate of occupancy, until such time as the *code official* has received a letter of transmittal from the *building* owner acknowledging that the *building* owner has received the ~~Preliminary~~ Commissioning Report required by Section C408.1.3.4 and the completed~~. Completion of the~~ Commissioning Compliance Checklist (Figure C408.1.2.1) ~~is deemed to satisfy this requirement.~~

~~**C408.1.2.2 Copy of report.** The *code official* shall be permitted to require that a copy of the Preliminary Commissioning Report be made available for review by the *code official*.~~

C408.1.3 Documentation requirements. The *construction documents* shall specify that the

manuals and system balancing report required by Sections C408.1.3.2 and C408.1.3.3 be provided to the *building* owner prior to issuance of the certificate of occupancy, the record *documents* required by Section C408.1.3.1 ((~~described in this section)~~) be provided to the *building* owner within 90 days of the date of receipt of the *certificate of occupancy*, and that ~~all other~~ the Commissioning Report *documents* described under Section C408.1.3.4 be provided to the *building* owner and the *code official* prior to issuance of the certificate of occupancy.

C408.1.3.1 Record documents. Construction documents shall be updated to convey a record of the alterations to the original design. The updates shall be provided to the *building* owner. Such updates shall include updated mechanical, electrical and control drawings red-lined, or redrawn if specified, that show all changes to size, type and locations of components, equipment and assemblies.

C408.1.3.2 Manuals. An operating and maintenance manual shall be provided and include all of the following:

1. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.
2. Manufacturer's operation manuals and maintenance manuals for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
3. Name and address of at least one service agency.
4. Controls system maintenance and calibration information, including wiring diagrams, schematics, record documents, and control sequence descriptions. Desired or field-determined setpoints shall be permanently recorded on control drawings at control devices or, for digital control systems, in system programming instructions.
5. A narrative of how each system is intended to operate, including recommended setpoints. Sequence of operation is not acceptable for this requirement.

C408.1.3.3 System balancing report. A written report describing the activities and measurements completed in accordance with Section C408.2.2.

C408.1.3.4 ((~~Final c~~)) Commissioning report. A report of test procedures and results identified as the "((~~Final~~)) Commissioning Report" shall be completed and certified by the *registered design professional* or *qualified commissioning authority* and delivered to the building owner and *code official* and shall include:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance ((~~, provided herein for repeatability~~.))
4. List and description of any deferred tests which cannot be completed at the time of report preparation because of climatic conditions, including anticipated date of completion, climatic conditions required for performance of the deferred tests, and parties to be involved, in checklist format.
5. List and description of any unresolved deficiencies or incomplete tasks, in checklist format.
6. A copy of a Commissioning Permit issued for the completion and resolution of items

identified in the lists required by items 4 and 5 above. The permit shall stipulate that all such work shall be completed within one year of issuance of the *certificate of occupancy*.

((**Exception:** If there are no deferred tests, unresolved deficiencies or incomplete tasks to be listed under items 4 and 5, the Commissioning Permit is not required. ~~– Deferred tests which cannot be performed at the time of report preparation due to climatic conditions.~~))

7. Completed Commissioning Compliance Checklist (Figure C408.1.2.1)

8. Record of progress and completion of systems operation training.

C408.1.4 Systems operation training. Training of the maintenance staff for equipment included in the manuals required by Section C408.1.3.2 shall include at a minimum:

1. Review of systems documentation.

2. Hands-on demonstration of all normal maintenance procedures, normal operating modes, and all emergency shutdown and start-up procedures.

3. Training completion report.

Figure C408.1.2.1
Commissioning Compliance Checklist

Project Information	**Project Name:**
	Project Address:
	Commissioning Authority:
Qualifications (Section C408.1) **Commissioning Plan** (Section C408.1.1)	☐ Statement of commissioning authority's formal training, experience and certification. ☐ **Commissioning Plan was used during construction and included items below** ☐ A narrative description of activities and the personnel intended to accomplish each one ☐ Measurable criteria for performance ☐ Functions to be tested
	☐ In-House Commissioning Disclosure and Conflict Management Plan, where applicable
Systems Balancing (Section C408.2.2)	☐ **Systems Balancing has been completed** ☐ Air and Hydronic systems are proportionately balanced in a manner to first minimize throttling losses. ☐ Test ports are provided on each pump for measuring pressure across the pump.
Functional Testing (Section C408.2.3, C408.3.1, C408.4.1, C408.4.1.3 and C408.5.1)	☐ **HVAC Systems Equipment Testing has been completed** (Section C408.2.3.1) ☐ HVAC equipment has been tested to demonstrate the installation and operation of components, systems and system-to-system interfacing relationships in accordance with approved plans and specifications ☐ **HVAC Controls Functional Testing has been completed** (Section C408.2.3.2)

	☐ HVAC controls have been tested to ensure that control devices are calibrated, adjusted and operate properly. Sequences of operation have been functionally tested to ensure they operate in accordance with approved plans and specifications ☐ **Economizers Functional Testing has been completed** (Section C408.2.3.3) ☐ Economizers operate in accordance with manufacturer's specifications ☐ **Lighting Controls Functional Testing has been completed** (Section C408.3.1) ☐ Lighting controls have been tested to ensure that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications ☐ **Service Water Heating System Functional Testing has been completed** (Section C408.4.1) ☐ Service water heating equipment has been tested to ensure that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications ☐ **Pool and Spa Functional Testing has been completed** (Section C408.4.1.3) ☐ Pools and spas have been tested to ensure that service water heating equipment, time switches and heat recovery equipment are calibrated, adjusted and operate in accordance with approved plans and specifications ☐ **Metering System Functional Testing has been completed** (Section C408.5.1) ☐ Energy source meters, energy end-use meters, the energy metering data acquisition system and required display are calibrated adjusted and operate in accordance with approved plans and specifications
Supporting Documents (Section 408.1.3.2)	☐ **Manuals, record documents and training have been completed or are scheduled** ☐ System documentation has been provided to the owner or scheduled date: ☐ Record documents have been submitted to owner or scheduled date: ____ ☐ Training has been completed or scheduled date: _____
Commissioning Report ~~(Section C408.1.2)~~	☐ ~~**Preliminary Commissioning Report submitted to Owner and includes items below**~~ ☐ ~~Deficiencies found during testing required by this section which have not been corrected at the time of report preparation~~ ☐ ~~Deferred tests, which cannot be performed at the time of report preparation due to climatic conditions~~
(Section C408.1.3.4)	☐ Commissioning Report submitted to Owner and *code official* and includes items below
	☐ 1. Results of functional performance tests.
	☐ 2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
	☐ 3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance.
	☐ 4. List and description of any deferred tests which cannot be completed at the time of report preparation because of climatic conditions, including anticipated date of completion, climatic conditions required for performance of the deferred tests, and parties to be involved, in checklist format.

	☐	5. List and description of any unresolved deficiencies or incomplete tasks
	☐	6. A copy of a Commissioning Permit issued for the completion and resolution of items identified in the lists required by items 4 and 5 above.
	☐	7. Record of progress and completion of systems operation training.
Certification	I hereby certify that all requirements for Commissioning have been completed in accordance with the ~~Washington State~~ Seattle Energy Code, including all items above Building Owner or Owner's Representative Date	

C408.2 Mechanical systems commissioning and completion requirements. Mechanical equipment and controls shall comply with Section C408.2.

Construction document notes shall clearly indicate provisions for *commissioning* and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements.

Exception: Systems which (a) qualify as simple systems using the criteria in Section C403.3, (b) are not required to have an economizer per Section C403.3.1, and (c) where the building total mechanical equipment capacity is less than 480,000 Btu/h (140,690 W) cooling capacity and 600,000 Btu/h (175,860 W) heating capacity.

C408.2.1 Reserved.

C408.2.2 Systems adjusting and balancing. HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the product specifications. Test and balance activities shall include air system and hydronic system balancing.

C408.2.2.1 Air systems balancing. Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp (0.74 kW), fan speed shall be adjusted to meet design flow conditions.

EXCEPTION: Fans with fan motors of 1 hp (0.74 kW) or less.

C408.2.2.2 Hydronic systems balancing. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the capability to measure pressure across the pump, or test ports at each side of each pump.

EXCEPTIONS:

1. Pumps with pump motors of 5 hp (3.7 kW) or less.
2. Where throttling results in no greater than five percent of the nameplate horsepower

draw above that required if the impeller were trimmed.

C408.2.3 Functional performance testing. Functional performance testing specified in Sections C408.2.3.1 through C408.2.3.3 shall be conducted. Written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion shall be followed. At a minimum, testing shall affirm operation during actual or simulated winter and summer design conditions and during full outside air conditions.

C408.2.3.1 Equipment. Equipment functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing relationships in accordance with approved plans and specifications such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed. Testing shall include all modes and *sequence of operation*, including under full-load, part-load and the following emergency conditions:

1. All modes as described in the *sequence of operation*;
2. Redundant or *automatic* back-up mode;
3. Performance of alarms; and
4. Mode of operation upon a loss of power and restoration of power.

C408.2.3.2 Controls. HVAC control systems shall be tested to document that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with *approved* plans and specifications.

C408.2.3.3 Economizers. Air economizers shall undergo a functional test to determine that they operate in accordance with manufacturer's specifications.

C408.3 Lighting system functional testing. Controls for automatic lighting systems shall comply with Section C408.3.1.

Exception: Lighting systems are exempt from the functional testing requirements in buildings where:

1. The total installed lighting load is less than 20 kW; and
2. Where the lighting load controlled by occupancy sensors or automatic daylighting controls is less than 10 kW.

C408.3.1 Functional testing. Testing shall ensure that control hardware and software are calibrated, adjusted, programmed and in proper working condition in accordance with the construction documents and manufacturer's installation instructions. Written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion shall be followed. At a minimum, testing shall affirm operation during normally occupied daylight conditions. The construction documents shall state the party who will conduct the required functional testing.

Where occupant sensors, time switches, programmable schedule controls, photosensors or daylighting controls are installed, the following procedures shall be performed:

1. Confirm that the placement, sensitivity and time-out adjustments for occupant sensors yield acceptable performance.

2. Confirm that the time switches and programmable schedule controls are programmed to turn the lights off.

3. Confirm that the placement and sensitivity adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space as specified.

C408.4 Service water heating systems commissioning and completion requirements. Service water heating equipment and controls shall comply with Section C408.4. Construction document notes shall clearly indicate provisions for *commissioning* and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements.

EXCEPTION: The following systems are exempt from the commissioning requirements:

1. Service water heating systems in buildings where the largest service water heating system capacity is less than 200,000 Btu/h (58,562 W) and where there are no pools or in-ground permanently installed spas.

C408.4.1 Functional performance testing. Functional performance testing specified in Sections C408.4.1.1 through C408.4.1.3 shall be conducted. Written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion shall be followed. At a minimum, testing shall affirm operation with the system under 50 percent water heating load.

C408.4.1.1 Equipment. Equipment functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing relationships in accordance with approved plans and specifications such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed. Testing shall include all modes and *sequence of operation*, including under full-load, part-load and the following emergency conditions:

1. Redundant or *automatic* back-up mode;
2. Performance of alarms; and
3. Mode of operation upon a loss of power and restoration of power.

C408.4.1.2 Controls. Service water heating controls shall be tested to document that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with *approved* plans and specifications.

C408.4.1.3 Pools and spas. Service water heating equipment, time switches, and heat recovery equipment which serve pools and in-ground permanently installed spas shall undergo a functional test to determine that they operate in accordance with manufacturer's specifications.

C408.5 Metering system commissioning. Energy metering systems required by Section C409 shall comply with Section C408.5 and be included in the commissioning process required by Section C408.1. Construction documents shall clearly indicate provisions for *commissioning* in accordance with Section C408 and are permitted to refer to specifications for further requirements.

C408.5.1 Functional testing. Functional testing shall be conducted by following written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion. Functional testing shall document that energy source meters, energy end-use meters, the energy metering data acquisition system, and required energy consumption display are calibrated, adjusted and operate in accordance with approved plans and specifications. At a minimum, testing shall confirm that:

1. The metering system devices and components work properly under low and high load conditions.
2. The metered data is delivered in a format that is compatible with the data collection system.
3. The energy display is accessible to building operation and management personnel.
4. The energy display meets code requirements regarding views required in Section C409.4.3. The display shows energy data in identical units (e.g., kWh).

Section C409--Energy metering and energy consumption management.

C409.1 General. Buildings 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 multi-family buildings, the floor area of dwelling units shall be excluded from the total conditioned floor area. Alterations and additions to existing buildings shall conform to Section C409.5.

EXCEPTIONS:

1. Tenant spaces 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.

C409.1.1 Alternate metering methods. Where approved by the building official, energy use metering systems may differ from those required by this section, provided that they are permanently installed and that the source energy measurement, end use category energy measurement, data storage and data display have similar accuracy to and are at least as effective in communicating actionable energy use information to the building management and users, as those required by this section.

C409.1.2 Conversion factor. Any threshold stated in kW 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 or 2,730 Btu per kVA ((~~at 50 percent demand~~)).

C409.2 Energy source metering. Buildings shall have a meter at each energy source. For each energy supply source listed in Section C409.2.1 through C409.2.4, meters shall collect data for the whole building or for each separately metered portion of the building where not exempted by the exception to Section C409.1.

EXCEPTIONS:

1. Energy source metering is not required where end use metering for an energy source accounts for all usage of that energy type within a building, and the data acquisition system accurately totals the energy delivered to the building or separately metered portion of the building.
2. Solid fuels such as coal, firewood or wood pellets that are delivered via mobile transportation do not require metering.

C409.2.1 Electrical energy. This category shall include all electrical energy supplied to the building and its associated site, including site lighting, parking, recreational facilities, and other areas that serve the building and its occupants.

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.

C409.2.2 Gas and liquid fuel supply energy. This category shall include all natural gas, fuel oil, propane and other gas or liquid fuel energy supplied to the building and site.

C409.2.3 District energy. This category shall include all net energy extracted from district steam systems, district chilled water loops, district hot water systems, or other energy sources serving multiple buildings.

C409.2.4 Site-generated renewable energy. This category shall include all net energy generated from on-site solar, wind, geothermal, tidal or other natural sources, and waste heat reclaimed from sewers or other off-site sources.

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 ((~~C409.3.2~~)) C409.3.6. These meters shall collect data for the whole building or for each separately metered portion of the building where not exempted by the exceptions to Section C409.1. Not more than 10 percent of the total connected load of any of the end-use metering categories C409.3.1 through C409.3.5 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 C409.3.1 through C409.3.5 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 sub-metering data shall be provided to the tenant in accordance with Section C409.3.5, and the data shall not be required to be included in other end-use categories.

EXCEPTIONS:

1. HVAC and water heating equipment serving only an individual dwelling 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 identified in Article 517 of the Seattle Electrical Code, except that submetering is required for the following load categories:

4.1 HVAC system energy use per the requirements of section C409.3.1

4.2 Water heating energy use per the requirements of section C409.3.2

4.3 Process load system energy per the requirements of section C409.3.5 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 that facility exceeds 100 kVA.

5. End-use metering is not required for electrical circuits serving only sleeping rooms and guest suites within R-1 occupancies. This exception does not apply to common areas or to equipment serving multiple sleeping rooms.

C409.3.1 HVAC system energy use. This category shall include all energy including electrical, gas, liquid fuel, district steam and district chilled water that is used by boilers, chillers, pumps, fans and other equipment used to provide space heating, space cooling, dehumidification and ventilation to the building, but not including energy that serves process loads, water heating or miscellaneous loads as defined in Section C409.3. Multiple HVAC energy sources, such as gas, electric and steam, are not required to be summed together.

EXCEPTIONS:

1. All 120 volt equipment.
2. 208/120 volt equipment in a building where the main service is 480/277 volt power.
3. Electrical energy fed through variable frequency drives that are connected to the energy metering data acquisition center.

C409.3.2 Water heating energy use. This category shall include all energy used for heating of domestic and service hot water, but not energy used for space heating.

EXCEPTION: Water heating energy use less than 50 ((~~kWV~~)) kVA does not require end-use metering.

C409.3.3 Lighting system energy use. This category shall include all energy used by interior and exterior lighting, including lighting in parking structures and lots, but not including plug-in task lighting.

C409.3.4 Plug load system energy use. This category shall include all energy used by appliances, computers, plugged-in task lighting, and other equipment and devices, but not including vertical transportation equipment or equipment covered by other end-use metering categories listed in C409.3. In a building where the main service is 480/277 volt, each 208/120 volt panel is permitted to be assumed to serve only plug load for the purpose of Section C409, unless it serves nonresidential refrigeration or cooking equipment.

Exception: Where the total connected load of all plug load circuits is less than 50 kVA, end-use metering is not required.

C409.3.5 Process load system energy use. Meters shall collect data for energy used by any non-building process load, including but not limited to nonresidential refrigeration and cooking equipment, laundry equipment, industrial equipment and stage lighting.

Exception: Process load energy use less than 50 kVA does not require end-use metering.

C409.3.6 Full-floor tenant space electrical sub-metering. In a multi-tenant building, where more than 90 percent of the leasable area of a floor is occupied by a single tenant, an electrical energy use display shall be provided to the tenant in accordance with the requirements of Section C409.4.3. Electrical loads from areas outside of the tenant space or from equipment that serves areas outside of the tenant space shall not be included in the tenant space sub-metering. A single display is permitted to serve multiple floors occupied by the same tenant.

C409.4 Measurement devices, data acquisition system and energy display.

C409.4.1 Meters. Meters and other measurement devices required by this section shall have local displays or be configured to automatically communicate energy data to a data acquisition system. Source meters may be any digital-type meters. Current sensors or flow meters are allowed for end use metering, provided that they have an accuracy of +/- 5%. All required metering systems and equipment shall provide at least hourly data that is fully integrated into the data acquisition and display system per the requirements of Section C409.

C409.4.2 Data acquisition system. The data acquisition system shall store the data from the required meters and other sensing devices for a minimum of 36 months. For each energy supply and end use category required by C409.2 and C409.3, it shall provide real-time energy consumption data and logged data for any hour, day, month or year.

C409.4.3 Energy display. For each building subject to Section C409.2 and C409.3, either a readily accessible and visible display, or a web page or other electronic document accessible to building management or to a third-party energy data analysis service shall be provided in the building accessible by 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 average and peak values for any day, week or year.

C409.4.4 Commissioning. The entire system shall be commissioned in accordance with Section C408.5. Deficiencies found during testing shall be corrected and retested and the commissioning report shall be updated to confirm that the entire metering and data acquisition and display system is fully functional.

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 C409.2. This includes systems or equipment added in conjunction with additions or alterations to existing buildings.

C409.5.1.1 Small existing buildings. For existing buildings that were constructed subject to the requirements of this code, but were exempt from the requirements of Section C409 due to being smaller than the thresholds set forth in Section C409.1, ((M)) metering and data acquisition systems shall be provided for additions over ((~~25,000~~)) 10,000 square feet in accordance with the requirements of sections C409.2, ((~~and~~)) C409.3 and C409.4.

C409.5.2 Metering for HVAC Equipment Replacement. 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.

C409.5.3 Tenant space electrical sub-metering for existing buildings. For tenant improvements in which a single tenant will occupy a full floor 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.

C409.5.4 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.

Section C410 Renewable energy and solar readiness

C410.1 On-site renewable energy systems. Each new building or addition larger than 25,000

square feet of gross conditioned floor area shall include a renewable energy generation system consisting of at least 70 Watts rated peak PV (photovoltaic) energy production, or 240 kBTU of annual SWH (solar water heating) energy production, per 1,000 square feet of conditioned space or fraction thereof. For buildings over 5 stories in height, the conditioned area for this calculation shall be based on the conditioned area of the largest 5 above-grade stories in the building. This system is permitted to be mounted either within the allocated *solar zone* required by Section C410.2.3, or elsewhere on the building or site.

Exceptions.

1. Higher-efficiency mechanical equipment is permitted to be provided in lieu of on-site renewable energy systems, where the capacity-weighted equipment efficiency for the total capacity of the space heating and space cooling equipment is a minimum of 1.10 times the corresponding minimum efficiency in Tables C403.2.3(1) through C403.2.3(8). The minimum efficiency for this exception shall be in excess of that required elsewhere in the Energy Code, including Section C403.4.1 (economizers). The Standard Reference Design determination from Section C407 shall be used to establish the baseline case for determination of the 1.10 factor.
2. Additional heat recovery systems beyond those required by this code are permitted to be provided in lieu of on-site renewable energy systems, where the calculated net annual energy savings from the heat recovery systems exceed the calculated net annual energy production of the required on-site renewable energy systems. Acceptable heat recovery systems include but are not limited to: exhaust air heat recovery in excess of that required by this code, waste water or sewer heat recovery, ground source heating and cooling, or heat recovered from other on-site or off-site sources that would otherwise be lost into the sewer or atmosphere.

C410.2 Solar Readiness.

C410.2.1 General. In addition to the requirements of C410.1, a *solar zone* shall be provided on non-residential buildings of any size that are five stories or less in height above grade plane, and 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 C410.2.2 through C410.2.8 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 unobstructed area, as defined in Section C410.2.3, in the same location, as measured by one of the following:

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

C410.2.2 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 and planted areas.

2. 20 percent of electrical service size. The electrical service size shall be 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 PV 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 C410.2.2 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% x (10,000 SF roof area – 1,000 SF skylights)] = 3,600 SF; or
2. [400 Amp x 240 Volts x 20% / 10 watts per SF] = 1,920 SF
Therefore, a *solar zone* of 1,920 square feet is required.

C410.2.3 Obstructions. The *solar zone* shall be free of pipes, vents, ducts, HVAC equipment, skylights and other obstructions, except those serving PV or SWH systems within the *solar zone*. PV or SHW systems are permitted to be installed 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 Seattle Land Use Code.

C410.2.4 Shading. The *solar zone* shall be set back from any existing or new object on the building or site that is located south, east, or west of the *solar zone* a distance at least two times the object's height above the nearest point on the roof surface. Such objects include but are not limited to taller portions of the building itself, parapets, chimneys, antennas, signage, rooftop equipment, trees and roof plantings. No portion of the *solar zone* shall be located on a roof slope greater than 2:12 that faces within 45° of true north.

C410.2.5 Contiguous area. The *solar zone* is permitted to be comprised of smaller separated sub-zones. Each subzone shall be at least 5 feet wide in the narrowest dimension.

C410.2.6 Access. Areas contiguous to the *solar zone* shall provide access pathways and provisions for emergency smoke ventilation as required by the International Fire Code.

C410.2.7 Structural integrity. If the *solar zone* is on the roof of the building or another structure on the site, the as-designed dead load and live load for the *solar zone* shall be clearly marked on the record drawings, and shall accommodate future PV or SHW arrays at an assumed dead load of 5 pounds per square foot in addition to other required live and dead loads. For PV systems, 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 PV or SWH systems are installed in the solar zone, structural analysis shall be based upon calculated loads,

not upon these assumed loads.

C410.2.8 PV or SWH interconnection provisions. Buildings shall provide for the future interconnection of either a PV system in accordance with Section C410.2.8.1 or an SWH system in accordance with Section C410.2.8.2.

C410.2.8.1 PV interconnection. A capped roof penetration sleeve shall be provided in the vicinity of the future inverter, sized to accommodate the future PV system conduit. Interconnection of the future PV 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:

a. 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.
b. 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:

a. *Solar zone* boundaries and access pathways;
b. Location for future inverters and metering equipment; and
c. Route for future wiring between the PV panels and the inverter, and between the inverter and the main service panel.

C410.2.8.2 SWH interconnection. Two capped pipe tees shall be provided upstream of the domestic water heating equipment to provide plumbing interconnections between a future SWH system and the domestic water heating system. Two roof penetration sleeves shall be provided in the vicinity of the *solar zone*, capable of accommodating supply and return piping for a future SWH system.
The plumbing construction documents shall indicate the following:

a. *Solar zone* boundaries and access pathways;
b. Location for future hot water storage tanks; and
c. Route for future piping between the *solar zone* and the plumbing interconnection point, following the shortest feasible pathway.

Chapter 5 [CE]
Referenced Standards.

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 106.

AAMA	American Architectural Manufacturers Association 1827 Walden Office Square Suite 550 Schaumburg, IL 60173-4268	
Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A C440--11	North American *Fenestration* Standard/Specifications for Windows, Doors and Unit Skylights	Table C402.4.3
AHAM	Association of Home Appliance Manufacturers 1111 19th Street, N.W., Suite 402 Washington, D.C. 20036	
Standard reference number	Title	Referenced in code section number
ANSI/AHAM RAC-1--2008	Room Air Conditioners	Table C403.2.3(3)
AHRI	Air Conditioning, Heating, and Refrigeration Institute 4100 North Fairfax Drive, Suite 200 Arlington, VA 22203	
Standard reference number	Title	Referenced in code section number
ISO/AHRI/ASHRAE 13256-1 (2005)	Water-source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-air and Brine-to-air Heat Pumps	Table C403.2.3(2)
ISO/AHRI/ASHRAE 13256-2 (1998)	Water-source Heat Pumps - Testing and Rating for Performance - Part 2: Water-to-water and Brine-to-water Heat Pumps	Table C403.2.3(2)

210/240--08	Unitary Air Conditioning and Air-source Heat Pump Equipment	. . . .	Table C403.2.3(1), Table C403.2.3(2)
310/380--04	Standard for Packaged Terminal Air Conditioners and Heat Pumps	. . . .	Table C403.2.3(3)
340/360--2007	Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment	. . . .	Table C403.2.3(1), Table C403.2.3(2)
365--09	Commercial and Industrial Unitary Air-conditioning Condensing Units	. . . .	Table C403.2.3(1), Table C403.2.3(6)
390--03	Performance Rating of Single Package Vertical Air Conditioners and Heat Pumps	. . . .	Table C403.2.3(3)
400--01	Liquid to Liquid Heat Exchangers with Addendum 2	. . . .	Table C403.2.3(9)
440--08	Room Fan Coil	. . . .	C403.2.8
460--05	Performance Rating Remote Mechanical Draft Air-cooled Refrigerant Condensers	. . . .	Table C403.2.3(8)
550/590--03	Water Chilling Packages Using the Vapor Compression Cycle--with Addenda	. . . .	C403.2.3.1, Table C403.2.3(7), Table C406.2(6)
560--00	Absorption Water Chilling and Water-heating Packages	. . . .	Table C403.2.3(7)
1160--08	Performance Rating of Heat Pump Pool Heaters	. . . .	Table C404.2
AMCA	Air Movement and Control Association International 30 West University Drive Arlington Heights, IL 60004-1806		
Standard reference number	Title		Referenced in code section number
500D--10	Laboratory Methods for Testing Dampers for Rating	. . . .	C402.4.5.1, C402.4.5.2
ANSI	American National Standards Institute 25 West 43rd Street Fourth Floor New York, NY 10036		
Standard reference number	Title		Referenced in code section number
ANSI/ASME A17.1-2010	Safety code for elevators and escalators	. . . .	C405.12.1

Z21.10.3/CSA 4.3--04	Gas Water Heaters, Volume III--Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous	. . . . .	Table C404.2
Z21.47/CSA 2.3--06	Gas-fired Central Furnaces	. . . . .	Table C403.2.3(4), Table C406.2(4)
Z83.8/CSA 2.6--09	Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-fired Duct Furnaces	. . . . .	Table C403.2.3(4), Table C406.2(4)
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 1791 Tullie Circle, N.E. 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	. . . . .	C403.2.1
ASHRAE--2004	ASHRAE HVAC Systems and Equipment Handbook--2004	. . . . .	C403.2.1
ISO/AHRI/ASHRAE 13256-1 (2005)	Water-source Heat Pumps--Testing and Rating for Performance-- Part 1: Water-to-air and Brine-to-air Heat Pumps	. . . . .	Table C403.2.3(2)
ISO/AHRI/ASHRAE 13256-2 (1998)	Water-source Heat Pumps--Testing and Rating for Performance--Part 2: Water-to-water and Brine-to-water Heat Pumps	. . . . .	Table C403.2.3(2)
90.1--2010	Energy Standard for Buildings Except Low-rise Residential Buildings (ANSI/ASHRAE/IESNA 90.1--2010)	. . . . .	C401.2, C401.2.1, C402.1.1, Table C402.1.2, Table C402.2, Table C407.6.1
119--88 (RA 2004)	Air Leakage Performance for Detached Single-family Residential Buildings	. . . . .	Table C405.5.2(1)

140--2010	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs	. . . . .	C407.6.1
146--2006	Testing and Rating Pool Heaters	. . . . .	Table C404.2
ASTM	ASTM International 100 Barr Harbor Drive West Conshohocken, PA 19428-2859		
Standard reference number	Title		Referenced in code section number
C 90--08	Specification for Load-bearing Concrete Masonry Units	. . . . .	Table C402.2
C 1371--04	Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers	. . . . .	Table C402.2.1.1
C 1549--04	Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using A Portable Solar Reflectometer	. . . . .	Table C405.2.1.1
D 1003--07e1	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics	. . . . .	C402.3.2.2
E 283--04	Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen	. . . . .	Table C402.2.1.1, C402.4.1.2.2, Table C402.4.3, C402.4.4, C402.4.8
E 408--71 (2002)	Test Methods for Total Normal Emittance of Surfaces Using Inspection-meter Techniques	. . . . .	Table C402.2.1.1
E 779--03	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	. . . . .	C402.4.1.2.3
E 903--96	Standard Test Method Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres (Withdrawn 2005)	. . . . .	Table C402.2.1.1
E 1677--05	Standard Specification for an Air-retarder (AR) Material or System for Low-rise Framed Building Walls	. . . . .	C402.4.1.2.2

E 1918--97	Standard Test Method for Measuring Solar Reflectance of Horizontal or Low-sloped Surfaces in the Field	. . . . .	Table C402.2.1.1
E 1980--(2001)	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-sloped Opaque Surfaces	. . . . .	Table C402.2.1.1
E 2178--03	Standard Test Method for Air Permanence of Building Materials	. . . . .	C402.4.1.2.1
E 2357--05	Standard Test Method for Determining Air Leakage of Air Barrier Assemblies	. . . . .	C404.1.2.2
CSA	Canadian Standards Association 5060 Spectrum Way Mississauga, Ontario, Canada L4W 5N6		
Standard reference number	Title		Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A440--11	North American *Fenestration* Standard/Specification for Windows, Doors and Unit Skylights	. . . . .	R402.4.3
CTI	Cooling Technology Institute 2611 FM 1960 West, Suite A-101 Houston, TX 77068		
Standard reference number	Title		Referenced in code section number
ATC 105 (00)	Acceptance Test Code for Water Cooling Tower	. . . . .	Table C403.2.3(8)
STD 201--09	Standard for Certification of Water Cooling Towers Thermal Performances	. . . . .	Table C403.2.3(8)
DASMA	Door and Access Systems Manufacturers Association 1300 Sumner Avenue Cleveland, OH 44115-2851		
Standard reference number	Title		Referenced in code section number
105--92 (R2004)	Test Method for Thermal Transmittance and Air Infiltration of Garage Doors	. . . . .	Table C402.4.3
DOE	U.S. Department of Energy		

	c/o Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402-9325		
Standard reference number	Title		Referenced in code section number
10 C.F.R., Part 430--1998	Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirement for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule	. . . . .	Table C403.2.3(4), Table C403.2.3(5), Table C404.2, Table C406.2(4), Table C406.2(5)
10 C.F.R., Part 430, Subpart B, Appendix N--1998	Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers	. . . . .	C202
10 C.F.R., Part 431--2004	Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards; Final Rules	. . . . .	Table C403.2.3(5), Table C406.2(5)
NAECA 87--(88)	National Appliance Energy Conservation Act 1987 [(Public Law 100-12 (with Amendments of 1988-P.L. 100-357)]	. . . . .	Tables C403.2.3 (1), (2), (4)
IAPMO	International Association of Plumbing and Mechanical Officials 4755 E. Philadelphia Street Ontario, CA 91761		
Standard reference number	Title		Referenced in code section number
UPC--2012	Uniform Plumbing Code	. . . . .	C201.3
ICC	International Code Council, Inc. 500 New Jersey Avenue, N.W., 6th Floor Washington, DC 20001		
Standard reference number	Title		Referenced in code section number
IBC--12	International Building Code	. . . . .	C201.3, C303.2, C402.4.4

IFC--12	International Fire Code	. . . . .	C201.3
IFGC--12	International Fuel Gas Code	. . . . .	C201.3
IMC--12	International Mechanical Code	. . . . .	C403.2.5, C403.2.5.1, C403.2.6, C403.2.7, C403.2.7.1, C403.2.7.1.1, C403.2.7.1.2, C403.2.7.1.3, C403.4.5, C408.2.2.1
IESNA	Illuminating Engineering Society of North America 120 Wall Street, 17th Floor New York, NY 10005-4001		
Standard reference number	Title		Referenced in code section number
ANSI/ASHRAE/IESNA 90.1--2010	Energy Standard for Buildings Except Low-rise Residential Buildings	. . . . .	C401.2, C401.2.1, C402.1.1, Table C402.1.2, Table C402.2, Table C407.6.1
ISO	International Organization for Standardization 1, rue de Varembe, Case postale 56, CH-1211 Geneva, Switzerland		
Standard reference number	Title		Referenced in code section number
ISO/AHRI/ASHRAE 13256-1 (2005)	Water-source Heat Pumps--Testing and Rating for Performance--Part 1: Water-to-air and Brine-to-air Heat Pumps	. . . . .	C403.2.3(2)
ISO/AHRI/ASHRAE 13256-2 (1998)	Water-Source Heat Pumps--Testing and Rating for Performance--Part 2: Water-to-water and Brine-to-water Heat Pumps	. . . . .	C403.2.3(2)
NEMA	National Electric Manufacturers Association 1300 North 17th Street Suite 1752 Rosslyn, VA 22209		

Standard reference number	Title		Referenced in code section number
TP-1-2002	Guide for Determining Energy Efficiency for Distribution Transformers	. . . .	C405.9
NFRC	National *Fenestration* Rating Council, Inc. 6305 Ivy Lane, Suite 140 Greenbelt, MD 20770		
Standard reference number	Title		Referenced in code section number
100--2010	Procedure for Determining *Fenestration* Product U-factors	. . . .	C303.1.2, C402.2.1
200--2010	Procedure for Determining *Fenestration* Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence	. . . .	C303.1.3, C402.3.1.1
400--2010	Procedure for Determining *Fenestration* Product Air Leakage	. . . .	Table C402.4.3
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc. 4021 Lafayette Center Drive Chantilly, VA 20151-1209		
Standard reference number	Title		Referenced in code section number
SMACNA--85	HVAC Air Duct Leakage Test Manual	. . . .	C403.2.7.1.3
UL	Underwriters Laboratories 333 Pfingsten Road Northbrook, IL 60062-2096		
Standard reference number	Title		Referenced in code section number
727--06	Oil-fired Central Furnaces--with Revisions through April 2010	. . . .	Table C403.2.3(4), Table C406.2(4)
731--95	Oil-fired Unit Heaters--with Revisions through April 2010	. . . .	Table C403.2.3(4), Table C406.2(4)
US-FTC	United States-Federal Trade Commission 600 Pennsylvania Avenue N.W. Washington, DC 20580		
Standard reference number	Title		Referenced in code section number

C.F.R. Title 16 (May 31, 2005)	R-value Rule	. . . . . .	C303.1.4
WDMA	Window and Door Manufacturers Association 1400 East Touhy Avenue, Suite 470 Des Plaines, IL 60018		
Standard reference number	Title		Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A440--11	North American *Fenestration* Standard/Specification for Windows, Doors and Unit Skylights	. . . . . .	Table C402.4.3

Appendix A--Default heat loss coefficients.

Section A101--General.

A101.1 Scope. The following defaults shall apply to Chapter 4 of both the (RE) and (CE) sections of the IECC. This chapter includes tables of seasonal average heat loss coefficients for specified nominal insulation.

A101.2 Description. These coefficients were developed primarily from data and procedures from the ASHRAE Fundamentals Handbook.

Coefficients not contained in this chapter may be computed using the procedures listed in this reference if the assumptions in the following sections are used, along with data from the sources referenced above.

A101.3 Air films. Default R-values used for air films shall be as follows:

R-Value	Condition
0.17	All exterior surfaces
0.61	Interior horizontal surfaces, heat flow up
0.92	Interior horizontal surfaces, heat flow down
0.68	Interior vertical surfaces

A101.4 Compression of insulation. Insulation which is compressed shall be rated in accordance with Table A101.4 or reduction in value may be calculated in accordance with the procedures in the ASHRAE Fundamentals Handbook.

Table A101.4
R-value of Fiberglass Batts Compressed Within Various Depth Cavities

Insulation R-Values at Standard Thickness													
Rated R-Value		**82**	**71**	**60**	**49**	**38**	**30**	**22**	**21**	**19**	**15**	**13**	**11**
Standard Thickness, Inches		**26.0**	**22.5**	**19.0**	**15.5**	**12**	**9.5**	**6.5**	**5.5**	**6**	**3.5**	**3.5**	**3.5**
Nominal Lumber Sizes, Inches	Actual Depth of Cavity, Inches	Insulation R-Values when Installed in a Confined Cavity											

Truss	26.0	82	--	--	--	--	--	--	--	--	--	--	--
Truss	22.5	--	71	--	--	--	--	--	--	--	--	--	--
Truss	19.0	--	--	60	--	--	--	--	--	--	--	--	--
Truss	15.5	--	--	--	49	--	--	--	--	--	--	--	--
Truss	12.0	--	--	--	--	38	--	--	--	--	--	--	--
2 x 12	11.25	--	--	--	--	37	--	--	--	--	--	--	--
2 x 10	9.25	--	--	--	--	32	30	--	--	--	--	--	--
2 x 8	7.25	--	--	--	--	27	26	22	21	19	--	--	--
2 x 6	5.5	--	--	--	--	--	21	20	21	18	--	--	--
2 x 4	3.5	--	--	--	--	--	--	14	--	13	15	13	11
	2.5	--	--	--	--	--	--	--	--	--	--	9.8	--
	1.5	--	--	--	--	--	--	--	--	--	--	6.3	6.0

A101.5 Building materials. Default R-values used for building materials shall be as shown in Table A101.5.

Table A101.5
Default R-values for Building Materials

Material	Nominal Size (in.)	Actual Size (in.)	R-Value (Heat Capacity[c])
Air cavity (unventilated), between metal studs at 16 inches on center[a]	-	-	0.79
Air cavity (unventilated), all other depths and framing materials[1]	-	-	0.91
Airfilm, exterior surfaces[b]	-	-	0.17
Airfilm, interior horizontal surfaces, heat flow up[b]	-	-	0.61
Airfilm, interior horizontal surfaces, heat flow down[b]	-	-	0.92
Airfilm, interior vertical surfaces[b]	-	-	0.68
Brick at R-0.12/in. (face brick, 75% solid/25% core area, 130 lbs/ft^3)	4	3.5	0.32 (5.9)
Carpet and rubber pad	-	-	1.23
Concrete at R-0.0625/in., heavyweight (144 lbs/ft^3)	-	2	0.13 (HC-4.8)
	-	4	0.25 (HC-9.6)

	-	6	0.38 (HC-14.4)
	-	8	0.50 (HC-19.2)
	-	10	0.63 (HC-24.0)
	-	12	0.75 (HC-28.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	6	-	0.80 (HC-11.4)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	6	-	0.51 (HC-13.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	6	-	1.33 (HC-6.7)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	6	-	0.82 (HC-9.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	8	-	1.05 (HC-15.5)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	8	-	0.69 (HC-17.9)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	8	-	1.44 (HC-9.6)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	8	-	0.98 (HC-12.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	10	-	1.30 (HC-19.7)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	10	-	0.87 (HC-22.6)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	10	-	1.61 (HC-11.9)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	10	-	1.11 (HC-14.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	12	-	1.53 (HC-23.9)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	12	-	1.06 (HC-27.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	12	-	1.75 (HC-14.2)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	12	-	1.23 (HC-17.5)
Flooring, wood subfloor	-	0.75	0.94
Gypsum board	-	0.5	0.45
	-	0.625	0.56
Metal deck	-	-	0

Roofing, built-up	-	0.375	0.33
Sheathing, vegetable fiber board, 0.78 in.	-	0.78	2.06
Soil at R-0.104/in.	-	12	1.25
Steel, mild		1	0.0031807
Stucco	-	0.75	0.08

[a]There is no credit for cavities that are open to outside air.

[b]Air films do not apply to air cavities within an assembly.

[c]For heat capacity for concrete and concrete masonry materials with densities other than the values listed in Table A101.5, see Tables A3.1B and A3.1C in ASHRAE/IESNA Standard 90.1.

Section A102--Ceilings.

A102.1 General. Table A102.1 lists heat loss coefficients for the opaque portion of exterior ceilings below vented attics, vaulted ceilings and roof decks in units of Btu/h · ft^2 · °F of ceiling.

They are derived from procedures listed in the ASHRAE Fundamentals Handbook. Ceiling U-factors are modified for the buffering effect of the attic, assuming an indoor temperature of 65°F and an outdoor temperature of 45°F.

A102.1.1 Metal framed ceilings. The nominal R-values in Table A103.3.6.2: Effective R-Values for Metal Framing and Cavity Only may be used for purposes of calculating metal framed ceiling section U-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of the ASHRAE Fundamentals Handbook.

Metal building roofs have a different construction and are addressed in Table A102.2.5.

Table A102.1
Default U-factors for Ceilings

	Standard Frame	**Advanced Frame**
Ceilings Below Vented Attics		
Flat	**Baffled**	
R-19	0.049	0.047
R-30	0.036	0.032
R-38	0.031	0.026
R-49	0.027	0.020
R-60	0.025	0.017

Scissors Truss			
R-30 (4/12 roof pitch)		0.043	0.031
R-38 (4/12 roof pitch)		0.040	0.025
R-49 (4/12 roof pitch)		0.038	0.020
R-30 (5/12 roof pitch)		0.039	0.032
R-38 (5/12 roof pitch)		0.035	0.026
R-49 (5/12 roof pitch)		0.032	0.020
Vaulted Ceilings		**16" O.C.**	**24" O.C.**
Vented			
R-19 2x10 joist		0.049	0.048
R-30 2x12 joist		0.034	0.033
R-38 2x14 joist		0.027	0.027
Unvented			
R-30 2x10 joist		0.034	0.033
R-38 2x12 joist		0.029	0.027
R-21 + R-21 2x12 joist		0.026	0.025
Roof Deck		**4 x Beams, 48" O.C.**	
R-12.5	2" Rigid insulation	0.064	
R-21.9	3.5" Rigid insulation	0.040	
R-37.5	6" Rigid insulation	0.025	
R-50	8" Rigid insulation	0.019	

A102.2 Component description. The four types of ceilings are characterized as follows:

A102.2.1 Ceilings below a vented attic. Attic insulation is assumed to be blown-in, loose-fill fiberglass with a K-value of 2.6 h · ft^2 · °F/Btu per inch. Full bag count for specified R-value is assumed in all cases. Ceiling dimensions for flat ceiling calculations are 45 by 30 feet, with a gabled roof having a 4/12 pitch. The attic is assumed to vent naturally at the rate of 3 air changes per hour through soffit and ridge vents. A void fraction of 0.002 is assumed for all attics with insulation baffles. Standard-framed, unbaffled attics assume a void fraction of 0.008.

Attic framing is either standard or advanced. Standard framing assumes tapering of insulation depth around the perimeter with resultant decrease in thermal resistance. An increased R-value is assumed in the center of the ceiling due to the effect of piling leftover insulation. Advanced framing assumes full and even depth of insulation extending to the

outside edge of exterior walls. Advanced framing does not change from the default value.

U-factors for flat ceilings below vented attics with standard framing may be modified with the following table:

Roof Pitch	U-Factor for Standard Framing	
	R-30	R-38
4/12	0.036	0.031
5/12	0.035	0.030
6/12	0.034	0.029
7/12	0.034	0.029
8/12	0.034	0.028
9/12	0.034	0.028
10/12	0.033	0.028
11/12	0.033	0.027
12/12	0.033	0.027

Vented scissors truss attics assume a ceiling pitch of 2/12 with a roof pitch of either 4/12 or 5/12. Unbaffled standard framed scissors truss attics are assumed to have a void fraction of 0.016.

A102.2.2 Vaulted ceilings. Insulation is assumed to be fiberglass batts installed in roof joist cavities. In the vented case, at least 1.5 inches between the top of the batts and the underside of the roof sheathing is left open for ventilation in each cavity. A ventilation rate of 3.0 air changes per hour is assumed. In the unvented or dense pack case, the ceiling cavity is assumed to be fully packed with insulation, leaving no space for ventilation.

A102.2.3 Roof decks. Rigid insulation is applied to the top of roof decking with no space left for ventilation. Roofing materials are attached directly on top of the insulation. Framing members are often left exposed on the interior side.

A102.2.4 Metal truss framing. Overall system tested values for the roof/ceiling U_o for metal framed truss assemblies from approved laboratories shall be used, when such data is acceptable to the building official.

Alternatively, the U_o for roof/ceiling assemblies using metal truss framing may be obtained from Tables A102.2.4(1) through A102.2.4(5).

A102.2.5 Metal building roof. Table A102.2.5: The base assembly is a roof where the insulation is compressed when installed beneath metal roof panels attached to the steel structure (purlins). Additional assemblies include continuous insulation, uncompressed and uninterrupted by framing.

U-factors for metal building roofs shall be taken from Table A102.2.5, provided the average purlin spacing is at least 52 inches and the R-value of the thermal spacer block is greater than or equal to the thermal spacer block R-value indicated in Table A107.2.5 for the assembly.

It is not acceptable to use the U-factors in Table A102.2.6 if additional insulated sheathing is not continuous.

A102.2.5.1 Single layer. The rated R-value of insulation is for insulation installed perpendicular to and draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

A102.2.5.2 Double layer. The first rated R-value of insulation is for insulation installed perpendicular to and draped over purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer and parallel to the purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

A102.2.5.3 Continuous insulation. For continuous insulation (e.g., insulation boards or blankets), it is assumed that the insulation is installed below the purlins and is uninterrupted by framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

A102.2.5.4 Liner system (Ls). A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated R-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

A102.2.5.5 Filled cavity. The first rated R-value of insulation is for faced insulation installed parallel to the purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer, parallel to and between the purlins and compressed when the metal roof panels are attached. The facer of the first layer of insulation is of sufficient width to be continuously sealed to the top flange of the purlins and to accommodate the full thickness of the second layer of insulation. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of the second layer of insulation being installed above it. A minimum R-5 (R-0.9) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

A102.2.6 Roofs with insulation entirely above deck (uninterrupted by framing). Table A102.2.6: The base assembly is continuous insulation over a structural deck. Added insulation is continuous and uninterrupted by framing. For the insulation, the first column lists the R-value for continuous insulation with a uniform thickness; the second column lists the comparable area-weighted average R-value for continuous insulation provided that the insulation thickness is never less than R-5 (except at roof drains) and that the slope is no greater than 1/4 inch per foot.

Table A102.2.4(1)
Steel Truss[a] Framed Ceiling U_o

Cavity	Truss Span (ft)												
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.1075	0.0991	0.0928	0.0878	0.0839	0.0807	0.0780	0.0757	0.0737	0.0720	0.0706	0.0693	0.0681
30	0.0907	0.0823	0.0760	0.0710	0.0671	0.0638	0.0612	0.0589	0.0569	0.0552	0.0538	0.0525	0.0513
38	0.0844	0.0759	0.0696	0.0647	0.0607	0.0575	0.0548	0.0525	0.0506	0.0489	0.0474	0.0461	0.0449
49	0.0789	0.0704	0.0641	0.0592	0.0552	0.0520	0.0493	0.0470	0.0451	0.0434	0.0419	0.0406	0.0395

Table A102.2.4(2)
Steel Truss[a] Framed Ceiling U_o with R-3 Sheathing

Cavity	Truss Span (ft)												
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0809	0.0763	0.0728	0.0701	0.0679	0.0661	0.0647	0.0634	0.0623	0.0614	0.0606	0.0599	0.0592
30	0.0641	0.0595	0.0560	0.0533	0.0511	0.0493	0.0478	0.0466	0.0455	0.0446	0.0438	0.0431	0.0424
38	0.0577	0.0531	0.0496	0.0469	0.0447	0.0430	0.0415	0.0402	0.0392	0.0382	0.0374	0.0367	0.0361
49	0.0523	0.0476	0.0441	0.0414	0.0393	0.0375	0.0360	0.0348	0.0337	0.0328	0.0319	0.0312	0.0306

Table A102.2.4(3)
Steel Truss[a] Framed Ceiling U_o with R-5 Sheathing

Cavity	Truss Span (ft)												
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0732	0.0697	0.0670	0.0649	0.0633	0.0619	0.0608	0.0598	0.0590	0.0583	0.0577	0.0571	0.0567
30	0.0564	0.0529	0.0502	0.0481	0.0465	0.0451	0.0440	0.0430	0.0422	0.0415	0.0409	0.0403	0.0399
38	0.0501	0.0465	0.0438	0.0418	0.0401	0.0388	0.0376	0.0367	0.0359	0.0351	0.0345	0.0340	0.0335
49	0.0446	0.0410	0.0384	0.0363	0.0346	0.0333	0.0322	0.0312	0.0304	0.0297	0.0291	0.0285	0.0280

Table A102.2.4(4)
Steel Truss[a] Framed Ceiling U_o with R-10 Sheathing

Cavity	Truss Span (ft)												
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0626	0.0606	0.0590	0.0578	0.0569	0.0561	0.0555	0.0549	0.0545	0.0541	0.0537	0.0534	0.0531
30	0.0458	0.0437	0.0422	0.0410	0.0401	0.0393	0.0387	0.0381	0.0377	0.0373	0.0369	0.0366	0.0363
38	0.0394	0.0374	0.0359	0.0347	0.0337	0.0330	0.0323	0.0318	0.0313	0.0309	0.0305	0.0302	0.0299

49	0.0339	0.0319	0.0304	0.0292	0.0283	0.0275	0.0268	0.0263	0.0258	0.0254	0.0251	0.0247	0.0245

Table A102.2.4(5)
Steel Truss[a] Framed Ceiling U_o with R-15 Sheathing

Cavity	Truss Span (ft)												
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0561	0.0550	0.0541	0.0535	0.0530	0.0526	0.0522	0.0519	0.0517	0.0515	0.0513	0.0511	0.0509
30	0.0393	0.0382	0.0373	0.0367	0.0362	0.0358	0.0354	0.0351	0.0349	0.0347	0.0345	0.0343	0.0341
38	0.0329	0.0318	0.0310	0.0303	0.0298	0.0294	0.0291	0.0288	0.0285	0.0283	0.0281	0.0279	0.0278
49	0.0274	0.0263	0.0255	0.0249	0.0244	0.0239	0.0236	0.0233	0.0230	0.0228	0.0226	0.0225	0.0223

Footnotes for Tables A102.2.4(1) through A102.2.4(5)

[a] Assembly values based on 24 inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); 1/2 inch drywall ceiling; all truss members are 2x4 "C" channels with a solid web.

[b]Ceiling sheathing installed between bottom chord and drywall.

Table A102.2.5
Default U-factors for Metal Building Roofs

Insulation System	Rated R-Value of Insulation	Overall U-Factor for Entire Base Roof Assembly	Overall U-Factor for Assembly of Base Roof Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation					
			R-6.5	R-13	R-19.5	R-26	R-32.5	R-39
Standing Seam Roofs with Thermal Spacer Blocks[a, b]								
Single Layer	None	1.280	0.137	0.073	0.049	0.037	0.030	0.025
	R-10	0.115	0.066	0.046	0.035	0.029	0.024	0.021
	R-11	0.107	0.063	0.045	0.035	0.028	0.024	0.021
	R-13	0.101	0.061	0.044	0.034	0.028	0.024	0.020
	R-16	0.096	0.059	0.043	0.033	0.027	0.023	0.020
	R-19	0.082	0.053	0.040	0.031	0.026	0.022	0.020
	R-10 + R-10	0.088	0.056	0.041	0.032	0.027	0.023	0.020
	R-10 + R-11	0.086	0.055	0.041	0.032	0.027	0.023	0.020
	R-11 + R-11	0.085	0.055	0.040	0.032	0.026	0.023	0.020
	R-10 + R-13	0.084	0.054	0.040	0.032	0.026	0.023	0.020

Double Layer	R-11 + R-13	0.082	0.053	0.040	0.032	0.026	0.022	0.020
	R-13 + R-13	0.075	0.050	0.038	0.030	0.025	0.022	0.019
	R-10 + R-19	0.074	0.050	0.038	0.030	0.025	0.022	0.019
	R-11 + R-19	0.072	0.049	0.037	0.030	0.025	0.022	0.019
	R-13 + R-19	0.068	0.047	0.036	0.029	0.025	0.021	0.019
	R-16 + R-19	0.065	0.046	0.035	0.029	0.024	0.021	0.018
	R-19 + R-19	0.060	0.043	0.034	0.028	0.023	0.020	0.018
Liner System	R-19 + R-11	0.035						
	R-25 + R-11	0.031						
	R-30 + R-11	0.029						
	R-25 + R-11 + R-11	0.026						
Filled Cavity with Thermal Spacer Blocks[c]								
	R-10 + R-19	0.057	0.042	0.033	0.027	0.023	0.020	0.018
Standing Seam Roofs without Thermal Spacer Blocks								
Liner System	R-19 + R-11	0.040						
Thru-Fastened Roofs without Thermal Spacer Blocks								
Single Layer	R-10	0.184						
	R-11	0.182						
	R-13	0.174						
	R-16	0.157						
	R-19	0.151						
Liner System	R-19 + R-11	0.044						

(Multiple R-values are listed in order from inside to outside)

[a]A standing seam roof clip that provides a minimum 1.5 inch distance between the top of the purlins and the underside of the metal roof panels is required.

[b]A minimum R-3 thermal spacer block is required.

[c]A minimum R-5 thermal spacer block is required.

Table A102.2.6
Assembly U-factors for Roofs with Insulation Entirely above Deck

(Uninterrupted by Framing)

Rated R-Value of Insulation Alone: Minimum Throughout, Unsloped	Rated R-Value of Insulation Alone: Average (R-5 minimum), Sloped (1/4 inch per foot maximum)	Overall U-Factor for Entire Assembly
R-0	Not Allowed	U-1.282
R-1	Not Allowed	U-0.562
R-2	Not Allowed	U-0.360
R-3	Not Allowed	U-0.265
R-4	Not Allowed	U-0.209
R-5	Not Allowed	U-0.173
R-6	R-7	U-0.147
R-7	R-8	U-0.129
R-8	R-9	U-0.114
R-9	R-10	U-0.102
R-10	R-12	U-0.093
R-11	R-13	U-0.085
R-12	R-15	U-0.078
R-13	R-16	U-0.073
R-14	R-18	U-0.068
R-15	R-20	U-0.063
R-16	R-22	U-0.060
R-17	R-23	U-0.056
R-18	R-25	U-0.053
R-19	R-27	U-0.051
R-20	R-29	U-0.048
R-21	R-31	U-0.046
R-22	R-33	U-0.044
R-23	R-35	U-0.042
R-24	R-37	U-0.040
R-25	R-39	U-0.039
R-26	R-41	U-0.037
R-27	R-43	U-0.036

R-28	R-46	U-0.035
R-29	R-48	U-0.034
R-30	R-50	U-0.032
R-35	R-61	U-0.028
R-40	R-73	U-0.025
R-45	R-86	U-0.022
R-50	R-99	U-0.020
R-55	R-112	U-0.018
R-60	R-126	U-0.016

Section A103--Above grade walls.

A103.1 General. Tables A103.1(1) through A103.3.3(2), A103.3.6(1) through A103.3.6(2), ((~~A103.1(2)~~)) and A103.7.1(1) through A103.3.7.1(3) list heat loss coefficients for the opaque portion of above-grade wood stud frame walls, metal stud frame walls and concrete masonry walls (Btu/h · ft^2 · °F) respectively. They are derived from procedures listed in the ASHRAE Fundamentals Handbook. For intermediate floor slabs which penetrate the insulated wall, use the concrete ((~~wall~~)) peripheral edge U-factors in Table ((~~A103.1(2)~~)) A103.3.7.2.

Insulation is assumed to uniformly fill the entire cavity and to be installed as per manufacturer's directions. All walls are assumed to be finished on the inside with 1/2 inch gypsum wallboard, and on the outside with either beveled wood siding over 1/2 inch plywood sheathing or with 5/8 inch T1-11 siding. Insulated sheathing (either interior or exterior) is assumed to cover the entire opaque wall surface, except where modified in accordance with footnote h to Table C402.1.1.

Metal building walls have a different construction and are addressed in Table A103.3.6.3.

A103.2 Framing description. For wood stud frame walls, three framing types are considered and defined as follows:

A103.2.1 Standard. Studs framed on 16 inch centers with double top plate and single bottom plate. Corners use three studs and each opening is framed using two studs. Headers consist of double 2x or single 4x material with an air space left between the header and the exterior sheathing. Interior partition wall/exterior wall intersections use two studs in the exterior wall.

Standard framing weighting factors:

Studs and plates	0.19
Insulated cavity	0.77
Headers	0.04

A103.2.2 Intermediate. Studs framed on 16 inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and each

opening is framed by two studs. Headers consist of double 2x material with R-10 insulation. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Intermediate framing weighting factors:

Studs and plates	0.18
Insulated cavity	0.78
Headers	0.04

A103.2.3 Advanced. Studs framed on 24 inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and one stud is used to support each header. Headers consist of double 2x material with R-10 insulation. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Advanced framing weighting factors:

Studs and plates	0.13
Insulated cavity	0.83
Headers	0.04

A103.3 Component description. Default coefficients for the following types of walls are listed: Single-stud walls, strap walls, double-stud walls, log walls, stress-skin panels, metal stud walls, and metal building walls.

A103.3.1 Single-stud wall. Tables A103.3.1(1) through A103.3.1(8): Assumes either 2 x 4 or 2 x 6 studs framed on 16 or 24 inch centers. Headers are solid for 2 x 4 walls and double 2x for 2 x 6 walls, with either dead-air or rigid-board insulation in the remaining space.

TABLE A103.3.1(1)

2 x 4 Single Wood Stud: R-11 Batt

	Siding Material/Framing Type			
	Lapped Wood		T1-11	
R-value of Foam Board	STD	ADV	STD	ADV
0	0.088	0.084	0.094	0.090
1	0.080	0.077	0.085	0.082
2	0.074	0.071	0.078	0.075
3	0.069	0.066	0.072	0.070
4	0.064	0.062	0.067	0.065

NOTE:

Nominal Batt R-value:
R-11 at 3.5 inch thickness

Installed Batt R-value:
R-11 in 3.5 inch cavity

5	0.060	0.058	0.063	0.061
6	0.056	0.055	0.059	0.057
7	0.053	0.052	0.055	0.054
8	0.051	0.049	0.052	0.051
9	0.048	0.047	0.050	0.049
10	0.046	0.045	0.047	0.046
11	0.044	0.043	0.045	0.044
12	0.042	0.041	0.043	0.042

TABLE A103.3.1(2)

2 x 4 Single Wood Stud: R-13 Batt

	Siding Material/Framing Type			
	Lapped Wood		**T1-11**	
R-value of Foam Board	**STD**	**ADV**	**STD**	**ADV**
0	0.082	0.078	0.088	0.083
1	0.075	0.072	0.080	0.076
2	0.069	0.066	0.073	0.070
3	0.065	0.062	0.068	0.065
4	0.060	0.058	0.063	0.061
5	0.057	0.055	0.059	0.057
6	0.053	0.052	0.056	0.054
7	0.051	0.049	0.052	0.051
8	0.048	0.047	0.050	0.048
9	0.046	0.045	0.047	0.046
10	0.044	0.043	0.045	0.044
11	0.042	0.041	0.043	0.042
12	0.040	0.039	0.041	0.040

NOTE:

Nominal Batt R-value:
R-13 at 3.63 inch thickness

Installed Batt R-value:
R-12.7 in 3.5 inch cavity

TABLE A103.3.1(3)

2 x 4 Single Wood Stud: R-15 Batt

	Siding Material/Framing Type			
	Lapped Wood		T1-11	
R-value of Foam Board	**STD**	**ADV**	**STD**	**ADV**
0	0.076	0.071	0.081	0.075
1	0.069	0.065	0.073	0.069
2	0.064	0.061	0.068	0.069
3	0.060	0.057	0.063	0.059
4	0.056	0.053	0.059	0.056
5	0.053	0.051	0.055	0.052
6	0.050	0.048	0.052	0.050
7	0.047	0.046	0.049	0.047
8	0.045	0.044	0.047	0.045
9	0.043	0.042	0.044	0.043
10	0.041	0.040	0.042	0.041
11	0.039	0.038	0.041	0.039
12	0.038	0.037	0.039	0.038

NOTE:

Nominal Batt R-value:
R-15 at 3.5 inch thickness

Installed Batt R-value:
R-15 in 3.5 inch cavity

TABLE A103.3.1(4)

2 x 6 Single Wood Stud: R-19 Batt

	Siding Material/Framing Type					
	Lapped Wood			T1-11		
R-value of Foam Board	**STD**	**INT**	**ADV**	**STD**	**INT**	**ADV**

NOTE:	0	0.062	0.058	0.055	0.065	0.061	0.058
Nominal Batt R-value: R-19 at 6 inch thickness							
Installed Batt R-value: R-18 in 5.5 inch cavity							
	1	0.058	0.055	0.052	0.060	0.057	0.055
	2	0.054	0.052	0.050	0.056	0.054	0.051
	3	0.051	0.049	0.047	0.053	0.051	0.049
	4	0.048	0.046	0.045	0.050	0.048	0.046
	5	0.046	0.044	0.043	0.048	0.046	0.044
	6	0.044	0.042	0.041	0.045	0.044	0.042
	7	0.042	0.040	0.039	0.043	0.042	0.040
	8	0.040	0.039	0.038	0.041	0.040	0.039
	9	0.038	0.037	0.035	0.039	0.038	0.037
	10	0.037	0.036	0.035	0.038	0.037	0.036
	11	0.036	0.035	0.034	0.036	0.035	0.035
	12	0.034	0.033	0.033	0.035	0.034	0.033

TABLE A103.3.1(5)

2 x 6 Single Wood Stud: R-21 Batt

	Siding Material/Framing Type					
	Lapped Wood			**T1-11**		
R-value of Foam Board	**STD**	**INT**	**ADV**	**STD**	**INT**	**ADV**
NOTE: 0	0.057	0.054	0.051	0.060	0.056	0.053
Nominal Batt R-value: R-21 at 5.5 inch thickness						
Installed Batt R-value: R-21 in 5.5 inch cavity						
1	0.054	0.051	0.048	0.056	0.053	0.050
2	0.050	0.048	0.045	0.052	0.050	0.047

3	0.048	0.045	0.043	0.049	0.047	0.045
4	0.045	0.043	0.041	0.047	0.045	0.043
5	0.043	0.041	0.040	0.044	0.042	0.041
6	0.041	0.039	0.038	0.042	0.041	0.039
7	0.039	0.038	0.036	0.040	0.039	0.037
8	0.038	0.036	0.035	0.039	0.037	0.036
9	0.036	0.035	0.034	0.037	0.036	0.035
10	0.035	0.034	0.033	0.036	0.035	0.033
11	0.033	0.033	0.032	0.034	0.033	0.032
12	0.032	0.031	0.031	0.033	0.032	0.031

TABLE A103.3.1(6)

2 x 6 Single Wood Stud: R-22 Batt

	Siding Material/Framing Type					
	Lapped Wood			T1-11		
R-value of Foam Board	**STD**	**INT**	**ADV**	**STD**	**INT**	**ADV**
0	0.059	0.055	0.052	0.062	0.058	0.054
1	0.055	0.052	0.049	0.057	0.054	0.051
2	0.052	0.049	0.047	0.054	0.051	0.048
3	0.049	0.046	0.044	0.050	0.048	0.046
4	0.046	0.044	0.042	0.048	0.046	0.044
5	0.044	0.042	0.041	0.045	0.043	0.042
6	0.042	0.040	0.039	0.043	0.042	0.040
7	0.040	0.039	0.037	0.041	0.040	0.038
8	0.038	0.037	0.036	0.039	0.038	0.037
9	0.037	0.036	0.035	0.038	0.037	0.035
10	0.035	0.034	0.033	0.036	0.035	0.034
11	0.034	0.033	0.032	0.035	0.034	0.033

NOTE:

Nominal Batt R-value:
R-22 at 6.75 inch thickness

Installed Batt R-value:
R-20 in 5.5 inch cavity

12	0.033	0.032	0.031	0.034	0.033	0.032

TABLE A103.3.1(7)

2 x 6 Single Wood Stud: Two R-11 Batts

	Siding Material/Framing Type					
	Lapped Wood			T1-11		
R-value of Foam Board	**STD**	**INT**	**ADV**	**STD**	**INT**	**ADV**
0	0.060	0.057	0.054	0.063	0.059	0.056
1	0.056	0.053	0.051	0.059	0.056	0.053
2	0.053	0.050	0.048	0.055	0.052	0.050
3	0.050	0.048	0.046	0.052	0.049	0.047
4	0.047	0.045	0.044	0.049	0.047	0.045
5	0.045	0.043	0.042	0.046	0.045	0.043
6	0.043	0.041	0.040	0.044	0.043	0.041
7	0.041	0.040	0.038	0.042	0.041	0.039
8	0.039	0.038	0.037	0.040	0.039	0.038
9	0.038	0.037	0.036	0.039	0.038	0.036
10	0.036	0.035	0.034	0.037	0.036	0.035
11	0.035	0.034	0.033	0.036	0.035	0.034
12	0.034	0.033	0.032	0.034	0.034	0.033

NOTE:

Nominal Batt R-value:
R-22 at 7 inch thickness

Installed Batt R-value:
R-18.9 in 5.5 inch cavity

TABLE A103.3.1(8)

2 x 8 Single Stud: R-25 Batt

	Siding Material/Framing Type					
	Lapped Wood			T1-11		
R-value of Foam Board	**STD**	**INT**	**ADV**	**STD**	**INT**	**ADV**

NOTE:							
	0	0.051	0.047	0.045	0.053	0.049	0.046
Nominal Batt R-value: R-25 at 8 inch thickness							
Installed Batt R-value: R-23.6 in 7.25 inch cavity							
	1	0.048	0.045	0.043	0.049	0.046	0.044
	2	0.045	0.043	0.041	0.047	0.044	0.042
	3	0.043	0.041	0.039	0.044	0.042	0.040
	4	0.041	0.039	0.037	0.042	0.040	0.038
	5	0.039	0.037	0.036	0.040	0.038	0.037
	6	0.037	0.036	0.035	0.038	0.037	0.036
	7	0.036	0.035	0.033	0.037	0.035	0.034
	8	0.035	0.033	0.032	0.035	0.034	0.033
	9	0.033	0.032	0.031	0.034	0.033	0.032
	10	0.032	0.031	0.030	0.033	0.032	0.031
	11	0.031	0.030	0.029	0.032	0.031	0.030
	12	0.030	0.029	0.028	0.031	0.030	0.029

A103.3.2 Strap wall. Table A103.3.2: Assumes 2 x 6 studs framed on 16 or 24 inch centers. 2 x 3 or 2 x 4 strapping is run horizontally along the interior surface of the wall to provide additional space for insulation.

Table A103.3.2
2 x 6: Strap Wall

	Siding Material/Frame Type			
	Lapped Wood		**T1-11**	
	STD	**ADV**	**STD**	**ADV**
R-19 + R-11 Batts	0.036	0.035	0.038	0.036
R-19 + R-8 Batts	0.041	0.039	0.042	0.040

A103.3.3 Double stud wall. Tables A103.3.3(1) and A103.3.3(2): Assumes an exterior structural wall and a separate interior, nonstructural wall. Insulation is placed in both wall cavities and in the space between the two walls. Stud spacing is assumed to be on 24 inch centers for both walls.

Table A103.3.3(1)

2 x 6 + 2 x 4: Double Wood Stud

Batt Configuration			Siding Material/Frame Type			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-19	------	R-11	0.040	0.037	0.041	0.038
R-19	------	R-19	0.034	0.031	0.035	0.032
R-19	R-8	R-11	0.029	0.028	0.031	0.029
R-19	R-11	R-11	0.027	0.026	0.028	0.027
R-19	R-11	R-19	0.024	0.023	0.025	0.023
R-19	R-19	R-19	0.021	0.020	0.021	0.020

Table A103.3.3(2)
2 x 4 + 2 x 4: Double Wood Stud

Batt Configuration			Siding Material/Frame Type			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-11	--------	R-11	0.050	0.046	0.052	0.048
R-19	--------	R-11	0.039	0.037	0.043	0.039
R-11	R-8	R-11	0.037	0.035	0.036	0.036
R-11	R-11	R-11	0.032	0.031	0.033	0.032
R-13	R-13	R-13	0.029	0.028	0.029	0.028
R-11	R-19	R-11	0.026	0.026	0.027	0.026

A103.3.4 Log wall. See Table A103.3.4.

Table A103.3.4
Log Walls

Average Log Diameter, Inches	U-factor

NOTE: R-value of wood: R-1.25 per inch thickness	6	0.148
Average wall thickness 90% average log diameter	8	0.111
	10	0.089
	12	0.074
	14	0.063
	16	0.056

A103.3.5 Stress-skin panel. See Table A103.3.5.

Table A103.3.5
Stress Skin Panel

	Panel Thickness, Inches	**U-factor**
NOTE: R-value of expanded polystyrene: R-3.85 per inch	3 1/2	0.071
Framing: 6% Spline: 8%	5 1/2	0.048
	7 1/4	0.037
	9 1/4	0.030
	11 1/4	0.025

No thermal bridging between interior and exterior splines

A103.3.6 Metal stud walls. The nominal R-values in Tables A103.3.6.1 through A103.3.6.3 may be used for purposes of calculating metal stud wall section U-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of the ASHRAE Fundamentals Handbook.

A103.3.6.1 Metal stud wall, overall assembly U-factors. Tables A103.3.6.1(1) and A103.6.1(2): Assumes metal studs spaced on 16 or 24 inch centers with insulation installed to fill wall cavities. Continuous rigid board insulation is applied without creating uninsulated voids in the wall assembly.

Table A103.3.6.1(1)
Overall Assembly U-factors for Metal Stud Walls with Continuous Insulation

Metal Framing	R-Value of Continuous Foam Board Insulation	Cavity Insulation					
		R-0	R-11	R-13	R-15	R-19	R-21
16" o.c.	R-0 (none)	0.352	0.132	0.124	0.118	0.109	0.106
	R-1	0.260	0.117	0.111	0.106	0.099	0.096
	R-2	0.207	0.105	0.100	0.096	0.090	0.087
	R-3	0.171	0.095	0.091	0.087	0.082	0.080
	R-4	0.146	0.087	0.083	0.080	0.076	0.074
	R-5	0.128	0.080	0.077	0.074	0.071	0.069
	R-6	0.113	0.074	0.071	0.069	0.066	0.065
	R-7	0.102	0.069	0.066	0.065	0.062	0.061
	R-8	0.092	0.064	0.062	0.061	0.058	0.057
	R-9	0.084	0.060	0.059	0.057	0.055	0.054
	R-10	0.078	0.057	0.055	0.054	0.052	0.051
	R-11	0.072	0.054	0.052	0.051	0.050	0.049
	R-12	0.067	0.051	0.050	0.049	0.047	0.047
	R-13	0.063	0.049	0.048	0.047	0.045	0.045
	R-14	0.059	0.046	0.045	0.045	0.043	0.043
	R-15	0.056	0.044	0.043	0.043	0.041	0.041
	R-20	0.044	0.036	0.036	0.035	0.034	0.034
24" o.c.	R-0 (none)	0.338	0.116	0.108	0.102	0.094	0.090

	R-1	0.253	0.104	0.098	0.092	0.086	0.083
	R-2	0.202	0.094	0.089	0.084	0.079	0.077
	R-3	0.168	0.086	0.082	0.078	0.073	0.071
	R-4	0.144	0.079	0.075	0.072	0.068	0.066
	R-5	0.126	0.073	0.070	0.067	0.064	0.062
	R-6	0.112	0.068	0.066	0.063	0.060	0.059
	R-7	0.100	0.064	0.062	0.059	0.057	0.055
	R-8	0.091	0.060	0.058	0.056	0.054	0.052
	R-9	0.084	0.057	0.055	0.053	0.051	0.050
	R-10	0.077	0.054	0.052	0.050	0.048	0.048
	R-11	0.072	0.051	0.049	0.048	0.046	0.045
	R-12	0.067	0.048	0.047	0.046	0.044	0.043
	R-13	0.063	0.046	0.045	0.044	0.042	0.042
	R-14	0.059	0.044	0.043	0.042	0.041	0.040
	R-15	0.056	0.042	0.041	0.040	0.039	0.038
	R-20	0.044	0.035	0.034	0.034	0.033	0.032

Continuous foam board insulation: Continuous insulation assumes no thermal bridging of insulation by framing or z-furring through applied foam board. Zone calculation method as provided in the ASHRAE Fundamentals Handbook must be used for thermally bridged foam board insulation. Values for attachment of insulation with z-furring are given in Table A103.3.6.1(2).

Table A103.3.6.1(2)
Overall Assembly U-factors for Metal Stud Walls with Insulation Supported by Z-furring

Metal Framing	R-Value of Foam Board Insulation	Z-furring Attachment	Cavity Insulation					
			R-0	R-11	R-13	R-15	R-19	R-21
16" o.c.	R-0 (none)	Horizontal	0.352	0.132	0.124	0.118	0.109	0.106
	R-5	Horizontal	0.155	0.089	0.086	0.083	0.078	0.077
	R-7.5	Horizontal	0.128	0.080	0.077	0.074	0.071	0.069
	R-10	Horizontal	0.110	0.072	0.070	0.068	0.065	0.064
	R-12.5	Horizontal	0.099	0.068	0.065	0.064	0.061	0.060
	R-15	Horizontal	0.091	0.064	0.062	0.060	0.058	0.057

	R-17.5	Horizontal	0.084	0.060	0.058	0.057	0.055	0.054
	R-20	Horizontal	0.078	0.057	0.056	0.054	0.052	0.052
	R-22.5	Horizontal	0.074	0.055	0.054	0.052	0.051	0.050
	R-25	Horizontal	0.071	0.053	0.052	0.051	0.049	0.048
	R-0 (none)	Vertical	0.352	0.132	0.124	0.118	0.109	0.106
	R-5	Vertical	0.165	0.093	0.089	0.086	0.081	0.079
	R-7.5	Vertical	0.142	0.085	0.081	0.079	0.075	0.073
	R-10	Vertical	0.126	0.079	0.076	0.074	0.070	0.069
	R-12.5	Vertical	0.115	0.074	0.072	0.070	0.066	0.065
	R-15	Vertical	0.107	0.071	0.069	0.067	0.064	0.063
	R-17.5	Vertical	0.100	0.068	0.065	0.064	0.061	0.060
	R-20	Vertical	0.094	0.065	0.063	0.061	0.059	0.058
	R-22.5	Vertical	0.090	0.063	0.061	0.060	0.057	0.056
	R-25	Vertical	0.086	0.061	0.059	0.058	0.056	0.055
24" o.c.	R-0 (none)	Horizontal	0.338	0.116	0.108	0.102	0.094	0.090
	R-5	Horizontal	0.152	0.082	0.078	0.074	0.070	0.068
	R-7.5	Horizontal	0.126	0.074	0.070	0.068	0.064	0.062
	R-10	Horizontal	0.109	0.067	0.065	0.062	0.059	0.058
	R-12.5	Horizontal	0.098	0.063	0.061	0.059	0.056	0.055
	R-15	Horizontal	0.090	0.060	0.058	0.056	0.053	0.052
	R-17.5	Horizontal	0.083	0.057	0.055	0.053	0.051	0.050
	R-20	Horizontal	0.078	0.054	0.052	0.051	0.049	0.048
	R-22.5	Horizontal	0.074	0.052	0.050	0.049	0.047	0.046
	R-25	Horizontal	0.070	0.050	0.049	0.047	0.046	0.045
	R-0 (none)	Vertical	0.338	0.116	0.108	0.102	0.094	0.090
	R-5	Vertical	0.162	0.084	0.080	0.077	0.072	0.070
	R-7.5	Vertical	0.140	0.078	0.074	0.071	0.067	0.065
	R-10	Vertical	0.124	0.073	0.070	0.067	0.063	0.062
	R-12.5	Vertical	0.113	0.069	0.066	0.064	0.061	0.059
	R-15	Vertical	0.106	0.066	0.063	0.061	0.058	0.057
	R-17.5	Vertical	0.098	0.063	0.061	0.059	0.056	0.055

	R-20	Vertical	0.093	0.061	0.059	0.057	0.054	0.053
	R-22.5	Vertical	0.089	0.059	0.057	0.055	0.053	0.051
	R-25	Vertical	0.085	0.057	0.055	0.054	0.051	0.050

Values in Table A103.3.6.1(2) may not be interpolated between. The value of the foam board insulation must meet or exceed the value listed in the table in order to use the value shown.

A103.3.6.2 Metal stud wall, effective R-values for metal framing and cavity only. Table A103.3.6.2: These values may be used for the metal-framing/cavity layers in walls with metal studs spaced on 16- or 24-inch centers with insulation installed to fill wall cavities in lieu of using the zone method provided in Chapter 25 of the ASHRAE Fundamentals Handbook.

Table A103.3.6.2
Effective R-values for Metal Framing and Cavity Only

	Cavity		**Insulation**		
	Nominal Depth, Inches	**Actual Depth, Inches**	**Nominal R-Value**	**Effective R-Value**	
				16" O.C.	**24" O.C.**
Air Cavity	any	any	R-0.91 (air)	0.79	0.91
Wall	4	3-1/2	R-11	5.5	6.6
	4	3-1/2	R-13	6.0	7.2
	4	3-1/2	R-15	6.4	7.8
	6	5-1/2	R-19	7.1	8.6
	6	5-1/2	R-21	7.4	9.0
	8	7-1/4	R-25	7.8	9.6
Roof		Insulation is uncompressed	R-11	5.5	6.1
			R-19	7.0	9.1
			R-30	9.3	11.4

A103.3.6.3 Metal building wall. Table A103.3.6.3: A wall whose structure consists of metal spanning panels supported by steel structural members (does not include spandrel glass or metal panels in curtain wall systems). The first nominal R-value is for insulation compressed between metal wall panels and the steel structure. For double-layer installations, the second rated R-value of insulation is for insulation installed from the inside, covering the girts. For continuous insulation (e.g., insulation boards) it is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

Table A103.3.6.3
Default Metal Building Wall U-factors

Insulation System	Rated R-Value of Insulation	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing)					
			R-6.5	R-13	R-19.5	R-26	R-32.5	R-39
Single Layer of Mineral Fiber								
	None	1.180	0.136	0.072	0.049	0.037	0.030	0.025
	R-10	0.186	0.084	0.054	0.040	0.032	0.026	0.023
	R-11	0.185	0.084	0.054	0.040	0.032	0.026	0.023
	R-13	0.162	0.079	0.052	0.039	0.031	0.026	0.022
	R-16	0.155	0.077	0.051	0.039	0.031	0.026	0.022
	R-19	0.147	0.075	0.050	0.038	0.030	0.025	0.022

A103.3.7 Concrete and masonry walls.

A103.3.7.1 Concrete masonry walls. The nominal R-values in Table A103.3.7.1(1) or Table A103.3.7.1(3) may be used for purposes of calculating concrete masonry wall section U-factors in lieu of the ASHRAE isothermal planes calculation method as provided in Chapter 27 of the ASHRAE Fundamentals Handbook. The nominal U-values in Table A103.3.7.1(2) are permitted to be used for purposes of calculating concrete wall U-factors.

Table A105.3.7.1(1)
Default U-Factors for Concrete Masonry (CMU) Walls

	8-inch Medium-Weight (115 lb/CF) CMU								
	All Cells Grouted	Grout @ 16-inches OC		Grout @ 32 inches OC		Grout @ 48 inches OC		No Grout (unreinforced)	
Additional Insulation		Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled
None	0.58	0.52	0.43	0.48	0.35	0.46	0.27	0.43	0.21
R-5 continuous insulation	0.15	0.14	0.14	0.14	0.12	0.14	0.11	0.14	0.10
R-10 continuous insulation	0.09	0.08	0.08	0.08	0.07	0.08	0.07	0.08	0.07
R-15 continuous insulation	0.06	0.06	0.06	0.06	0.05	0.06	0.05	0.06	0.05
R-13 insulation 2x4 wood studs	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.07

R-21 insulation 2x6 wood studs	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.05
R-13 insulation 3-5/8" metal studs	0.16	0.15	0.14	0.14	0.13	0.14	0.12	0.14	0.11
R-21 insulation 6" metal studs	0.12	0.11	0.11	0.11	0.10	0.11	0.09	0.11	0.09

	12-inch Medium-Weight (115 lb/CF) CMU								
	All Cells Grouted	Grout @ 16 inches OC		Grout @ 32 inches OC		Grout @ 48 inches OC		No Grout (unreinforced)	
Additional Insulation	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled
None	0.47	0.44	0.34	0.42	0.28	0.41	0.21	0.40	0.15
R-5 continuous insulation	0.14	0.14	0.12	0.14	0.11	0.13	0.10	0.13	0.09
R-10 continuous insulation	0.08	0.08	0.08	0.08	0.07	0.08	0.07	0.08	0.06
R-15 continuous insulation	0.06	0.06	0.06	0.06	0.05	0.06	0.05	0.06	0.05
R-13 insulation 2x4 wood studs	0.08	0.08	0.08	0.08	0.07	0.08	0.07	0.08	0.06
R-21 insulation 2x6 wood studs	0.06	0.06	0.05	0.06	0.05	0.06	0.05	0.06	0.05
R-13 insulation 3-5/8" metal studs	0.15	0.14	0.13	0.14	0.12	0.14	0.11	0.14	0.11
R-21 insulation 6" metal studs	0.11	0.11	0.10	0.11	0.09	0.11	0.08	0.11	0.09

Notes:

1. Interpolation is allowed between 8-inch and 12-inch CMU values (for 10-inch CMU).
2. Interpolation is allowed between 16 and 32-inch grout spacing (for 24-inch spacing)
3. Interpolation is allowed between 32 and 48-inch grout spacing (for 40-inch spacing)
4. "Cores filled" means that all cores not grouted are filled with perlite or vermiculite insulation.
5. Values are based on stud spacing of 16 inches on center
6. Values are based on horizontal grout spacing of 48 inches OC
7. Stud wall values include one layer of gypsum board on the interior.

Table A103.3.7.1(~~1~~ 2) Default U-factors for Concrete ((~~and Masonry~~)) Walls

((~~8" Concrete Masonry~~

Wall Description	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			
	Empty	Loose-fill insulated		Solid Grout
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.40	0.23	0.24	0.43
R-5 Interior Insulation, Wood Furring	0.14	0.11	0.12	0.15
R-6 Interior Insulation, Wood Furring	0.14	0.11	0.11	0.14
R-10.5 Interior Insulation, Wood Furring	0.11	0.09	0.09	0.11
R-8 Interior Insulation, Metal Clips	0.11	0.09	0.09	0.11
R-6 Exterior Insulation	0.12	0.10	0.10	0.12
R-10 Exterior Insulation	0.08	0.07	0.07	0.08
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.09	0.09	0.12

12" Concrete Masonry

Wall Description	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			
	Empty	Loose-fill insulated		Solid Grout
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.35	0.17	0.18	0.33
R-5 Interior Insulation, Wood Furring	0.14	0.10	0.10	0.13
R-6 Interior Insulation, Wood Furring	0.13	0.09	0.10	0.13
R-10.5 Interior Insulation, Wood Furring	0.11	0.08	0.08	0.10
R-8 Interior Insulation, Metal Clips	0.10	0.08	0.08	0.09
R-6 Exterior Insulation	0.11	0.09	0.09	0.11
R-10 Exterior Insulation	0.08	0.06	0.06	0.08

R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.08	0.09	0.12

8" Clay Brick

Wall Description	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			
	Empty	Loose-fill insulated		Solid Grout
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.50	0.31	0.32	0.56
R-5 Interior Insulation, Wood Furring	0.15	0.13	0.13	0.16
R-6 Interior Insulation, Wood Furring	0.15	0.12	0.12	0.15
R-10.5 Interior Insulation, Wood Furring	0.12	0.10	0.10	0.12
R-8 Interior Insulation, Metal Clips	0.11	0.10	0.10	0.11
R-6 Exterior Insulation	0.12	0.11	0.11	0.13
R-10 Exterior Insulation	0.08	0.08	0.08	0.09))

6" Concrete Poured or Precast

Wall Description	*CORE TREATMENT*			
	Partial Grout with Ungrouted Cores			
	Empty	**Loose-fill insulated**		**Solid Grout**
		Perlite	**Vermiculite**	
Exposed Concrete, Both Sides	NA	NA	NA	0.61
R-5 Interior Insulation, Wood Furring	NA	NA	NA	0.16
R-6 Interior Insulation, Wood Furring	NA	NA	NA	0.15
R-10.5 Interior Insulation, Wood Furring	NA	NA	NA	0.12
R-8 Interior Insulation, Metal Clips	NA	NA	NA	0.12
R-6 Exterior Insulation	NA	NA	NA	0.13
R-10 Exterior Insulation	NA	NA	NA	0.09

((~~1. Grouted cores at 40" x 48" on center vertically and horizontally in partial grouted walls.~~

~~2. Interior insulation values include 1/2" gypsum board on the inner surface.~~

~~3. Furring and stud spacing is 16" on center. Insulation is assumed to fill furring space and is not compressed.~~

~~4. Intermediate values may be interpolated using this table. Values not contained in this table may be computed using the procedures listed in the ASHRAE Fundamentals Handbook.~~

~~5. Concrete Masonry Unit (CMU) assembly U-values are based on local test data for Washington state CMU block material using the ASTM C-236-87 steady state thermal conductance test. Tests included an 8"x8"x16" CMU with all cells filled with vermiculite (1995) and 8"x8"x16" CMU with all cells filled with polymaster foam in place insulation (1996). Refer to ASHRAE Standard 90.1 for additional nationally recognized data on the thermal performance of CMU block walls.~~))

Table A103.3.7.1(~~2~~ 3) Default U-Factors for Concrete and Masonry Walls[a, b, c, d]

Framing Type and Depth	Rated R-value of Insulation Alone	Assembly U-factors for Solid Concrete Walls	Assembly U-factors for Concrete Block Walls: Solid Grouted	Assembly U-factors for Concrete Block Walls: Partially Grouted (Cores Uninsulated Except Where Specified)
Base Wall only				
No Framing	R-0	U-0.740	U-0.580	U-0.480
	Ungrouted Cores Filled with Loose-Fill Insulation	N.A.	N.A.	U-0.350
Continuous Wood Framing				
0.75 in.	R-3.0	U-0.247	U-0.226	U-0.210
1.5 in.	R-6.0	U-0.160	U-0.151	U-0.143
2.0 in.	R-10.0	U-0.116	U-0.111	U-0.107
3.5 in.	R-11.0	U-0.094	U-0.091	U-0.088
3.5 in.	R-13.0	U-0.085	U-0.083	U-0.080
3.5 in.	R-15.0	U-0.079	U-0.077	U-0.075
5.5 in.	R-19.0	U-0.060	U-0.059	U-0.058

5.5 in.	R-21.0	U-0.057	U-0.055	U-0.054
Continuous Metal Framing at 24 in. on center horizontally				
1.0 in.	R-0.0	U-0.414	U-0.359	U-0.318
1.0 in.	R-3.8	U-0.325	U-0.290	U-0.263
1.0 in.	R-5.0	U-0.314	U-0.281	U-0.255
1.0 in.	R-6.5	U-0.305	U-0.274	U-0.249
1.5 in.	R-11.0	U-0.267	U-0.243	U-0.223
2.0 in.	R-7.6	U-0.230	U-0.212	U-0.197
2.0 in.	R-10.0	U-0.219	U-0.202	U-0.188
2.0 in.	R-13.0	U-0.210	U-0.195	U-0.182
3.0 in.	R-11.4	U-0.178	U-0.167	U-0.157
3.0 in.	R-15.0	U-0.168	U-0.158	U-0.149
3.0 in.	R-19.0	U-0.161	U-0.152	U-0.144
3.5 in.	R-11.0	U-0.168	U-0.158	U-0.149
3.5 in.	R-13.0	U-0.161	U-0.152	U-0.144
3.5 in.	R-15.0	U-0.155	U-0.147	U-0.140
4.5 in.	R-17.1	U-0.133	U-0.126	U-0.121
4.5 in.	R-22.5	U-0.124	U-0.119	U-0.114
4.5 in.	R-25.2	U-0.122	U-0.116	U-0.112
5.0 in.	R-19.0	U-0.122	U-0.117	U-0.112
5.0 in.	R-25.0	U-0.115	U-0.110	U-0.106
5.0 in.	R-28.0	U-0.112	U-0.107	U-0.103
5.0 in.	R-32.0	U-0.109	U-0.105	U-0.101
5.5 in.	R-19.0	U-0.118	U-0.113	U-0.109
5.5 in.	R-20.9	U-0.114	U-0.109	U-0.105
5.5 in.	R-21.0	U-0.113	U-0.109	U-0.105
5.5 in.	R-27.5	U-0.106	U-0.102	U-0.099
5.5 in.	R-30.8	U-0.104	U-0.100	U-0.096
6.0 in.	R-22.8	U-0.106	U-0.102	U-0.098
6.0 in.	R-30.0	U-0.099	U-0.095	U-0.092
6.0 in.	R-33.6	U-0.096	U-0.093	U-0.090

6.5 in.	R-24.7	U-0.099	U-0.096	U-0.092
7.0 in.	R-26.6	U-0.093	U-0.090	U-0.087
7.5 in.	R-28.5	U-0.088	U-0.085	U-0.083
8.0 in.	R-30.4	U-0.083	U-0.081	U-0.079
1 in. Metal Clips at 24 in. on center horizontally and 16 in. vertically (also, where allowed by Section C402.1.2, for assemblies with a ratio of metal penetration area/mass wall area of < 0.0004 or < 0.04% of the mass wall area) See ASHRAE Fundamentals for determination of U-factors for assemblies that include metal other than screws and nails.				
1.0 in.	R-3.8	U-0.210	U-0.195	U-0.182
1.0 in.	R-5.0	U-0.184	U-0.172	U-0.162
1.0 in.	R-5.6	U-0.174	U-0.163	U-0.154
1.5 in.	R-5.7	U-0.160	U-0.151	U-0.143
1.5 in.	R-7.5	U-0.138	U-0.131	U-0.125
1.5 in.	R-8.4	U-0.129	U-0.123	U-0.118
2.0 in.	R-7.6	U-0.129	U-0.123	U-0.118
2.0 in.	R-10.0	U-0.110	U-0.106	U-0.102
2.0 in.	R-11.2	U-0.103	U-0.099	U-0.096
2.5 in.	R-9.5	U-0.109	U-0.104	U-0.101
2.5 in.	R-12.5	U-0.092	U-0.089	U-0.086
2.5 in.	R-14.0	U-0.086	U-0.083	U-0.080
3.0 in.	R-11.4	U-0.094	U-0.090	U-0.088
3.0 in.	R-15.0	U-0.078	U-0.076	U-0.074
3.0 in.	R-16.8	U-0.073	U-0.071	U-0.069
3.5 in.	R-13.3	U-0.082	U-0.080	U-0.077
3.5 in.	R-17.5	U-0.069	U-0.067	U-0.065
3.5 in.	R-19.6	U-0.064	U-0.062	U-0.061
4.0 in.	R-15.2	U-0.073	U-0.071	U-0.070
4.0 in.	R-20.0	U-0.061	U-0.060	U-0.058
4.0 in.	R-22.4	U-0.057	U-0.056	U-0.054
5.0 in.	R-28.0	U-0.046	U-0.046	U-0.045
6.0 in.	R-33.6	U-0.039	U-0.039	U-0.038
7.0 in.	R-39.2	U-0.034	U-0.034	U-0.033
8.0 in.	R-44.8	U-0.030	U-0.030	U-0.029

9.0 in.	R-50.4	U-0.027	U-0.027	U-0.026
10 in.	R-56.0	U-0.024	U-0.024	U-0.024
11 in.	R-61.6	U-0.022	U-0.022	U-0.022
Continuous Insulation Uninterrupted by Framing				
No Framing	R-1.0	U-0.425	U-0.367	U-0.324
	R-2.0	U-0.298	U-0.269	U-0.245
	R-3.0	U-0.230	U-0.212	U-0.197
	R-4.0	U-0.187	U-0.175	U-0.164
	R-5.0	U-0.157	U-0.149	U-0.141
No Framing	R-6.0	U-0.136	U-0.129	U-0.124
	R-7.0	U-0.120	U-0.115	U-0.110
	R-8.0	U-0.107	U-0.103	U-0.099
	R-9.0	U-0.097	U-0.093	U-0.090
	R-10.0	U-0.088	U-0.085	U-0.083
No Framing	R-11.0	U-0.081	U-0.079	U-0.076
	R-12.0	U-0.075	U-0.073	U-0.071
	R-13.0	U-0.070	U-0.068	U-0.066
	R-14.0	U-0.065	U-0.064	U-0.062
	R-15.0	U-0.061	U-0.060	U-0.059
No Framing	R-16.0	U-0.058	U-0.056	U-0.055
	R-17.0	U-0.054	U-0.053	U-0.052
	R-18.0	U-0.052	U-0.051	U-0.050
	R-19.0	U-0.049	U-0.048	U-0.047
	R-20.0	U-0.047	U-0.046	U-0.045
No Framing	R-21.0	U-0.045	U-0.044	U-0.043
	R-22.0	U-0.043	U-0.042	U-0.042
	R-23.0	U-0.041	U-0.040	U-0.040
	R-24.0	U-0.039	U-0.039	U-0.038
	R-25.0	U-0.038	U-0.037	U-0.037
No Framing	R-30.0	U-0.032	U-0.032	U-0.031
	R-35.0	U-0.028	U-0.027	U-0.027
	R-40.0	U-0.024	U-0.024	U-0.024

	R-45.0	U-0.022	U-0.021	U-0.021
	R-50.0	U-0.019	U-0.019	U-0.019
	R-55.0	U-0.018	U-0.018	U-0.018
	R-60.0	U-0.016	U-0.016	U-0.016
Brick cavity wall with continuous insulation				
No Framing	R-0.0	U-0.337	U-0.299	U-0.270
No Framing	R-3.8	U-0.148	U-0.140	U-0.133
No Framing	R-5.0	U-0.125	U-0.120	U-0.115
No Framing	R-6.5	U-0.106	U-0.102	U-0.098
No Framing	R-7.6	U-0.095	U-0.091	U-0.088
No Framing	R-10.0	U-0.077	U-0.075	U-0.073
No Framing	R-10.5	U-0.079	U-0.077	U-0.075
No Framing	R-11.4	U-0.070	U-0.068	U-0.066
No Framing	R-15.0	U-0.056	U-0.055	U-0.053
No Framing	R-16.5	U-0.054	U-0.053	U-0.052
No Framing	R-19.0	U-0.046	U-0.045	U-0.044
No Framing	R-22.5	U-0.041	U-0.040	U-0.039
No Framing	R-28.5	U-0.033	U-0.032	U-0.032
Continuous Insulation Uninterrupted by Framing with Stucco and Continuous Metal Framing at 24 in. on center horizontally				
1.0 in.	R-0.0 + R-19 c.i.	U-0.047	U-0.046	U-0.045
1.0 in.	R-3.8 + R-19 c.i.	U-0.045	U-0.044	U-0.044
1.0 in.	R-5.0 + R-19 c.i.	U-0.045	U-0.044	U-0.043
1.0 in.	R-6.5 + R-19 c.i.	U-0.045	U-0.044	U-0.043
1.5 in.	R-11.0 + R-19 c.i.	U-0.044	U-0.043	U-0.043
2.0 in.	R-7.6 + R-19 c.i.	U-0.043	U-0.042	U-0.041
2.0 in.	R-10.0 + R-19 c.i.	U-0.042	U-0.041	U-0.041
2.0 in.	R-13.0 + R-19 c.i.	U-0.042	U-0.041	U-0.041
3.0 in.	R-11.4 + R-19 c.i.	U-0.041	U-0.040	U-0.039
3.0 in.	R-15.0 + R-19 c.i.	U-0.040	U-0.039	U-0.039

3.0 in.	R-19.0 + R-19 c.i.	U-0.040	U-0.039	U-0.038
3.5 in.	R-11.0 + R-19 c.i.	U-0.040	U-0.039	U-0.039
3.5 in.	R-13.0 + R-19 c.i.	U-0.040	U-0.039	U-0.038
5.0 in.	R-19.0 + R-19 c.i.	U-0.037	U-0.036	U-0.036
5.0 in.	R-25.0 + R-19 c.i.	U-0.036	U-0.035	U-0.035
5.0 in.	R-32.5 + R-19 c.i.	U-0.035	U-0.035	U-0.034
5.5 in.	R-19.0 + R-19 c.i.	U-0.036	U-0.036	U-0.035
5.5 in.	R-21.0 + R-19 c.i.	U-0.035	U-0.035	U-0.035

Note for Default Table A103.3.7.1(2):

a. It is acceptable to use the U-factors in Table A103.3.7.1(2) for all concrete and masonry walls, provided that the grouting is equal to or less than that specified.

-For ungrouted walls, use the partially grouted column.

-For metal studs and z-furring, use the continuous-metal-framing category.

-For discontinuous metal clips 1 inch square or smaller, use the metal-clip category.

-For insulation that is attached without any framing members (e.g. glued), use the continuous-insulation uninterrupted-by-framing category. Continuous insulation may be installed on the interior or exterior of masonry walls, or between stand-alone walls in multilayer masonry walls, or on the interior or exterior of the concrete.

b. For Table A103.3.7.1(2), the U-factor includes R-0.17 for exterior air film and R-0.68 for interior air film-vertical surfaces. For insulated walls, the U-factor also includes R-0.45 for 0.5 in. gypsum board. U-factors are provided for the following configurations:

(1) Concrete wall: 8-in. normal weight concrete wall with a density of 145 lb/ft^3.

(2) Solid grouted concrete block wall: 8-in. medium weight ASTM C90 concrete block with a density of 115 lb/ft^3 and solid grouted cores.

(3) Partially grouted concrete block wall: 8-in. medium weight ASTM C90 concrete block with a density of 115 lb/ft^3 having reinforcing steel every 32 in. vertically and every 48 in. horizontally, with cores grouted in those areas only. Other cores are filled with insulating material only if there is no other insulation.

c. For walls with insulation contained in a framing layer, the U-factors in Table A103.3.7.1(2) assume contact (and thermal bridging) between the mass wall and other framing. For wall assemblies with multiple layers where the wood or metal framing layer does not contact the concrete or masonry layer (i.e., walls with an airspace between the stud wall layer and the mass wall layer), it is acceptable to use the appropriate wood or metal frame wall default U-factors in Tables A103.3.1 or A103.3.6.1. Note: It is acceptable to use this approach where the insulation extends beyond the framing and is in contact with the mass wall layer (e.g. a nominal four-inch metal stud containing insulation that is nominally six inches thick and therefore extends two inches beyond the back of the metal stud).

d. Except for wall assemblies qualifying for note 3, if not taken from Table A103.3.7.1(2), mass wall U-factors shall be determined in accordance with ASHRAE 90.1, Appendix A, Section A3.1 and Tables A3.1A to A3.1D, or Section A9.4.

A103.3.7.2 Peripheral edges of intermediate concrete floors. See Table A103.3.7.2.

Table A103.3.7.2
Default U-factors for Peripheral Edges of Intermediate Concrete Floors[a, b, c, d]

Slab Edge Treatment	Average Thickness of Wall above and below			
	6 inches	8 inches	10 inches	12 inches
Exposed Concrete	0.816	0.741	0.678	0.625
R-5 Exterior Insulation	0.161	0.157	0.154	0.152
R-6 Exterior Insulation	0.138	0.136	0.134	0.132
R-7 Exterior Insulation	0.122	0.120	0.118	0.116
R-8 Exterior Insulation	0.108	0.107	0.106	0.104
R-9 Exterior Insulation	0.098	0.097	0.095	0.094
R-10 Exterior Insulation	0.089	0.088	0.087	0.086
R-11 Exterior Insulation	0.082	0.081	0.080	0.079
R-12 Exterior Insulation	0.076	0.075	0.074	0.074
R-13 Exterior Insulation	0.070	0.070	0.069	0.068
R-14 Exterior Insulation	0.066	0.065	0.065	0.064
R-15 Exterior Insulation	0.062	0.061	0.061	0.060

Note for Table A103.3.7.2:

a. Exterior insulation values listed above are continuous R-values on the exterior side of the concrete floor.

b. For conditions with an exterior wall above the peripheral edge of intermediate concrete floor but with no wall below the

intermediate concrete floor this table may be used as long as the code minimum insulation is applied to the floor slab below the concrete floor.

c. Typical conditions where conditioned space building envelope wall thermal insulation values are broken concrete floors include, but are not limited to, the following examples:

1. Elevator hoistway shafts that serve the conditioned building and pass through unconditioned floors such as parking garage levels;

2. Stairwell enclosures that serve the conditioned building and pass through unconditioned floors such as parking garage levels;

3. Walls between interior and exterior building envelope that separate the interior conditioned space from an exterior courtyard or roofdeck;

4. Walls between interior and exterior building envelope that separate the interior conditioned space from an exterior unconditioned space on parking garage levels.

Section A104--Below-grade walls and slabs.

A104.1 General. Table A104.1 lists heat loss coefficients for below-grade walls and floors.

Coefficients for below-grade walls are given as U-factors (Btu/h · ft^2 · °F of wall area). Coefficients for below-grade slabs are listed as F-factors (Btu/h · ft · °F per lineal foot of slab perimeter).

Below-grade wall U-factors are only valid when used with the accompanying below-grade slab F-factor, and vice versa.

Table A104.1
Default Wall U-factors and Slab F-factors for Basements

	Below Grade Wall U-factor	Below Grade Slab F-factor
2 Foot Depth Below Grade		
Uninsulated	0.350	0.59
R-11 Interior	0.066	0.68
R-11 Interior w/TB	0.070	0.60
R-19 Interior	0.043	0.69
R-19 Interior w/TB	0.045	0.61
R-10 Exterior	0.070	0.60

R-12 Exterior	0.061	0.60
3.5 Foot Depth Below Grade		
Uninsulated	0.278	0.53
R-11 Interior	0.062	0.63
R-11 Interior w/TB	0.064	0.57
R-19 Interior	0.041	0.64
R-19 Interior w/TB	0.042	0.57
R-10 Exterior	0.064	0.57
R-12 Exterior	0.057	0.57
7 Foot Depth Below Grade		
Uninsulated	0.193	0.46
R-11 Interior	0.054	0.56
R-11 Interior w/TB	0.056	0.42
R-19 Interior	0.037	0.57
R-19 Interior w/TB	0.038	0.43
R-10 Exterior	0.056	0.42
R-12 Exterior	0.050	0.42

TB = Thermal Break

A104.2 Component description. All below-grade walls are assumed to be 8 inch concrete. The wall is assumed to extend from the slab upward to the top of the mud sill for the distance specified in Table A104.1, with 6 inches of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by 2 x 4 framing on 24 inch centers with 1/2 inch gypsum board as the interior finish material. Exterior insulation is assumed to be applied directly to the exterior of the below-grade wall from the top of the wall to the footing. The exterior case does not assume any interior framing or sheetrock.

In all cases, the entire wall surface is assumed to be insulated to the indicated nominal level with the appropriate framing and insulation application. Coefficients are listed for wall depths of 2, 3-1/2 and 7 feet below grade. Basements shallower than two feet should use on-grade slab coefficients.

Heat-loss calculations for wall areas above-grade should use above-grade wall U-factors, beginning at the mudsill.

A104.3 Insulation description. Coefficients are listed for the following four configurations:

1. **Uninsulated:** No insulation or interior finish.

2. **Interior insulation:** Interior 2 x 4 insulated wall without a thermal break between concrete wall and slab.

3. **Interior insulation with thermal break:** Interior 2 x 4 insulated wall with R-5 rigid board providing a thermal break between the concrete wall and the slab.

4. **Exterior insulation:** Insulation applied directly to the exterior surface of the concrete wall.

Section A105--Floors over unconditioned space.

A105.1 General. Tables A105.1(1), A105.1(2) and A105.1(3) list heat loss coefficients for floors over unconditioned spaces in units of Btu/h · ft^2 ·°F.

They are derived from procedures listed in the ASHRAE Fundamentals Handbook, assuming an average outdoor temperature of 45°F, an average indoor temperature of 65°F and a crawlspace area of 1350 ft^2 and 100 feet of perimeter. The crawlspace is assumed to be 2.5 feet high, with 24 inches below grade and 6 inches above grade.

Table A105.1(1)
Default U-factors for Floors over Vented Crawlspace or Unheated Basement

Nominal R-value		U-factor	
Floor	**Perimeter**	**Post & Beam**	**Joists**
0	0	0.112	0.134
	11	0.100	0.116
	19	0.098	0.114
	30	0.093	0.107
11	0	0.052	0.056
	11	0.048	0.052
19	0	0.038	0.041
	11	0.036	0.038
22	0	0.034	0.037
	11	0.033	0.035
25	0	0.032	0.034
	11	0.031	0.033
30	0	0.028	0.029
	11	0.027	0.028
38	0	0.024	0.025
	11	0.024	0.024

Table A105.1(2)
Default U-factors for Floors over Heated Plenum Crawlspaces

Nominal R-value Perimeter	U-factor
11	0.085
19	0.075
30	0.069

Note: Crawlspaces used as heated plenums have approximately 30 percent higher heat loss rate than unvented crawlspaces with the same assumed ACH. Default U-factors in Table A105.1(2) reflect this higher rate of heat loss.

Table A105.1(3)
Default U-factors for Exposed Floors

Nominal R-value	U-factor		
	Concrete	Wood Joist	Metal Joist
R-11	0.077	0.088	0.14
R-15	0.059	0.076	0.12
R-19	0.048	0.062	0.11
R-21	0.043	0.057	0.11
R-25	0.037	0.051	0.10
R-30	0.031	0.040	0.09
R-38	0.025	0.034	0.08

A105.2 Crawlspace description. Four configurations are considered: Naturally ventilated crawlspace, mechanically vented crawlspace, heated plenum crawlspace and exposed floor.

A105.2.1 Naturally ventilated crawlspaces. Assumed to have 3.0 air changes per hour, with at least 1.0 ft^2 of net-free ventilation in the foundation for every 300 ft^2 of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated areas, such as garages, may only use those values which have R-0 perimeter insulation.

A105.2.2 Mechanically ventilated crawlspaces. Assume to have 1.5 air changes per hour, with less than 1.0 ft^2 of net-free ventilation in the foundation for every 300 ft^2 of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated basements may only use those values which have R-0 perimeter insulation.

A105.2.3 Heated plenum crawlspaces. Assumed to have 0.25 air changes per hour, with no foundation vents. Heated supply air from central furnace is blown into a crawlspace and allowed to enter the living space unducted via holes cut into the floor.

A105.2.4 Exposed floors. Assumes no buffer space, and a covering of 1/2 inch T1-11 on the exterior of the cavity exposed to the outside air or rigid insulation below a concrete floor, such as over parking garages.

A105.3 Construction description. Floors are assumed to be either joisted floors framed on 16 inch centers, or post and beam on 4 foot by 8 foot squares. Insulation is assumed to be installed under the subflooring between the joists or beams with no space between the insulation and the subfloor. Insulation is assumed to be uncompressed. Exposed floors also include concrete with continuous rigid insulation assumed.

Perimeter insulation is assumed to extend from the top of the rim joist to the crawlspace floor and then inward along the ground (on top of the ground cover) for at least 24 inches.

Floor coverings are assumed to be light carpet with rubber pad.

Section A106--On-grade slab floors.

A106.1 General. Table A106.1 lists heat loss coefficients for heated on-grade slab floors, in units of Btu/h · °F per lineal foot of perimeter.

Table A106.1
Default F-factors for On-Grade Slabs

Insulation Type	R-0	R-5	R-10	R-15	R-20	R-30
Unheated Slab						
Uninsulated slab	0.73	--	--	--	--	--
2 ft. Horizontal (No thermal break)	--	0.70	0.70	0.69	--	--
4 ft. Horizontal (No thermal break)	--	0.67	0.64	0.63	--	--
2 ft. Vertical	--	0.58	0.54	0.52	--	--
4 ft. Vertical	--	0.54	0.48	0.45	--	--
Fully insulated slab*	--	--	0.36	0.31	0.26	0.21
Heated Slab						
Uninsulated slab	0.84	--	--	--	--	--
Fully insulated slab*	--	0.74	0.55	0.44	0.39	0.32
R-5 Center (With perimeter insulation)	--	--	0.66	0.62	--	--
R-10 Center (With perimeter insulation)	--	--	--	0.51	--	--
3 ft. Vertical	--	--	0.78	--	--	--

*Edge insulation R-10 regardless of the below slab insulation level.

A106.2 Component description. All on-grade slab floors are assumed to be 6 inch concrete poured directly onto the earth. The bottom of the slab is assumed to be at grade line.

Monolithic and floating slabs are not differentiated.

Soil is assumed to have a conductivity of 0.75 Btu/h · ft^2 · °F. Slabs 2 feet or more below grade should use basement coefficients.

A106.3 Insulation description. Coefficients are provided for the following three configurations:

1. **Two foot (or four foot) vertical:** Insulation is applied directly to the slab exterior, extending downward from the top of the slab to a depth of 2 feet (or 4 feet) below grade.

2. **Two foot (or four foot) horizontal:** Insulation is applied directly to the underside of the slab, and run horizontally from the perimeter inward for 2 feet (or 4 feet). The slab edge is exposed in this configuration.

Note: A horizontal installation with a thermal break of at least R-5 at the slab edge should use the vertical-case F-factors.

3. **Fully insulated slab:** Insulation extends from the top of the slab, along the entire perimeter, and completely covers the area under the slab. Thicker perimeter insulation covers the slab edge and extends 2 feet under the slab.

Section A107--Default U-factors for doors.

A107.1 Doors without NFRC certification. Doors that do not have NFRC certification shall be assigned the appropriate U-factor from Tables A107.1(1) through A107.1(4).

Table A107.1(1)
Default U-factors for Doors

Door Type	**No Glazed *Fenestration***	**Single Glazing**	**Double Glazing with 1/4 in. Airspace**	**Double Glazing with 1/2 in. Airspace**	**Double Glazing with e = 0.10, 1/2 in. Argon**
Swinging Doors (Rough opening - 38 in. x 82 in.)					
Slab Doors					
Wood slab in wood frame[a]	0.46				
6% glazed *fenestration* (22 in. x 8 in. lite)	-	0.48	0.47	0.46	0.44
25% glazed *fenestration* (22 in. x 36 in. lite)	-	0.58	0.48	0.46	0.42
45% glazed *fenestration* (22 in. x 64 in. lite)	-	0.69	0.49	0.46	0.39
More than 50% glazed *fenestration*	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Insulated steel slab with wood edge in wood frame[a]	0.16				
6% glazed *fenestration* (22 in. x 8 in. lite)	-	0.21	0.20	0.19	0.18

25% glazed *fenestration* (22 in. x 36 in. lite)	-	0.39	0.28	0.26	0.23
45% glazed *fenestration* (22 in. x 64 in. lite)	-	0.58	0.38	0.35	0.26
More than 50% glazed fenestration	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Foam insulated steel slab with metal edge in steel frame[b]	0.37				
6% glazed *fenestration* (22 in. x 8 in. lite)	-	0.44	0.42	0.41	0.39
25% glazed *fenestration* (22 in. x 36 in. lite)	-	0.55	0.50	0.48	0.44
45% glazed *fenestration* (22 in. x 64 in. lite)	-	0.71	0.59	0.56	0.48
More than 50% glazed *fenestration*	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Cardboard honeycomb slab with metal edge in steel frame[b]	0.61				
Style and Rail Doors					
Sliding glass doors/French doors	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Site-Assembled Style and Rail Doors					
Aluminum in aluminum frame	-	1.32	0.99	0.93	0.79
Aluminum in aluminum frame with thermal break	-	1.13	0.80	0.74	0.63

[a]Thermally broken sill (add 0.03 for nonthermally broken sill)

[b]Nonthermally broken sill

[c]Nominal U-factors are through the center of the insulated panel before consideration of thermal bridges around the edges of the door sections and due to the frame.

Table A107.1(2)
Default U-factors for Revolving Doors

Revolving Doors	
Size (W x H)	**U-Factor**

3-wing	
8 ft. x 7 ft.	0.79
10 ft. x 8 ft.	0.80
4-wing	
7 ft. x 6.5 ft.	0.63
7 ft. x 7.5 ft.	0.64
Open	
82 in. x 84 in.	1.32

Table A107.1(3)
Default U-factors for Steel Emergency Doors

Double-skin Steel Emergency Exit Doors		
Core Insulation	**3 ft. x 6 ft. 8 in.**	**6 ft. x 6 ft. 8 in.**
1-3/8 in. thickness		
Honeycomb kraft paper	0.57	0.52
	0.44	0.36
Mineral wool, steel ribs	0.34	0.28
Polyurethane foam		
1-3/4 in. thickness		
Honeycomb kraft paper	0.57	0.54
	0.41	0.33
Mineral wool, steel ribs	0.31	0.26
Polyurethane foam		
1-3/8 in. thickness		
Honeycomb kraft paper	0.60	0.55
	0.47	0.39
Mineral wool, steel ribs	0.37	0.31
Polyurethane foam		
1-3/4 in. thickness		
Honeycomb kraft paper	0.60	0.57
	0.44	0.37
Mineral wool, steel ribs	0.34	0.30
Polyurethane foam		

Table A107.1(4)

Default U-factors for Steel Garage and Hangar Doors

Double-skin Steel Garage and Aircraft Hangar Doors					
	One-piece tilt-up[a]		Sectional tilt-up[b]	Aircraft hangar	
Insulation[e]	8 ft. x 7 ft.	16 ft. x 7 ft.	9 ft. x 7 ft.	72 ft. x 12 ft.[c]	240 ft. x 50 ft.[d]
1-3/8 in. thickness					
EPS, steel ribs	0.36	0.33	0.34 - 0.39		
XPS, steel ribs	0.33	0.31	0.31 - 0.36		
2 in. thickness					
EPS, steel ribs	0.31	0.28	0.29 - 0.33		
XPS, steel ribs	0.29	0.26	0.27 - 0.31		
3 in. thickness					
EPS, steel ribs	0.26	0.23	0.25 - 0.28		
XPS, steel ribs	0.24	0.21	0.24 - 0.27		
4 in. thickness					
EPS, steel ribs	0.23	0.20	0.23 - 0.25		
XPS, steel ribs	0.21	0.19	0.21 - 0.24		
6 in. thickness					
EPS, steel ribs	0.20	0.16	0.20 - 0.21		
XPS, steel ribs	0.19	0.15	0.19 - 0.21		
4 in. thickness					
Noninsulated				1.10	1.23
Expanded polystyrene				0.25	0.16
Mineral wool, steel ribs				0.25	0.16
Extruded polystyrene				0.23	0.15
6 in. thickness					
Noninsulated				1.10	1.23
Expanded polystyrene				0.21	0.13
Mineral wool, steel ribs				0.23	0.13
Extruded polystyrene				0.20	0.12
Uninsulated					
All products	1.15				

[a]Values are for thermally broken or thermally unbroken doors.

[b]Lower values are for thermally broken doors; upper values are for doors with no thermal break.

[c]Typical size for a small private airplane (single-engine or twin).

[d]Typical hangar door for a midsize commercial jet airliner.

[e]EPS is extruded polystyrene, XPS is expanded polystyrene.

Section A108--Air infiltration.

A108.1 General. Tables A108.1(1) and A108.1(2) list effective air change rates and heat capacities for heat loss due to infiltration for Single-Family Residential.

The estimated seasonal average infiltration rate in air changes per hour (ACH) is given for standard air-leakage control (see Section R402.4 for air leakage requirements for Single-Family Residential). The effective air change rate shall be used in calculations for compliance under either the Component Performance or Systems Analysis approaches.

Heat loss due to infiltration shall be computed using the following equation:

$$Q_{infil} = ACH_{eff} * HCP$$

Where:

Q_{infil} = Heat loss due to air infiltration.

ACH_{eff} = The effective air infiltration rate in Table A108.1(1)

HCP = The Heat Capacity Density Product for the appropriate elevation or climate zone as given below.

Table A108.1(1)
Assumed Effective Air Changes per Hour

Air-Leakage Control Package	Air Changes per Hour	
	Natural	Effective
Standard	0.35	0.35

Table A108.1(2)

Default Heat Capacity/Density Product for Air

Zone	Average Elevation	Heat Capacity/Density
1	Mean Sea Level	0.0180 Btu/h · °F
2	2000	0.0168 Btu/h · °F
3	3000	0.0162 Btu/h · °F

Appendix B--Default internal load values and schedules.
Section B101--General.

B101.1 Scope. The following default internal load values and schedules shall apply to Section C407.

B102 Default tables of internal loads. Default occupancy densities, receptacle power densities and service hot water consumption are included in Table B102.

TABLE B102

Acceptable Occupancy Densities, Receptacle Power Densities and Service Hot Water Consumption[a]

Building Type	Occupancy Density[b] ft^2/Person (Btu/h · ft^2)	Receptacle Power Density[c], Watts/ft^2 (Btu/h · ft^2)	Service Hot Water Quantities[d] Btu/h per person
Assembly	50 (4.60)	0.25 (0.85)	215
Health/Institutional	200 (1.15)	1.00 (3.41)	135
Hotel/Motel	250 (0.92)	0.25 (0.85)	1,110
Light Manufacturing	750 (0.31)	0.20 (0.68)	225
Office	275 (0.84)	0.75 (2.56)	175
Parking Garage	NA	NA	NA
Restaurant	100 (2.30)	0.10 (0.34)	390
Retail	300 (3.07)	0.25 (0.85)	135
School	75 (3.07)	0.50 (1.71)	215
Warehouse	15,000 (0.02)	0.10 (0.34)	225

[a]The occupancy densities, receptacle power densities, and service hot water consumption values are from ASHRAE Standard 90.1-1989 and addenda.

[b]Values are in square feet of conditioned floor area per person. Heat generation in Btu per person per hour is 230 sensible and 190 latent. Figures in parenthesis are equivalent Btu per hour per square foot.

[c]Values are in watts per square foot of conditioned floor area. Figures in parenthesis are equivalent Btu per hour per square foot. These values are the minimum acceptable. If other process loads are not input (such as for computers, cooking, refrigeration, etc.), it is recommended that receptacle power densities be increased until total process energy consumption is equivalent to 25 percent of the total.

[d]Values are in Btu per person per hour.

B103 Default schedules. Default schedules for occupancy, lighting, receptacles, HVAC, service hot water, and elevators are included in Tables B103(1) through B103(10).

Table B103(1)
Assembly Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0

2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
6 (5-6am)	0	0	0	5	5	5	On	Off	Off	0	0	0	0	0	0
7 (6-7am)	0	0	0	35/40	5	5	On	On	On	0	0	0	0	0	0
8 (7-8am)	0	0	0	35/40	30	30	On	On	On	0	0	0	0	0	0
9 (8-9am)	20	20	10	35/40	30	30	On	On	On	0	0	0	0	0	0
10 (9-10am)	20	20	10	65/75	40/50	30	On	On	On	5	5	5	0	0	0
11 (10-11am)	20	20	10	65/75	40/50	30	On	On	On	5	5	5	0	0	0
12 (11-12pm)	80	60	10	65/75	40/50	30	On	On	On	35	20	10	0	0	0
13 (12-1pm)	80	60	10	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
14 (1-2pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
15 (2-3pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
16 (3-4pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
17 (4-5pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
18 (5-6pm)	80	60	70	65/75	40/50	55/65	On	On	On	0	0	0	0	0	0
19 (6-7pm)	20	60	70	65/75	40/50	55/65	On	On	On	0	0	0	0	0	0
20 (7-8pm)	20	60	70	65/75	40/50	55/65	On	On	On	0	65	65	0	0	0
21 (8-9pm)	20	60	70	65/75	40/50	55/65	On	On	On	0	30	30	0	0	0
22 (9-10pm)	20	80	70	65/75	40/50	55/65	On	On	On	0	0	0	0	0	0
23 (10-11pm)	10	10	20	25	40/50	5	On	On	On	0	0	0	0	0	0
24 (11-12am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
Total/Day	710	750	700	1010/ 1155	660/ 800	745/845	1800	1700	1700	70	125	115	0	0	0
Total/Week		50.50	hours		64.55/7 4.20	hours		124	hours		5.9	hours		0	hours
Total/Year		2633	hours		3357/ 3869	hours		6465	hours		308	hours		0	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0

percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(2)
Health Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
2 (1-2am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
3 (2-3am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
4 (3-4am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
5 (4-5am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
6 (5-6am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
7 (6-7am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
8 (7-8am)	10	10	0	45/50	20	5	On	On	On	17	1	1	2	2	0
9 (8-9am)	50	30	5	80/90	35/40	10	On	On	On	58	20	1	75	46	2
10 (9-10am)	80	40	5	80/90	35/40	10	On	On	On	66	28	1	100	70	2
11 (10-11am)	80	40	5	80/90	35/40	10	On	On	On	78	30	1	100	70	2
12 (11-12pm)	80	40	5	80/90	35/40	10	On	On	On	82	30	1	100	70	2
13 (12-1pm)	80	40	5	80/90	35/40	10	On	On	On	71	24	1	75	51	2
14 (1-2pm)	80	40	5	80/90	35/40	10	On	On	On	82	24	1	100	51	2
15 (2-3pm)	80	40	5	80/90	35/40	10	On	On	On	78	23	1	100	51	2
16 (3-4pm)	80	40	5	80/90	35/40	10	On	On	On	74	23	1	100	51	2
17 (4-5pm)	80	40	0	30	35/40	5	On	On	On	63	23	1	100	51	0
18 (5-6pm)	50	10	0	30	35/40	5	On	On	On	41	10	1	100	25	0
19 (6-7pm)	30	10	0	30	10	5	On	On	On	18	1	1	52	2	0
20 (7-8pm)	30	0	0	30	10	5	On	On	On	18	1	1	52	0	0
21 (8-9pm)	20	0	0	30	10	5	On	On	On	18	1	1	52	0	0
22 (9-10pm)	20	0	0	30	10	5	On	On	On	10	1	1	28	0	0
23 (10-11pm)	0	0	0	30	10	5	On	On	On	1	1	1	0	0	0

24 (11-12am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
Total/Day	850	380	40	975/ 1060	500/ 550	160	2400	2400	2400	783	249	24	1136	540	16
Total/Week		46.70	hours		55.35/ 60.10	hours		168	hours		41.88	hours		62.36	hours
Total/Year		2435	hours		2878/ 3134	hours		8760	hours		2148	hours		3251	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(3)
Hotel/Motel Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	90	90	70	20	20	30	On	On	On	20	20	25	40	44	55
2 (1-2am)	90	90	70	15	20	30	On	On	On	15	15	20	33	35	55
3 (2-3am)	90	90	70	10	10	20	On	On	On	15	15	20	33	35	43
4 (3-4am)	90	90	70	10	10	20	On	On	On	15	15	20	33	35	43
5 (4-5am)	90	90	70	10	10	20	On	On	On	20	20	20	33	35	43
6 (5-6am)	90	90	70	20	10	20	On	On	On	25	25	30	33	35	43
7 (6-7am)	70	70	70	40	30	30	On	On	On	50	40	50	42	40	52
8 (7-8am)	40	50	70	50	30	40	On	On	On	60	50	50	42	32	52
9 (8-9am)	40	50	50	40	40	40	On	On	On	55	50	50	52	45	65
10 (9-10am)	20	30	50	40	40	30	On	On	On	45	50	55	52	45	65
11 (10-11am)	20	30	50	25	30	30	On	On	On	40	45	50	40	42	53
12 (11-12pm)	20	30	30	25	25	30	On	On	On	45	50	50	51	60	60
13 (12-1pm)	20	30	30	25	25	30	On	On	On	40	50	40	51	65	53

14 (1-2pm)	20	30	20	25	25	20	On	On	On	35	45	40	51	65	51
15 (2-3pm)	20	30	20	25	25	20	On	On	On	30	40	30	51	65	50
16 (3-4pm)	30	30	20	25	25	20	On	On	On	30	40	30	51	65	44
17 (4-5pm)	50	30	30	25	25	20	On	On	On	30	35	30	63	65	64
18 (5-6pm)	50	50	40	25	25	20	On	On	On	40	40	40	80	75	62
19 (6-7pm)	50	60	40	60	60	50	On	On	On	55	55	50	86	80	65
20 (7-8pm)	70	60	60	80	70	70	On	On	On	60	55	50	70	80	63
21 (8-9pm)	70	60	60	90	70	80	On	On	On	50	50	40	70	75	63
22 (9-10pm)	80	70	80	80	70	60	On	On	On	55	55	50	70	75	63
23 (10-11pm)	90	70	80	60	60	50	On	On	On	45	40	40	45	55	40
24 (11-12am)	90	70	80	30	30	30	On	On	On	25	30	20	45	55	40
Total/Day	1390	1390	1300	855	785	810	2400	2400	2400	915	930	900	1217	1303	1287
Total/Week		96.40	hours		58.70	hours		168.0	hours		64.05	hours		86.75	hours
Total/Year		5026	hours		3061	hours		8760	hours		3340	hours		4523	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

Table B103(4)
Light Manufacturing Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0

6 (5-6am)	0	0	0	10	5	5	Off	Off	Off	8	8	7	0	0	0
7 (6-7am)	10	10	5	10	10	5	On	On	Off	7	7	4	0	0	0
8 (7-8am)	20	10	5	30	10	5	On	On	Off	19	11	4	35	16	0
9 (8-9am)	95	30	5	85/90	30	5	On	On	Off	35	15	4	69	14	0
10 (9-10am)	95	30	5	85/90	30	5	On	On	Off	38	21	4	43	21	0
11 (10-11am)	95	30	5	85/90	30	5	On	On	Off	39	19	4	37	18	0
12 (11-12pm)	95	30	5	85/90	30	5	On	On	Off	47	23	6	43	25	0
13 (12-1pm)	50	10	5	75/80	15	5	On	On	Off	57	20	6	58	21	0
14 (1-2pm)	95	10	5	85/90	15	5	On	On	Off	54	19	9	48	13	0
15 (2-3pm)	95	10	5	85/90	15	5	On	On	Off	34	15	6	37	8	0
16 (3-4pm)	95	10	5	85/90	15	5	On	On	Off	33	12	4	37	4	0
17 (4-5pm)	95	10	5	85/90	15	5	On	On	Off	44	14	4	46	5	0
18 (5-6pm)	30	5	5	50	5	5	On	On	Off	26	7	4	62	6	0
19 (6-7pm)	10	5	0	30	5	5	On	Off	Off	21	7	4	20	0	0
20 (7-8pm)	10	0	0	30	5	5	On	Off	Off	15	7	4	12	0	0
21 (8-9pm)	10	0	0	20	5	5	On	Off	Off	17	7	4	4	0	0
22 (9-10pm)	10	0	0	20	5	5	On	Off	Off	8	9	7	4	0	0
23 (10-11pm)	5	0	0	10	5	5	Off	Off	Off	5	5	4	0	0	0
24 (11-12am)	5	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
Total/Day	920	200	60	995/ 1040	280	120	1600	1200	0	537	256	113	555	151	0
Total/Week		48.60	hours		53.75/5 6.00	hours		92.00	hours		30.54	hours		29.26	hours
Total/Year		2534	hours		2795/ 2920	hours		4797	hours		1592	hours		1526	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(5)
Office Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
6 (5-6am)	0	0	0	10	5	5	Off	Off	Off	8	8	7	0	0	0
7 (6-7am)	10	10	5	10	10	5	On	On	Off	7	7	4	0	0	0
8 (7-8am)	20	10	5	30	10	5	On	On	Off	19	11	4	35	16	0
9 (8-9am)	95	30	5	65/90	30	5	On	On	Off	35	15	4	69	14	0
10 (9-10am)	95	30	5	65/90	30	5	On	On	Off	38	21	4	43	21	0
11 (10-11am)	95	30	5	65/90	30	5	On	On	Off	39	19	4	37	18	0
12 (11-12pm)	95	30	5	65/90	30	5	On	On	Off	47	23	6	43	25	0
13 (12-1pm)	50	10	5	55/80	15	5	On	On	Off	57	20	6	58	21	0
14 (1-2pm)	95	10	5	65/90	15	5	On	On	Off	54	19	9	48	13	0
15 (2-3pm)	95	10	5	65/90	15	5	On	On	Off	34	15	6	37	8	0
16 (3-4pm)	95	10	5	65/90	15	5	On	On	Off	33	12	4	37	4	0
17 (4-5pm)	95	10	5	65/90	15	5	On	On	Off	44	14	4	46	5	0
18 (5-6pm)	30	5	5	35/50	5	5	On	On	Off	26	7	4	62	6	0
19 (6-7pm)	10	5	0	30	5	5	On	On	Off	21	7	4	20	0	0
20 (7-8pm)	10	0	0	30	5	5	On	Off	Off	15	7	4	12	0	0
21 (8-9pm)	10	0	0	20	5	5	On	Off	Off	17	7	4	4	0	0
22 (9-10pm)	10	0	0	20	5	5	On	Off	Off	8	9	7	4	0	0
23 (10-11pm)	5	0	0	10	5	5	Off	Off	Off	5	5	4	0	0	0
24 (11-12am)	5	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
Total/Day	920	200	60	800/ 1040	280	120	1600	1200	0	537	256	113	555	151	0
Total/Week		48.60	hours		44.00/ 56.00	hours		92.00	hours		30.54	hours		29.26	hours
Total/Year		2534	hours		2288/ 2920	hours		4797	hours		1592	hours		1526	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(6)
Parking Garage Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)				50/100	50/100	50/100									
2 (1-2am)				50/100	50/100	50/100									
3 (2-3am)				50/100	50/100	50/100									
4 (3-4am)				50/100	50/100	50/100									
5 (4-5am)				50/100	50/100	50/100									
6 (5-6am)				50/100	50/100	50/100									
7 (6-7am)				100	100	50/100									
8 (7-8am)				100	100	50/100									
9 (8-9am)				100	100	50/100									
10 (9-10am)				100	100	50/100	Based						Included		
11 (10-11am)				100	100	50/100	on						with		
12 (11-12pm)	N/A			100	100	50/100	likely			N/A			other		
13 (12-1pm)				100	100	50/100	use						occupancies		
14 (1-2pm)				100	100	50/100									
15 (2-3pm)				100	100	50/100									
16 (3-4pm)				100	100	50/100									
17 (4-5pm)				100	100	50/100									
18 (5-6pm)				100	50/100	50/100									

19 (6-7pm)		100	50/100	50/100				
20 (7-8pm)		100	50/100	50/100				
21 (8-9pm)		100	50/100	50/100				
22 (9-10pm)		100	50/100	50/100				
23 (10-11pm)		50/100	50/100	50/100				
24 (11-12am)		50/100	50/100	50/100				
Total/Day		2000/ 2400	1750/ 2400	1200/ 2400				
Total/Week			129.50/ 168	hours				
Total/Year			6734/ 8760	hours				

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2. For parking garage lighting, the schedule has been revised to accompany the office schedule: The lighting in the parking garage is set to be on at 100 percent for all hours when the building occupancy is 10 percent or greater, but reduced to 50 percent (per Section C405.2) for all hours when the building occupancy is less than 10 percent. For a parking garage serving a use other than office, it is acceptable to modify the parking garage schedule to parallel that use.

Table B103(7)
Restaurant Occupancy[a]

Hour of Day (time)	Schedule for Occupancy			Schedule for Lighting[b]/ Receptacle			Schedule for HVAC System			Schedule for Service Hot Water			Schedule for Elevator		
	Percent of Maximum Load			*Percent of* Maximum Load						*Percent of* Maximum Load			*Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	15	30	20	15	20	20	On	On	On	20	20	25	0	0	0
2 (1-2am)	15	25	20	15	15	15	On	On	On	15	15	20	0	0	0

3 (2-3am)	5	5	5	15	15	15	On	On	On	15	15	20	0	0	0
4 (3-4am)	0	0	0	15	15	15	Off	Off	Off	0	0	0	0	0	0
5 (4-5am)	0	0	0	15	15	15	Off	Off	Off	0	0	0	0	0	0
6 (5-6am)	0	0	0	20	15	15	Off	Off	Off	0	0	0	0	0	0
7 (6-7am)	0	0	0	35/40	30	30	Off	Off	Off	0	0	0	0	0	0
8 (7-8am)	5	0	0	35/40	30	30	On	Off	Off	60	0	0	0	0	0
9 (8-9am)	5	0	0	55/60	55/60	45/50	On	Off	Off	55	0	0	0	0	0
10 (9-10am)	5	5	0	55/60	55/60	45/50	On	On	Off	45	50	0	0	0	0
11 (10-11am)	20	20	10	85/90	75/80	65/70	On	On	On	40	45	50	0	0	0
12 (11-12pm)	50	45	20	85/90	75/80	65/70	On	On	On	45	50	50	0	0	0
13 (12-1pm)	80	50	25	85/90	75/80	65/70	On	On	On	40	50	40	0	0	0
14 (1-2pm)	70	50	25	85/90	75/80	65/70	On	On	On	35	45	40	0	0	0
15 (2-3pm)	40	35	15	85/90	75/80	65/70	On	On	On	30	40	30	0	0	0
16 (3-4pm)	20	30	20	85/90	75/80	65/70	On	On	On	30	40	30	0	0	0
17 (4-5pm)	25	30	25	85/90	75/80	55/60	On	On	On	30	35	30	0	0	0
18 (5-6pm)	50	30	35	85/90	85/90	55/60	On	On	On	40	40	40	0	0	0
19 (6-7pm)	80	70	55	85/90	85/90	55/60	On	On	On	55	55	50	0	0	0
20 (7-8pm)	80	90	65	85/90	85/90	55/60	On	On	On	60	55	50	0	0	0
21 (8-9pm)	80	70	70	85/90	85/90	55/60	On	On	On	50	50	40	0	0	0
22 (9-10pm)	50	65	35	85/90	85/90	55/60	On	On	On	55	55	50	0	0	0
23 (10-11pm)	35	55	20	45/50	45/50	45/50	On	On	On	45	40	40	0	0	0
24 (11-12am)	20	35	20	30	30	30	On	On	On	25	30	20	0	0	0
Total/Day	750	740	485	1370/ 1455	1290/ 1365	1040/ 1115	2000	1800	1700	790	730	625	0	0	0
Total/Week		49.75	hours		91.80/ 97.55	hours		135	hours		53.05	hours		0	hours
Total/Year		2594	hours		4774/ 5086	hours		7039	hours		2766	hours		0	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0

percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(8)
Retail Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	4	11	7	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	5	10	7	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	5	8	7	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
6 (5-6am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
7 (6-7am)	0	0	0	5	5	5	On	On	Off	4	7	7	0	0	0
8 (7-8am)	10	10	0	20	10	5	On	On	Off	15	20	10	12	9	0
9 (8-9am)	20	20	0	50	30	10	On	On	On	23	24	12	22	21	0
10 (9-10am)	50	50	10	85/90	55/60	10	On	On	On	32	27	14	64	56	11
11 (10-11am)	50	60	20	85/90	85/90	40	On	On	On	41	42	29	74	66	13
12 (11-12pm)	70	80	20	85/90	85/90	40	On	On	On	57	54	31	68	68	35
13 (12-1pm)	70	80	40	85/90	85/90	55/60	On	On	On	62	59	36	68	68	37
14 (1-2pm)	70	80	40	85/90	85/90	55/60	On	On	On	61	60	36	71	69	37
15 (2-3pm)	70	80	40	85/90	85/90	55/60	On	On	On	50	49	34	72	70	39
16 (3-4pm)	80	80	40	85/90	85/90	55/60	On	On	On	45	48	35	72	69	41
17 (4-5pm)	70	80	40	85/90	85/90	55/60	On	On	On	46	47	37	73	66	38
18 (5-6pm)	50	60	20	85/90	85/90	40	On	On	Off	47	46	34	68	58	34
19 (6-7pm)	50	20	10	55/60	50	20	On	On	Off	42	44	25	68	47	3
20 (7-8pm)	30	20	0	55/60	30	5	On	On	Off	34	36	27	58	43	0
21 (8-9pm)	30	20	0	50	30	5	On	On	Off	33	29	21	54	43	0
22 (9-10pm)	0	10	0	20	10	5	Off	On	Off	23	22	16	0	8	0

23 (10-11pm)	0	0	0	5	5	5	Off	Off	Off	13	16	10	0	0	0
24 (11-12am)	0	0	0	5	5	5	Off	Off	Off	8	13	6	0	0	0
Total/Day	750	750	280	1060/1115	940/ 985	500/ 525	1500	1600	900	662	690	459	844	761	288
Total/Week		46.30	hours		67.40/ 70.85	hours		100	hours		44.59	hours		52.69	hours
Total/Year		2414	hours		3505/ 3694	hours		5214	hours		2325	hours		2747	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(9)
School Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
6 (5-6am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
7 (6-7am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0
8 (7-8am)	5	0	0	30	5	5	On	Off	Off	10	3	3	0	0	0
9 (8-9am)	75	10	0	60/85	15	5	On	On	Off	34	3	5	30	0	0
10 (9-10am)	90	10	0	65/95	15	5	On	On	Off	60	5	5	30	0	0
11 (10-11am)	90	10	0	65/95	15	5	On	On	Off	63	5	5	30	0	0
12 (11-12pm)	80	10	0	65/95	15	5	On	On	Off	72	5	5	30	0	0

13	(12-1pm)	80	10	0	55/80	15	5	On	On	Off	79	5	5	30	0	0
14	(1-2pm)	80	0	0	55/80	5	5	On	Off	Off	83	3	5	30	0	0
15	(2-3pm)	80	0	0	55/80	5	5	On	Off	Off	61	3	3	30	0	0
16	(3-4pm)	45	0	0	50/70	5	5	On	Off	Off	65	3	3	15	0	0
17	(4-5pm)	15	0	0	35/50	5	5	On	Off	Off	10	3	3	0	0	0
18	(5-6pm)	5	0	0	35/50	5	5	On	Off	Off	10	3	3	0	0	0
19	(6-7pm)	15	0	0	35	5	5	On	Off	Off	19	3	3	0	0	0
20	(7-8pm)	20	0	0	35	5	5	On	Off	Off	25	3	3	0	0	0
21	(8-9pm)	20	0	0	35	5	5	On	Off	Off	22	3	3	0	0	0
22	(9-10pm)	10	0	0	30	5	5	On	Off	Off	22	3	3	0	0	0
23	(10-11pm)	0	0	0	5	5	5	Off	Off	Off	12	3	3	0	0	0
24	(11-12am)	0	0	0	5	5	5	Off	Off	Off	9	3	3	0	0	0
Total/Day		710	50	0	750/990	170	120	1500	500	0	691	80	84	285	0	0
Total/Week			36.00	hours		40.40/ 52.40	hours		80.00	hours		36.19	hours		14.25	hours
Total/Year			1877	hours		2101/ 2732	hours		4171	hours		1887	hours		743	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(10)
Warehouse Occupancy[a]

Hour of Day (time)	Schedule for Occupancy *Percent of* Maximum Load			Schedule for Lighting[b]/ Receptacle *Percent of* Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water *Percent of* Maximum Load			Schedule for Elevator *Percent of* Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0

4	(3-4am)	0	0	0	5	5	5	Off	Off	Off	2	2	2	0	0	0
5	(4-5am)	0	0	0	5	5	5	Off	Off	Off	5	2	2	0	0	0
6	(5-6am)	0	0	0	5	5	5	Off	Off	Off	7	2	2	0	0	0
7	(6-7am)	0	0	0	5	5	5	Off	Off	Off	7	2	2	0	0	0
8	(7-8am)	15	0	0	25/40	5	5	On	Off	Off	10	2	2	0	0	0
9	(8-9am)	70	20	0	45/70	8	5	On	On	Off	30	6	2	0	0	0
10	(9-10am)	90	20	0	55/90	24	5	On	On	Off	36	12	2	0	0	0
11	(10-11am)	90	20	0	55/90	24	5	On	On	Off	36	12	2	30	0	0
12	(11-12pm)	90	20	0	55/90	24	5	On	On	Off	46	17	2	0	0	0
13	(12-1pm)	50	10	0	50/80	5	5	On	On	Off	57	4	4	0	0	0
14	(1-2pm)	85	10	0	55/90	5	5	On	On	Off	43	4	4	0	0	0
15	(2-3pm)	85	10	0	55/90	5	5	On	On	Off	38	2	2	0	0	0
16	(3-4pm)	85	10	0	55/90	5	5	On	On	Off	40	2	2	40	0	0
17	(4-5pm)	20	0	0	55/90	5	5	On	Off	Off	30	2	2	0	0	0
18	(5-6pm)	0	0	0	30	5	5	Off	Off	Off	18	2	2	0	0	0
19	(6-7pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
20	(7-8pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
21	(8-9pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
22	(9-10pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
23	(10-11pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
24	(11-12am)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
Total/Day		680	120	0	600/915	180	120	1000	800	0	429	91	52	70	0	0
Total/Week			35.20	hours		33.00/ 48.75	hours		58.00	hours		22.88	hours		3.50	hours
Total/Year			1835	hours		1716/ 2542	hours		3024	hours		1193	hours		182	hours

Wk = Weekday

[a]Schedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

[b]Lighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Appendix C--Exterior design conditions. As required by Sections C302.2 and R302.2, the heating or cooling outdoor design temperatures shall be selected from Table C-1.

Table C-1
Outdoor Design Temperatures

Location	Outdoor Design Temp. Heating (°F)	Outdoor Design Temp. Cooling (°F)
Aberdeen 20 NNE	25	83
Anacortes	24	72
Anatone	-4	89
Auburn	25	84
Battleground	19	91
Bellevue	24	83
Bellingham 2 N	19	78
Blaine	17	73
Bremerton	29	83
Burlington	19	77
Chehalis	21	87
Chelan	10	89
Cheney	4	94
Chesaw	-11	81
Clarkston	10	94
Cle Elum	1	91
Colfax 1 NW	2	94
Colville AP	-2	92
Concrete	19	83

Connell 4 NNW	6	100
Cougar 5 E	25	93
Dallesport AP	14	99
Darrington RS	13	85
Davenport	5	92
Edmonds	24	82
Ellensburg AP	2	90
Elma	24	88
Ephrata AP	7	97
Everett Paine AFB	21	79
Forks 1 E	23	81
Glacier RS	13	82
Glenoma (Kosmos)	18	89
Goldendale	7	94
Grays River Hatchery	24	86
Greenwater	1.4	84
Grotto	21	84
Hoquiam AP	26	79
Inchelium 2 NW	0	92
John Day Dam	19	100
Kent	21	85
Kirkland	17	83
La Grande	23	88
Leavenworth	-3	93
Little Goose Dam	22	101
Long Beach 3 NNE	25	77
Longview	24	87
Lower Granite Dam	14	98

Lower Monument Dam	18	103
Marysville	23	79
Metaline Falls	-1	89
Methow 2 W	1	89
Nespelem 2 S	-4	93
Newhalem	19	89
Newport	-5	92
Northport	2	92
Oak Harbor	16	74
Odessa	7	100
Olga 2 SE	24	71
Olympia, AP	17	85
Omak 2 NW	3	90
Oroville	5	93
Othello	9	98
Packwood	16	90
Plain	-3	89
Pleasant View	16	98
Pomeroy	3	95
Port Angeles	28	75
Port Townsend	25	76
Prosser	12	97
Puyallup	19	86
Quilcene 2 SW	23	83
Quinault RS	25	84
Rainier, Longmire	15	85
Paradise RS	8	71
Raymond	28	81
Redmond	17	83
Republic	-9	87

Richland	11	101
Ritzville	6	99
Satus Pass	10	90
Seattle: Sea-Tac AP	24	((~~83~~)) <u>82</u> <u>Dry bulb</u> <u>66</u> <u>Wet bulb</u>
Sedro Woolley 1 E	19	78
Sequim	23	78
Shelton	23	85
Smyrna	8	102
Snohomish	21	81
Snoqualmie Pass	6	80
Spokane AP	4	92
Spokane CO	10	96
Stampede Pass	7	76
Stehekin 3 NW	12	85
Stevens Pass	6	77
Tacoma CO	29	82
Tatoosh Island	31	63
Toledo AP	17	84
Vancouver	22	88
Vashon Island	28	78
Walla Walla AP	6	96
Waterville	1	88
Wellpinit	1	93
Wenatchee CO	10	92
Whidbey Island	11	71
Willapa Harbor	26	81
Wilson Creek	3	96
Winthrop 1 WSW	-12	91
Yakima AP	11	94

ABBREVIATIONS:

AFB Air Force Base
AP Airport
CO City Office
RS Ranger Station
Typical: "4(miles)NE"

Appendix D – Total Building Performance Reporting Format.
(Note – This entire appendix is a Seattle amendment and is not underlined.)

The reporting format has been developed to guide both staff and applicants through the energy analysis process. The report (three copies are to be submitted) begins with a text summary including project description, methodology description, and a discussion of the estimated energy consumption differences. These are accompanied by an appendix which has summary forms, calculations to support the inputs, and copies of the computer inputs and outputs (all with numbered pages).

The text and summary forms are among the most important parts of the submittal. This information is read prior to any review of the computer inputs and outputs to give an overall orientation to the project. The first evaluation of the project is based on a review of the text and summary forms. These indicate what the key energy efficiency strategies are and form the basis for a more detailed review of the drawings and of the computer analysis. Information for statistical summaries or other evaluations is drawn from the text and summary forms. While these may be the last items completed by the applicant prior to submittal, the importance of having the complete and accurate cannot be overemphasized.

REPORTING FORMAT OUTLINE

(See detailed description below)

I. Executive Summary

II. Project Description

III. Methodology Description

IV. Discussion of Estimated Energy Consumption Differences

Appendices (Supporting Material)

A. Energy Analysis Summary Form

1. Energy Consumption by End-use portion
2. Design Parameter Comparison portion

B. General Information

1. Site Plan
2. HVAC Zoning Diagram

C. Building Envelope

1. Fenestration: NFRC Certification Authorization Report (CAR) or Simulation Report for U-factor and SHGC
2. Opaque Elements: Cross-sections and U-factor Calculations
3. Shading Diagrams

D. Lighting System

1. Lighting for Interior
2. Lighting for Parking and Outdoor Areas
3. Lighting for Façade

E. Space Heating and Space Cooling

1. Equipment Efficiency – Manufacturer's Specifications

F. Ventilation

G. Interior Exhaust Fans

H. Parking Ventilation Fans

I. Service Water Heating

J. Other End-uses

1. Office Equipment
2. Elevators and Escalators
3. Refrigeration
4. Cooking
5. Other

K. Computer Printout of Inputs and Outputs

I. Executive Summary

The executive summary is the condensed version of the text. This is usually several paragraphs long, never more than one page, and includes:

1. A brief description of the project with name, address, number of stories, and total square footage, as well as a listing of the various uses and the square footage of each use.
2. An explanation about why the systems analysis compliance option was chosen (i.e. what elements of the Proposed Design do not comply with the prescriptive option).
3. A listing of the key energy efficiency features that are being used to compensate for the elements that do not comply.
4. The total energy consumption on a Btu-per-conditioned-square-foot-per-year basis for both the Standard Reference Design and the Proposed Design, and the percentage ratio of the Proposed Design to the Standard Reference Design (i.e. what the energy efficiency improvement has been).

II. Project Description

The project description is a detailed summary of the project. First is the name and the street address as well as adjacent cross-streets or streets on all four sides of the building if it is a full-block development. Indicate the number of stories and total square footage. A listing of the various uses and square footage of each use should be done on a floor-by-floor or a system-by-system basis. Thus, for mixed-use floors, specify how much is office and how much is retail, or how much is office and how much is lab. Include parking garage number of floors and area in the listing. The description should also include information on the energy efficiency of the Proposed Design systems.

1. For the building envelope: indicate the glazing area, and how the fenestration U-factor and SHGC compare with the Standard Reference Design requirements; and point out any opaque component U-factors or R-values which are better than the Standard Reference Design requirements.
2. For each HVAC system: provide an explanation of the system including area served, key features, economizer percentage, control strategies, etc. Indicate any differences between the Standard Reference Design and the Proposed Design, such as equipment efficiency.
3. For the lighting: indicate whether any tradeoffs are included in this analysis, and, if so, what they are.
4. For other end-uses: indicate any differences between the Standard Reference Design and the Proposed Design. It is intended that the material in this section be descriptive, supporting calculations are to be included in the appendices.

III. Methodology Description

The methodology description is an explanation of any aspects of the modeling which are unusual or not perfectly clear. (The algorithms in approved analysis programs are generally acceptable and do not need to be explained.) For example:

1. Explain what shading by adjacent buildings has been included in the analysis and how it has been modeled (e.g. either using the program capabilities or as a north-facing wall, etc.).
2. If there are below-grade walls and floors, explain how the heat loss has been modeled for these (e.g. either as an exterior wall with a limited ground temperature variation or as a constant negative load to a zone, etc.)
3. If a program cannot model a system exactly, explain why the modeling assumptions used are the best representation of that system. It is intended that the material in this section provide a heads-up for anything unusual. Again, it is intended that the material in this section be descriptive, supporting calculations are to be included in the appendices.

IV. Discussion of Estimated Energy Consumption Differences

The discussion of estimated energy consumption differences is a summary and explanation of the energy savings.

1. First, list the total energy consumption on a Btu-per-conditioned-square-foot-per-year basis for both the Standard Reference Design and the Proposed Design, and the percentage ratio of the Proposed Design to the Standard Reference Design (i.e. what the energy efficiency improvement would be).
2. Then, review the energy savings by end-use, starting with the end-use which has the largest difference as

a percent of the Standard Reference Design total. Attempt to correlate the differences by end-use with the strategies used. While some changes will have a simple, direct correlation with consumption, other end-use differences may have a more complex explanation due to interactive effects. For example:
- Changes in exterior lighting will have a simple, direct correlation with consumption.
- Differences in space heating and space cooling are likely due to a combination of building envelope and HVAC system strategies. (Lacking any better information, the following procedure can provide a rough-cut disaggregation. First, determine the ratio of the design heating load of the Proposed Design to the design heating load of the Standard Reference Design. Multiply the space heating energy consumption of the Standard Reference Design by this ratio and assume that the resulting figure is what the space heating energy consumption would have been for the Proposed Design if only the building envelope had changed. This difference is what could be attributed to the building envelope. Second, determine the ratio of the average equipment efficiency of the Proposed Design to the average equipment efficiency of the Standard Reference Design. Multiply the space heating energy consumption from the first step by this ratio and assume that the resulting figure is what the space heating energy consumption would have been for the Proposed Design if only the building envelope and equipment efficiency had changed. This second difference is what could be attributed to changes in equipment efficiency. Finally, assume that whatever energy consumption differences remain are due to other HVAC system strategies. Follow this same process for space cooling, starting with a comparison of loads, then equipment efficiency, then system type. Differences in economizer cycle, however, add another layer of complexity.)

This section should, at a minimum, provide confirmation that the results of the analysis are reasonable.

Appendices (Supporting Materials)

A. Energy Analysis Summary Form (required)

1. Complete the Energy Consumption by End-use portion of the form for each project. Where a project has multiple buildings which are individually analyzed, complete the form for each building as well as for the overall project. (An automated electronic spreadsheet version of this page is on the DPD Seattle Energy Code website at: www.seattle.gov/dpd/energy.)
2. Complete the Design Parameter Comparison portion of the form for each project. Where a project has multiple HVAC systems, complete the HVAC information for each system. (An electronic version of these pages is on the DPD Seattle Energy Code website at: www.seattle.gov/dpd/energy.)

B. General Information

1. Site Plan (required) – provide site plan (8½ x 11 preferred) showing location and height, in feet or stories, of all adjacent buildings and also any other buildings and topography which would provide significant shading of the proposed building.
2. HVAC zoning diagram used in the modeling process (required) – provide zoning diagram indicating zone lines and with zones labeled to match the modeling, plus takeoff sheets with area inputs for DPD review.)

C. Building Envelope

1. Glazing and opaque doors, including windows, skylights, sliding/swinging/rollup doors, glass block (required):
    a. U-factor, with basis for information (NFRC Certification Authorization Report, simulation report or approved alternate source).
    b. Solar Heat Gain Coefficient (SHGC), with basis for information (NFRC Certification Authorization Report, simulation report or approved alternate source)
2. Opaque roof, wall, floor (required):
    a. provide cross-sections and U-factor calculations for each different assembly where default U-factors from Chapter 3 and Appendix A have not been used;
    b. if multiple elements (e.g.. three wall types) are combined into one value for modeling purposes, provide calculations used to determine weighted-average value.
3. Shading diagrams (required):
    a. provide information on how shading by adjacent buildings and topography has been modeled,
    b. provide wall and roof sections showing overhangs and setbacks for glazing to justify the shading modeled.
4. Building air leakage:
    a. the standard reference design building air leakage test rate shall equal that required by Section

C402.4.1.2.3,
b. provide calculation showing how the building air leakage test rate at the standard rating conditions in Section C402.4.1.2.3has been converted to an air leakage test rate appropriate for the energy modeling,
c. for modeling, indicate:
i. what percentage of air leakage is modeled for the hours when the building fan system is off and
ii. what percentage of air leakage is modeled for the hours when the building fan system is on.

D. Lighting
1. Interior lighting (as applicable):
a. explain any special assumptions about interior lighting,
b. discuss lighting inputs to account for any exempt lighting (e.g. retail, kitchen).
2. Parking/outdoor areas lighting (as applicable):
a. provide calculation of areas for parking garages, then multiply by allowed Watts/square foot; provide calculation of areas for surface parking, and other lighted outdoor areas, then multiply by allowed Watts/square foot to obtain Standard Reference Design;
b. provide supporting information for Proposed only if different from Standard Reference Design;
c. if program does not list parking/outdoor area lighting energy consumption separately, then provide calculation of annual energy consumption for this end-use.
3. Façade lighting (required):
a. provide calculation of building façade, then multiply by allowed Watts/square foot to obtain Standard Reference Design;
b. provide supporting information for Proposed only if different from Standard Reference Design;
c. if program does not list facade lighting energy consumption separately, then provide calculation of annual energy consumption for this end-use.

E. Space Heating and Space Cooling Equipment and Plant
1. provide manufacturer's specifications for equipment efficiency,
2. provide calculations per AHRI standards for COP, EER, IPLV,
3. provide list of equipment and size and calculations to justify if Proposed Design includes multiple pieces of equipment and a weighted average equipment efficiency is used in the energy analysis,
4. provide calculations to justify the equipment size for the Standard Reference Design
a. provide calculations of ratio of Proposed Design equipment size to Proposed Design design heating load and design cooling load,
b. provide calculations of ratio of Standard Reference Design equipment size to Standard Reference Design design heating load and design cooling load.

F. Ventilation - interior (required):
1. provide W/CFM calculations for the ventilation system for the Proposed Design and for the Standard Reference Design to justify inputs for the Standard Reference Design,
2. if program does not list energy consumption for interior ventilation separately in the output, then provide calculation of annual energy consumption for this end-use.

G. Interior Exhaust Fans (as applicable):
1. where multiple toilet exhaust and relief fans are to be installed, provide listing of capacity for each and total for the interior exhaust fans,
2. if program does not list energy consumption for interior exhaust fans separately in the output, then provide calculation of annual energy consumption for this end-use.

H. Parking Garage Fans (as applicable):
1. where multiple parking garage fans are to be installed, provide listing of capacity for each and total for the parking garage fans,
2. if program does not list energy consumption for parking garage fans separately in the output, then provide calculation of annual energy consumption for this end-use.

I. Service Water Heating (required):
1. provide calculations used to size equipment (see Appendix B, Table B102, for default assumptions for service hot water quantities in Btuh per person),
2. if program does not list energy consumption for service water heating separately in the output, then provide calculation of annual energy consumption for this end-use.

J. Other End-uses

1. Office/miscellaneous equipment (as applicable):
    a. if program requires an input of total equipment capacity rather than capacity on a square foot basis, then provide calculations used to size equipment (see Appendix B, Table B102, for default assumptions for service hot water quantities in Watts/square foot),
    b. if program does not list energy consumption for office/miscellaneous equipment separately in the output, then provide calculation of annual energy consumption for this end-use.
2. Elevators and escalators (as applicable):
    a. where multiple elevators and escalators are to be installed, provide listing of capacity for each and total for the system,
    b. if program does not list energy consumption for elevators and escalators separately in the output, then provide calculation of annual energy consumption for this end-use.
3. Refrigeration - food, etc. (as applicable):
    a. where multiple units are to be installed for refrigeration other than for comfort cooling, provide listing of capacity for each and total for the system,
    b. if program does not list energy consumption for refrigeration other than for comfort cooling separately in the output, then provide calculation of annual energy consumption for this end-use.
4. Cooking (as applicable):
    a. where multiple units are to be installed for cooking, provide listing of capacity for each and total for the system,
    b. if program does not list energy consumption for cooking separately in the output, then provide calculation of annual energy consumption for this end-use.
5. Other (as applicable):
    a. provide supporting data for other end-uses (e.g. commercial washers and dryers, etc.),
    b. if program does not list energy consumption for other end-uses separately in the output, then provide calculation of annual energy consumption for these end-uses.

K. Computer Printout of Inputs and Outputs

Provide inputs and outputs with pages numbered so cross-references can be made to the Energy Analysis Summary Form.

ENERGY ANALYSIS SUMMARY FORM

PROJECT INFORMATION

DPD Project Address:							DPD Project Number:			
Project Name:							Date of this submittal:			
	Conditioned Space						Unconditioned Space			
Bldg Use	Office	Retail	Group R			Subtotal	Parking		Subtotal	
Area (SF)										

ENERGY CONSUMPTION BY END-USE

		STANDARD REFERENCE DESIGN			PROPOSED DESIGN			DIFFERENCES		
END-USE	FUEL SOURCE	Total Energy Use Estimate	BTU/ Cond. Sq.Ft.-Year	% of Standard Design Total	Total Energy Use Estimate	BTU/ Cond. Sq.Ft.-Year	% of Standard Design Total	Total Energy Use Estimate	BTU/ Cond. Sq.Ft.-Year	% of Standard Design Total
Lighting - interior				____%			____%			____%
Lighting - parking				____%			____%			____%
Lighting - façade				____%			____%			____%
Space Heating (1)				____%			____%			____%
Space Heating (2)				____%			____%			____%
Space Cooling				____%			____%			____%
Fans – interior ventilation				____%			____%			____%
Fans – interior exhaust				____%			____%			____%
Fans – parking garage				____%			____%			____%
Service water heating				____%			____%			____%
Office equipment				____%			____%			____%
Elevators & escalators				____%			____%			____%
Refrigeration (food, etc.)				____%			____%			____%
Cooking (commercial)				____%			____%			____%
_____				____%			____%			____%

_____				_____%			_____%			_____%
Total				100%			100%			100%
Percent of Standard Reference Design: 100% = _____ % + _____ % = _____ %										

INSTRUCTIONS:
Electronic Version:
A spreadsheet version is available on the Seattle Energy Code website @ www.seattle.gov/dpd/energy
Project Information:
Enter DPD address, project number, and date of this Energy End-use Summary Form.
Enter the space uses in the building and the gross square footage of each.
(Add/revise headings as necessary.) Spreadsheet automatically calculates subtotals and total.
Energy Consumption by End-use:
Enter fuel source for each end-use (e.g. electric, gas, oil, steam, etc.).
Enter total energy consumption in **BTU** for each end-use for both the Standard Reference Design and Proposed Design.

(Spreadsheet calculates the BTU/conditioned-square-foot-year, percentages, and differences

DESIGN PARAMETER COMPARISON

Element	Standard Design Value	(Page)	Proposed Design Value	(Page)
Building Envelope				
Space heat type (electric resistance vs. other):				
Glazing: total vertical + overhead area (sq. feet):				
Glazing area as a percentage of gross wall (%):				
Overhead: total area (square feet):				
Overhead U-factor (weighted-average):				
Overhead SHGC (weighted-average):				
Vertical: total area (square feet):				
Vertical U-factor (weighted-average):				
Vertical SHGC (weighted-average):				
Roof: total area (square feet):				
Opaque roof: net area (square feet):				
Opaque roof U-factor (weighted-average):				
Wall: total above-grade area (square feet):				
Opaque above-grade wall: net area (square feet):				
Above-grade wall U-factor (weighted-average):				
Below-grade wall: net area (square feet):				
Below-grade wall U-factor (weighted-average):				
Opaque door: area (sq. feet):				
Opaque door U-factor (weighted-average):				
Floor over unconditioned space: area (sq. feet):				
Floor U-factor (weighted-average):				

Slab-on-grade floor: perimeter (lineal feet):				
Slab-on-grade F-factor (weighted-average):				
Below-grade slab floor: net area (square feet):				
Below-grade floor U-factor (weighted-average):				
Infiltration rate:				
Design heating load:				
Design cooling load:				
Lighting				
Interior				
Watts/sq.ft.: Office				
Watts/sq.ft.: Retail				
Watts/sq.ft.:				
Watts/sq.ft.:				
Parking/outdoor: total area (square feet)				
Watts/square foot				
Façade: total area (square feet)				
Watts/square foot				
Space Heating and Space Cooling System				
Space Heating: system type:				
Peak equipment efficiency:				
Output capacity:				
Percent of design heating load:				
Other features:				
Space Cooling: system type:				

Peak equipment efficiency:				
Output capacity:				
Percent of design cooling load:				
Other features:				
Ventilation				
Interior ventilation fans				
Economizer type (air or water):				
Economizer percentage:				
Supply fan: total CFM:				
Fan KW:				
Return fan: total CFM:				
Fan KW:				
Exhaust fan: total CFM:				
Fan KW:				
System Watts/CFM:				
Other features:				
Other features				
Service Water Heating				
Capacity:				
Other End-uses				
Fans – toilet and other exhaust: capacity (KW)				
Fans – parking garage: capacity (KW)				
Elevator and escalator: capacity				
Refrigeration: capacity				

Cooking: capacity				
_____: capacity				
_____: capacity				
_____: capacity				