ADDENDA

ANSI/ASHRAE/IES Addenda k, o, x, ab, ac, ad, ae, ag, ah, ak, am to ANSI/ASHRAE/IES Standard 90.1-2016

Energy Standard for Buildings Except Low-Rise Residential Buildings

See Informative Appendix H for ASHRAE, IES, and ANSI approval dates.

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The track changes in this document show the changes made in addenda ab, ac, ad, ae, ag, ah, ak, am, k, o, and x.

3 Definitions, Abbreviations, and Acronyms

3.1 General

Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this standard. When the tense or plurality of the term is different than the defined term, the definition still applies. These definitions are applicable to all sections of this standard, wherever italicized. Terms that are not ~~defined~~ italicized shall have their ordinarily accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based on American standard English language usage as documented in an unabridged dictionary accepted by the *adopting authority*.

~~***Informative Note***~~
~~Throughout the standard, words that have definitions in this section are italicized.~~

3.2 Definitions

A

above-grade wall: see *wall*.

access hatch: see *door*.

addition: an extension or increase in ~~*floor*~~floor area or height of a *building* outside of the *existing building envelope*.

adopting authority: the agency or agent that adopts this standard.

air economizer: see *economizer, air*.

air system balancing: see *balancing, air system*.

alteration: a replacement or ~~addition~~*addition* to a *building* or its *systems* and *equipment*; routine maintenance, *repair*, and ~~*service*~~service, or a change in the *building*'s use classification or category shall not constitute an *alteration*.

annual fuel utilization efficiency (AFUE): an *efficiency* descriptor of the ratio of annual output *energy* to annual input *energy* as developed in accordance with the requirements of U.S. Department of Energy (DOE) 10 CFR Part 430.

attic and other roofs: see *roof.*

authority having jurisdiction: the agency or agent responsible for enforcing this standard.

automatic or automatically: self-acting, operating by its own mechanism when actuated by some nonmanual influence, such as a change in current strength, pressure, temperature, or mechanical configuration.

automatic control device: a device capable of ~~automatically~~*automatically* turning loads off and on without *manual* intervention.

B

balancing, air system: adjusting airflow rates through air *distribution system* devices, such as fans and diffusers, by manually adjusting the position of dampers, splitter vanes, extractors, etc., or by using *automatic control devices*, such as constant-air-volume or variable-air-volume (*VAV*) boxes.

balancing, hydronic system: adjusting water flow rates through hydronic *distribution system* devices, such as pumps and coils, by manually adjusting the position valves or by using *automatic control devices*, such as *automatic* flow *control* valves.

ballast: a device used in conjunction with an electric-discharge *lamp* to cause the *lamp* to start and operate under the proper circuit conditions of voltage, current, wave form, electrode heat, etc.

baseline building design: a computer representation of a hypothetical design based on the proposed design. This representation is used as the basis for calculating the *baseline building performance* for rating above-standard design or when using the *performance rating method* as an alternative path for minimum standard compliance in accordance with Section 4.2.1.1.

baseline building performance: the annual *energy* cost for a *building* design intended for use as a baseline for rating above-standard design or when using the *performance rating method* as an alternative path for minimum standard compliance in accordance with Section 4.2.1.1.

below-grade wall: see *wall*.

boiler: a self-contained, low-pressure appliance for supplying steam or hot water.

modulating boiler: a *boiler* that is capable of more than a single firing rate in response to a varying temperature or heating load.

packaged boiler: a *boiler* that is shipped complete with heating *equipment*, mechanical draft *equipment*, and *automatic controls*, and that is usually shipped in one or more sections. A *packaged boiler* includes factory-built *boilers* manufactured as a unit or *system*, disassembled for shipment, and reassembled at the site.

boiler system: one or more *boilers* and their *piping* and *controls* that work together to supply steam or hot water to heat output devices remote from the *boiler*.

branch circuit: the circuit conductors between the final *overcurrent* device protecting the circuit and the outlets; the final wiring run to the load.

bubble point: the refrigerant liquid saturation temperature at a specified pressure.

budget building design: a computer representation of a hypothetical design based on the actual *proposed design*. This representation is used as the basis for calculating the *energy cost budget*.

building: any structure used or intended for supporting or sheltering any use or occupancy.

building entrance: any doorway, set of *doors*, revolving *door*, vestibule, or other form of portal that is ordinarily used to gain access to the *building* or to exit from the *building* by its users and occupants. This does not include *doors* solely used to directly enter mechanical, electrical, and other *building* utility ~~*service*~~service *equipment* rooms.

building envelope: the exterior plus the semiexterior portions of a *building*. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

exterior building envelope: the elements of a *building* that separate *conditioned spaces* from the exterior.

semiexterior building envelope: the elements of a *building* that separate *conditioned space* from *unconditioned space* or that enclose *semiheated spaces* through which thermal *energy* may be transferred to or from the exterior, to or from *unconditioned spaces*, or to or from *conditioned spaces*.

building envelope trade-off schedules and loads: the schedules and internal loads[1], by *building* area type, to be used in the *building envelope* trade-off option simulations described in Appendix C.

building exit: any doorway, set of *doors*, or other form of portal that is ordinarily used only for emergency egress or convenience exit.

building grounds lighting: lighting provided through a *building*'s electrical *service* for parking lot, site, roadway, pedestrian pathway, loading dock, or security applications.

building material: any element of the *building envelope*, other than air films and insulation, through which heat flows and that is included in the component *U-factor* calculations.

building official: the officer or other designated *authority having jurisdiction* charged with the administration and enforcement of this standard, or a duly authorized representative.

building service: the *equipment* for delivering *energy* from the supply or *distribution system* to the premises served.

building service equipment: the necessary *equipment*, usually consisting of a *circuit breaker* or switch and fuses and accessories, located near the point of entrance of supply conductors to a *building* or other structure (or an otherwise defined area) and intended to constitute the main *control* and means of cutoff of the supply. Service *equipment* may consist of *circuit breakers* or fused switches provided to *disconnect* all under-grounded conductors in a *building* or other structure from the service-entrance conductors.

C

C-factor: see *thermal conductance*.

circuit breaker: a device designed to open and close a circuit by *nonautomatic* means and to open the circuit ~~automatically~~*automatically* at a predetermined *overcurrent* without damage to itself when properly applied within its rating.

class of construction: for the *building envelope*, a subcategory of *roof*, *above-grade wall*, *below-grade wall*, *floor*, *slab-on-grade floor*, *opaque door*, *vertical fenestration*, or *skylight*. (See *roof*, *wall*, *floor*, *slab-on-grade floor*, *door*, and *fenestration*.)

code official: see *building official.*

coefficient of performance (COP_C)—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_H), heat pump—heating: the ratio of the rate of heat delivered to the rate of *energy* input, in consistent units, for a complete heat pump *system*, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.

computer room: a room whose primary function is to house *equipment* for the processing and storage of electronic data and that has a design electronic data *equipment* power density exceeding 20 W/ft^2 of conditioned ~~*floor area*~~floor area.

computer room energy: annual *energy* use of the data center, including all *IT equipment energy*, plus *energy* that supports the IT *equipment* and *computer room space*, calculated in accordance with industry-accepted standards defined as Total Annual *Energy* (see Informative Appendix E).

[1]Schedules and internal loads by *building* area type are at ~~http://sspc901.ashraepcs.org/content.html~~ http://sspc901.ashraepcs.org/documents.php.

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

conditioned floor area, gross: see *floor area, gross.*

conditioned space: see *space.*

conductance: see *thermal conductance.*

construction: the fabrication and erection of a new *building* or any ~~addition~~*addition* to or *alteration* of an *existing building*.

construction documents: drawings and specifications used to construct a *building*, *building systems*, or portions thereof.

continuous air barrier: the combination of interconnected materials, assemblies, and sealed joints and components of the *building envelope* that minimize air leakage into or out of the *building envelope*.

continuous daylight dimming: method of *automatic* lighting *control* using daylight *photosensors*, where the lights are dimmed continuously, or using at least four preset levels with at least a five-second fade between levels, where the *control* turns the lights off when sufficient daylight is available.

continuous insulation (c.i.): insulation that is uncompressed and continuous across all structural members without thermal bridges other than fasteners and ~~*service*~~service openings. It is installed on the interior or exterior or is integral to any *opaque* surface of the *building envelope*.

control: to regulate the operation of *equipment*.

control device: a specialized device used to regulate the operation of *equipment*.

cooldown: reduction of *space* temperature down to occupied *set point* after a period of shutdown or setup.

cooled space: see *space, conditioned space*.

cooling degree-day, base (CDD): see *degree-day*.

cooling design temperature: the outdoor dry-bulb temperature equal to the temperature that is exceeded by 1% of the number of hours during a typical weather year.

cooling design wet-bulb temperature: the mean coincident outdoor wet-bulb temperature utilized in conjunction with the cooling design dry-bulb temperature, often used for the sizing of cooling *systems*.

critical circuit: the hydronic circuit that determines the minimum differential pressure that the pump must produce to satisfy the zone loads (e.g., the circuit with the most-open valve). The *critical circuit* is the one with the highest pressure drop required to satisfy its load. At part-load conditions, the *critical circuit* can change based on zone loads.

D

daylight area:

daylight area under roof monitors: the *daylight area under roof monitors* is the combined *daylight area* under each *roof monitor* within each *space*. The *daylight area* under each *roof monitor* is the product of

a. the width of the *vertical fenestration* above the ceiling level plus, on each side, the smallest of

1. 2 ft,

2. the distance to any 5 ft or higher vertical obstruction, or
3. the distance to the edge of any *primary sidelighted area*

and

b. the smaller of the following horizontal distances inward from the bottom edge of the *vertical fenestration* (see Figure 3.2-1):

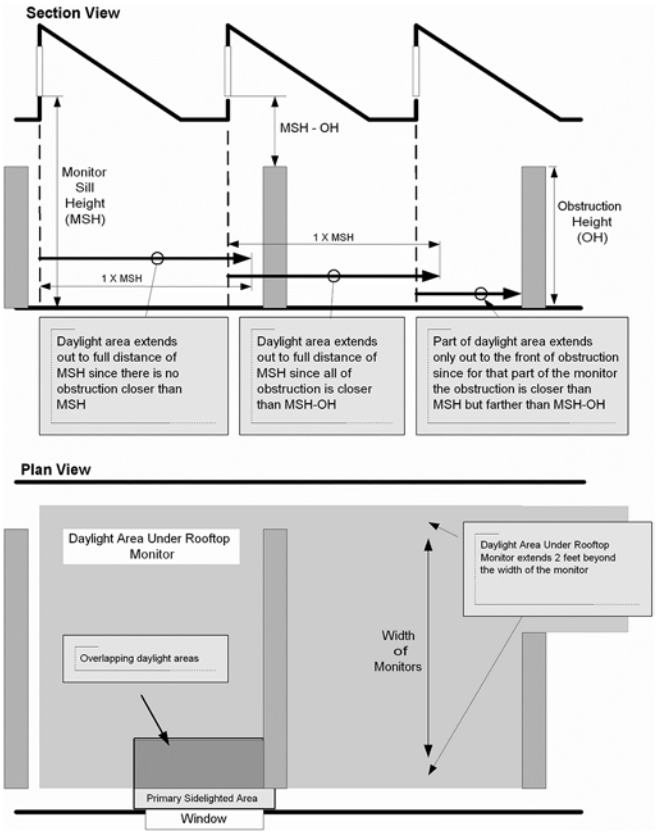

Figure 3.2-1 Computing the *daylight area under roof monitors*.

1. The monitor sill height (MSH) (the vertical distance from the *floor* to the bottom edge of the monitor glazing).
2. The distance to the nearest face of any opaque vertical obstruction, where any part of the obstruction is farther away than the difference between the height of the obstruction and the monitor sill height (MSH – OH).

daylight area under skylights: the *daylight area under skylights* is the combined *daylight area* under each *skylight* within a *space*. The *daylight area* under each *skylight* is bounded by the opening beneath the *skylight* and horizontally in each direction (see Figure 3.2-2), the smaller of

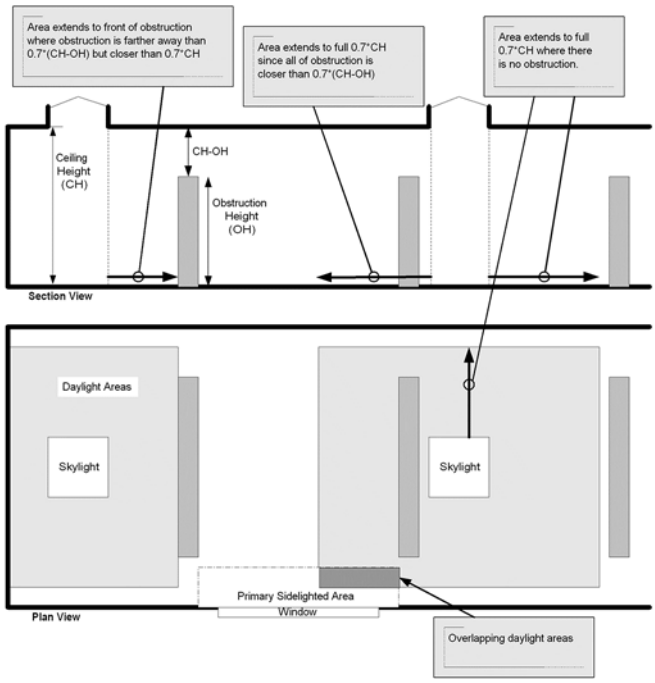

Figure 3.2-2 Computing the *daylight area under skylights*.

a. 70% of the ceiling height (0.7 × CH) or

b. the distance to the nearest face of any opaque vertical obstruction, where any part of the obstruction is farther away than 70% of the distance between the top of the obstruction and the ceiling (0.7 × [CH – OH], where CH = the height of the ceiling at the lowest edge of the *skylight* and OH = the height to the top of the obstruction).

primary sidelighted area: the total *primary sidelighted area* is the combined *primary sidelighted area* within each *space*. Each *primary sidelighted area* is directly adjacent to *vertical fenestration* below the ceiling (see Figure 3.2-3).

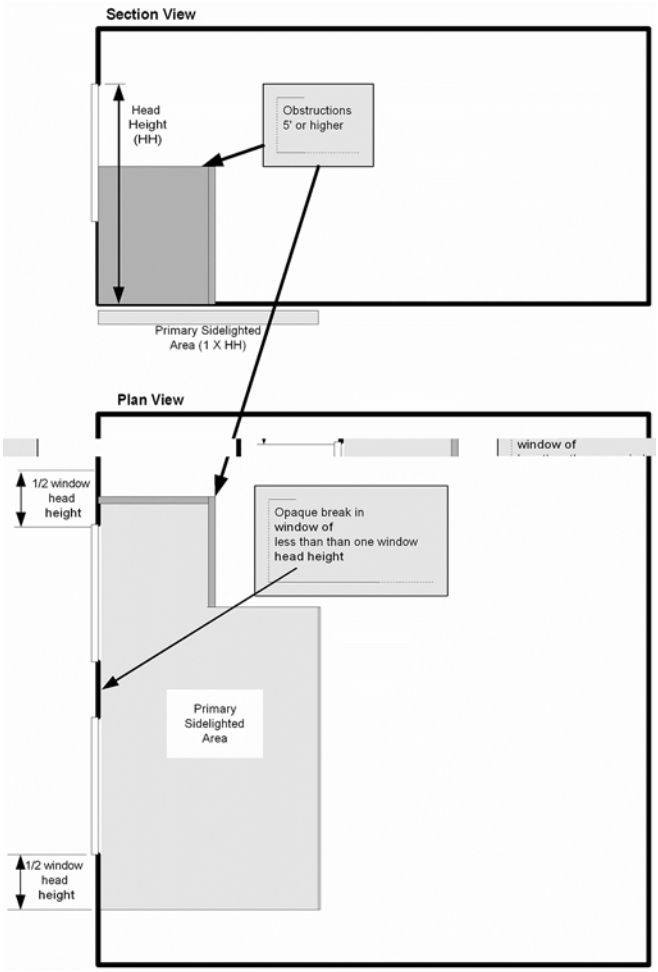

Figure 3.2-3 Computing the *primary sidelighted area*.

a. The *primary sidelighted area* width is the width of the *vertical fenestration* plus, on each side, the smaller of

1. one half of the *vertical fenestration* head height (where head height is the distance from the *floor* to the top of the glazing) or
2. the distance to any 5 ft or higher opaque vertical obstruction.

b. The *primary sidelighted area* depth is the horizontal distance perpendicular to the *vertical fenestration*, which is the smaller of

1. one *vertical fenestration* head height or
2. the distance to any 5 ft or higher opaque vertical obstruction.

secondary sidelighted area: the total *secondary sidelighted area* is the combined *secondary sidelighted area* within a *space*. Each *secondary sidelighted area* is directly adjacent to a *primary sidelighted area* (see Figure 3.2-4):

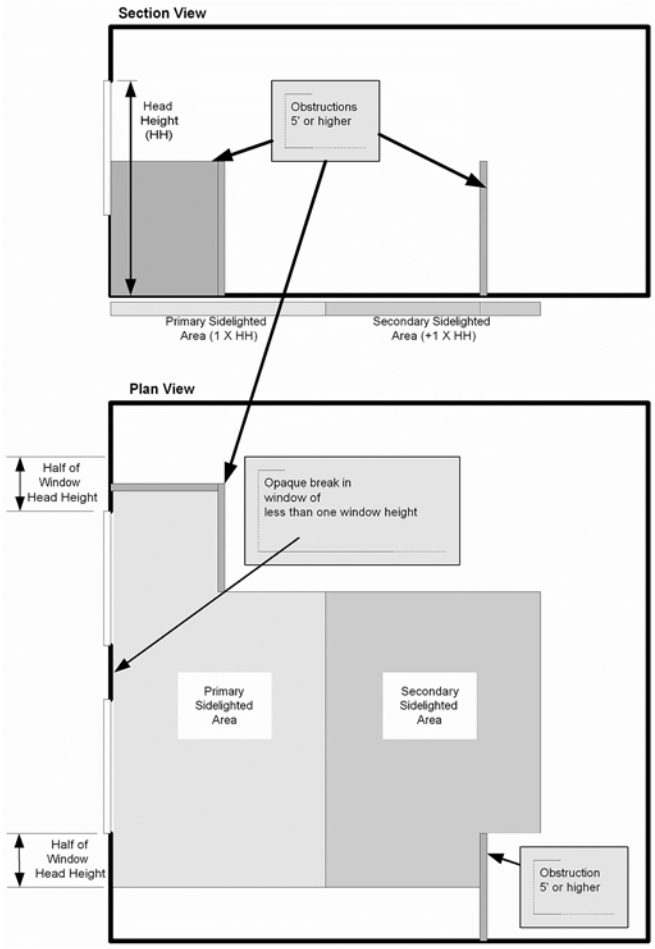

Figure 3.2-4 Computing the *secondary sidelighted area*.

a. The *secondary sidelighted area* width is the width of the *vertical fenestration* plus, on each side, the smaller of

1. one half of the *vertical fenestration* head height or
2. the distance to any 5 ft or higher opaque vertical obstruction.

b. The *secondary sidelighted area* depth is the horizontal distance perpendicular to the *vertical fenestration*, which begins at the edge of the *primary sidelighted area* depth and ends at the smaller of

1. one *vertical fenestration* head height or
2. the distance to any 5 ft or higher opaque vertical obstruction.

If the adjacent *primary sidelighted area* ends at a 5 ftor higher opaque vertical obstruction, there is no *secondary sidelighted area* beyond such obstruction.

daylighted area: the ~~*floor area*~~floor area substantially illuminated by daylight.

dead band: the range of values within which a sensed variable can vary without initiating a change in the controlled process.

decorative lighting: see *lighting, decorative*.

dedicated replacement air: see *makeup air*.

degree-day: the difference in temperature between the outdoor *mean temperature* over a twenty-four-hour period and a given base temperature. The classifications are defined as follows:

> ***cooling degree-day base 50°F (CDD50):*** for any one day, when the *mean temperature* is more than 50°F, there are as many *degree-days* as degrees Fahrenheit temperature difference between the *mean temperature* for the day and 50°F. Annual *cooling degree-days* (CDDs) are the sum of the *degree-days* over a calendar year.
>
> ***heating degree-day base 65°F (HDD65):*** for any one day, when the *mean temperature* is less than 65°F, there are as many *degree-days* as degrees Fahrenheit temperature difference between the *mean temperature* for the day and 65°F. Annual *heating degree-days* (HDDs) are the sum of the *degree-days* over a calendar year.

demand: the highest amount of power (average Btu/h over an interval) recorded for a *building* or facility in a selected time frame.

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.

design capacity: output capacity of a *system* or piece of *equipment* at *design conditions*.

design conditions: specified environmental conditions, such as temperature and light intensity, required to be produced and maintained by a *system* and under which the *system* must operate.

design energy cost: the annual *energy* cost calculated for a *proposed design*.

design professional: an architect or engineer licensed to practice in accordance with applicable state licensing laws.

dimmer: a lighting *control device* that is capable of varying the light output and *energy* usage of light sources.

direct digital control (DDC): a type of *control* where controlled and monitored analog or binary data (e.g., temperature, contact closures) are converted to digital format for manipulation and calculations by a digital computer or microprocessor and then converted back to analog or binary form to *control* physical devices.

distribution system: conveying means, such as ducts, pipes, and wires, to bring substances or *energy* from a source to the point of use. The *distribution system* includes such auxiliary *equipment* as fans, pumps, and *transformers*.

door ~~***(access hatch)***~~***:*** ~~all~~ an ~~*operable*~~operable opening area~~s (that are not *fenestration*)~~ in the *building envelope* that is not *fenestration*~~, including swinging and roll-up *doors*, fire *doors*, and *access hatches*~~. A ~~*Doors*~~ door ~~that are~~where more than one-half of the *door area* is ~~glass~~ glazed ~~are~~ is considered *fenestration*~~. (see *fenestration*).~~ and a *door* where one-half or less of the *door area* is glazed is considered an *opaque door*. An *access hatch* is considered a *door*. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

> ***metal coiling door:*** an upward-acting, *nonswinging door* assembly consisting of interlocking horizontal slats or sheets that, upon opening the *door*, roll up around a horizontal barrel above the *door* opening.
>
> ***nonswinging door:*** roll-up, metal coiling, sliding, and ~~all~~ any other *door*~~s~~ that ~~are~~ is not a *swinging door*~~s~~.
>
> ***sectional garage door:*** an upward-acting, *nonswinging door* assembly made of two or more horizontal panels hinged together vertically.
>
> ***swinging door:*** ~~all~~ a *door* having an ~~*operable*~~operable opaque panel~~s~~ with hinges or pivots on one side ~~and *opaque* revolving *doors*~~.

door area: total area of the *door* measured using the rough opening and including the *door* slab and the frame. (See *fenestration area*.)

driver: a device designed to operate a solid-state (e.g., LED) light source.

ductwork: a *system* of ducts for distribution and extraction of air.

dwelling unit: a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

DX-dedicated outdoor air system units (DX-DOAS units): a type of air-cooled, water-cooled, or water source factory assembled product that dehumidifies 100% *outdoor air* to a low dew point and includes *reheat* that is capable of controlling the supply dry-bulb temperature of the dehumidified air to the designed supply air temperature. This conditioned *outdoor air* is then delivered directly or indirectly to the *conditioned spaces*. It may precondition *outdoor air* by containing an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes, or other heat or mass transfer apparatus.

dynamic glazing: any glazing *system*/glazing infill that has the fully reversible ability to change its performance properties, including *U-factor*, *solar heat gain coefficient*, or *visible transmittance*. This includes, but is not limited to, shading *systems* between the glazing layers and chromogenic glazing.

E

economizer, air: a duct and damper arrangement and *automatic control system* that together allow a cooling *system* to supply *outdoor air* to reduce or eliminate the need for *mechanical cooling* during mild or cold weather.

economizer, fluid: a *system* by which the supply air of a cooling *system* is cooled indirectly with a fluid that is itself cooled by heat or mass transfer to the environment without the use of *mechanical cooling*. Examples of commonly used fluids are water, glycol mixtures, and refrigerants.

effective panel surface: see *thermally effective panel surface*.

efficacy (of a lamp): the ratio of the total luminous output of a *lamp* to the total power input to the *lamp*, typically expressed in lm/W.

efficiency: performance at specified rating conditions.

electric resistance: see *resistance, electric*

emittance: the ratio of the radiant heat flux emitted by a specimen to that emitted by a blackbody at the same temperature and under the same conditions.

enclosed space: a volume substantially surrounded by solid surfaces, such as *walls*, *floors*, *roofs*, and openable devices, such as *doors* and ~~*operable*~~operable windows.

energy: the capacity for doing work. It takes a number of forms that may be transformed from one into another such as thermal (heat), mechanical (work), electrical, and chemical (Btu).

energy cost budget: the annual *energy* cost for the *budget building design* intended for use in determining minimum compliance with this standard.

energy efficiency ratio (EER): the ratio of net cooling capacity (Btu/h) to total rate of electric input in watts under designated operating conditions. (See *coefficient of performance [COP]—cooling*.)

energy factor (EF): a measure of *water heater* overall *efficiency*.

enthalpy recovery ratio: change in the enthalpy of the *outdoor air* supply divided by the difference between the *outdoor air* and entering exhaust air enthalpy, expressed as a percentage.

entrance door: see *vertical fenestration.*

envelope performance factor: the trade-off value for the *building envelope* performance compliance option calculated using the procedures specified in Section 5.6. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

base envelope performance factor: the *building envelope performance factor* for the base design.

proposed envelope performance factor: the *building envelope performance factor* for the *proposed design*.

equipment: devices for ~~comfort conditioning,~~ space heating, space cooling, *ventiliation*, humidification, dehumidification, electric power, lighting, transportation, refrigeration, cooking, or *service water heating*, including but not limited to furnaces, *boilers*, air conditioners, heat pumps, chillers, *water heaters*, *lamps*, *luminaires*, *ballasts*, elevators, escalators, or other devices or installations.

essential facility: those portions of a *building* serving one of the following functions:

a. Hospitals and other health care facilities having surgery or emergency treatment facilities
b. Fire, rescue, and police stations and emergency vehicle garages
c. Designated earthquake, hurricane, or other emergency shelters
d. Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response
e. Power-generating stations and other public utility facilities required as emergency backup facilities for other *essential facilities*
f. Structures containing highly toxic materials where the quantity of the material exceeds the maximum allowable quantities
g. Aviation *control* towers, air traffic *control* centers, and emergency aircraft hangars
h. Buildings and other structures having critical national defense functions

evaporation design wet-bulb temperature: the outdoor wet-bulb temperature utilized in conjunction with the mean coincident dry-bulb temperature, often used for the sizing of evaporative *systems* such as cooling towers.

existing building: a *building* or portion thereof that was previously occupied or approved for occupancy by the *authority having jurisdiction*.

existing equipment: *equipment* previously installed in an *existing building*.

existing system: a *system* or *systems* previously installed in an *existing building.*

exterior building envelope: see *building envelope*.

exterior lighting power allowance: see *lighting power allowance, exterior*.

exterior wall: see *building envelope* and *wall*.

eye adaptation: the process by which the retina becomes accustomed to more or less light than it was exposed to during an immediately preceding period. It results in a change in the sensitivity to light.

F

F-factor: the perimeter heat loss factor for *slab-on-grade floors* (Btu/h·ft·°F).

façade area: area of the façade, including overhanging soffits, cornices, and protruding columns, measured in elevation in a vertical plane parallel to the plane of the face of the *building*. Nonhorizontal *roof* surfaces shall be included in the calculation of vertical *façade area* by measuring the area in a plane parallel to the surface.

fan brake horsepower (bhp): the horsepower delivered to the fan's shaft. Brake horsepower does not include the mechanical drive losses (belts, gears, etc.).

fan efficiency grade (FEG): the fan *efficiency* without consideration of drives, as defined in AMCA 205.

fan system brake horsepower (bhp): the sum of the *fan brake horsepower* of all fans that are required to operate at *fan system design conditions* to supply air from the heating or cooling source to the *conditioned spaces* and return it to the source or exhaust it to the outdoors.

fan system design conditions: operating conditions that can be expected to occur during normal *system* operation that result in the highest supply airflow rate to *conditioned spaces* served by the *system*, other than during *air economizer* operation.

fan system motor nameplate horsepower (hp): the sum of the motor *nameplate horsepower* of all fans that are required to operate at *design conditions* to supply air from the heating or cooling source to the *conditioned spaces* and return it to the source or exhaust it to the outdoors.

feeder conductors: the wires that connect the ~~*service*~~service *equipment* to the *branch circuit breaker* panels.

fenestration: ~~all areas~~ an assembly, ~~(~~including the frame~~,s)~~ in the *building envelope* that ~~let in~~ allows light to pass.~~,~~ *Fenestration* assemblies ~~including~~ include, but are not limited to, windows, plastic panels, clerestories, *roof monitors*, *skylights*, glass block, and *doors* ~~that are~~ where more than one-half of the *door area* is glazed~~glass, and glass block *walls*~~. For the purposes of determining *building envelope* requirements, the classifications are defined as follows: ~~(See *building envelope* and *door*.)~~

field-fabricated fenestration: *fenestration* whose frame is made at the *construction* site of materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a *fenestration* product or exterior glazed *door*. *Field-fabricated fenestration* does not include site-built *fenestration* designed to be glazed or assembled in the field using specific factory-cut or otherwise factory-formed framing and glazing units, such as storefront systems, curtain walls, and atrium *roof systems*.

skylight: a *fenestration* surface having a slope of less than 60 degrees from the horizontal plane. Other *fenestration*, even if mounted on the *roof* of a *building*, is considered *vertical fenestration*.

vertical fenestration: all *fenestration* other than *skylights*. Trombe *wall* assemblies, where glazing is installed within 12 in. of a *mass wall*, are considered *walls*, not *fenestration*.

fenestration area: total area of the *fenestration* measured using the rough opening and including the glazing, sash, and frame. For *doors* where the glazed vision area is less than 50% of the *door area*, the *fenestration area* is the glazed vision area. For all other *doors*, the *fenestration area* is the *door area*. (See *door area*.)

~~***fixed:*** see *vertical fenestration.*~~

fixture: the component of a *luminaire* that houses the *lamp* or *lamps* or positions the *lamp*, shields it from view, and distributes the light. The *fixture* also provides for connection to the power supply, which may require the use of a *ballast*/*driver*.

floor: that lower portion of the *building envelope*, including *opaque* area and *fenestration*, that has conditioned or *semiheated space* above and is horizontal or tilted at an angle of less than 60 degrees from horizontal but excluding *slab-on-grade floors*. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

mass floor: a *floor* with a *heat capacity* that exceeds (a) 7 Btu/ft^2·°F or (b) 5 Btu/ft^2·°F, provided that the *floor* has a material unit mass not greater than 120 lb/ft^3.

steel-joist floor: a *floor* that (a) is not a *mass floor* and (b) has *steel joist* members supported by structural members.

wood-framed and other floors: all other *floor* types, including wood-joist *floors*.

(See *building envelope, fenestration, opaque, and slab-on-grade floor*).

floor area, gross: the sum of the floor areas of the *spaces* within the *building*, including basements, mezzanine and intermediate-floored tiers, and penthouses with a headroom height of 7.5 ft or greater. It is measured from the exterior faces of *walls* or from the centerline of *walls* separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar *spaces*, pipe trenches, exterior terraces or steps, chimneys, *roof* overhangs, and similar features.

gross building envelope floor area: the *gross floor area* of the *building envelope*, but excluding *slab-on-grade floors*.

gross conditioned floor area: the *gross floor area* of *conditioned spaces*.

gross lighted floor area: the *gross floor area* of lighted *spaces*.

gross semiheated floor area: the *gross floor area* of *semiheated spaces*.

(See *building envelope, floor, slab-on-grade floor, and space*.)

flue damper: a device in the flue outlet or in the inlet of or upstream of the draft *control device* of an individual, ~~automatically~~*automatically* operated, *fossil-fuel*-fired appliance that is designed to ~~automatically~~*automatically* open the flue outlet during appliance operation and to ~~automatically~~*automatically* close the flue outlet when the appliance is in a standby condition.

fluid economizer: see *economizer, fluid*.

fuel: a material that may be used to produce heat or generate power by combustion.

fossil fuel: *fuel* derived from a hydrocarbon deposit, such as petroleum, coal, or natural gas derived from living matter of a previous geologic time.

G

general lighting: see *lighting, general*.

generally accepted engineering standard: a specification, rule, guide, or procedure in the field of engineering, or related thereto, recognized and accepted as authoritative.

grade: the finished ground level adjoining a *building* at all *walls*.

gross conditioned floor area: see *floor area, gross.*

gross floor area: see *floor area, gross*.

gross lighted floor area (GLA): see *floor area, gross*.

gross roof area: see *roof area, gross*.

gross wall area: see *wall area, gross*.

growth media: an engineered formulation of inorganic and organic materials including but not limited to heat-expanded clays, slates, shales, aggregate, sand, perlite, vermiculite, and organic material including but not limited to compost worm castings, coir, peat, and other organic material.

H

heat capacity (HC): the amount of heat necessary to raise the temperature of a given mass 1°F. Numerically, the *HC* per unit area of surface (Btu/ft^2·°F) is the sum of the products of the mass per unit area of each individual material in the *roof*, *wall*, or *floor* surface multiplied by its individual specific heat.

heat trace: a heating *system* where the externally applied heat source follows (traces) the object to be heated (e.g., water *piping*).

heated space: see *space*.

heating degree-day, base: see *degree-day*.

heating design temperature: the outdoor dry-bulb temperature equal to the temperature that is exceeded at least 99.6% of the number of hours during a typical weather year.

heating seasonal performance factor (HSPF): the total heating output of a heat pump during its normal annual usage period for heating (Btu) divided by the total electric *energy* input during the same period.

historic: a *building* or *space* that has been specifically designated historically significant by the *adopting authority* or is listed in The National Register of *Historic* Places or has been determined to be eligible for such listing by the U.S. Secretary of the Interior.

hot-water supply boiler: a *boiler* used to heat water for purposes other than *space* heating.

humidistat: an *automatic control device* used to maintain humidity at a ~~*fixed*~~fixed or adjustable *set point*.

humidistatic controls: *automatic controls* used to maintain humidity at a *fixed* or adjustable *set point.*

HVAC system: the *equipment*, *distribution systems*, and *terminals* that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning to a *building* or portion of a *building*.

HVAC zone: a *space* or group of *spaces* within a *building* with heating and cooling requirements that are sufficiently similar so that desired conditions (e.g., temperature) can be maintained throughout using a single sensor (e.g., *thermostat* or temperature sensor).

hydronic system balancing: see *balancing, hydronic system*.

I

IEC Design H motor: an electric motor that

a. is an induction motor designed for use with three-phase power;
b. contains a cage rotor;
c. is capable of direct-on-line starting;
d. has 4, 6, or 8 poles;
e. is rated from 0.4 to 1600 *kW* at a frequency of 60 Hz; and
f. conforms to Sections 8.1, 8.2, and 8.3 of IEC 60034-12, edition 2.1, requirements for starting torque, locked rotor apparent power, and starting.

IEC Design N motor: an electric motor that

a. is an induction motor designed for use with three-phase power;
b. contains a cage rotor;
c. is capable of direct-on-line starting;
d. has 2, 4, 6, or 8 poles;

e. is rated from 0.4 to 1600 *kW* at a frequency of 60 Hz; and

f. conforms to Sections 6.1, 6.2, and 6.3 of IEC 60034-12, edition 2.1, requirements for torque characteristics, locked rotor apparent power, and starting.

indirectly conditioned space: see *space*.

indoor pool dehumidifier: a type of air-cooled or water-cooled electrically operated vapor compression refrigeration *system*, factory assembled as a single package or split *system*, which includes an indoor cooling/dehumidifying coil, an air *reheat* coil, one or more compressors, and an air moving device. It may also include a refrigerant heat recovery unit, an auxiliary refrigerant condenser, an economizer, and an air-to-air heat recovery device. It shall provide the function of dehumidification, air circulation, and air *reheating* and may include the function of air-cooling, air-cleaning, *pool* water heating, and air-to-air heat recovery.

ineffective panel surface: see *thermally ineffective panel surface*.

infiltration: the uncontrolled inward air leakage through cracks and crevices in any *building* element and around windows and *doors* of a *building* caused by pressure differences across these elements due to factors such as wind, inside and outside temperature differences (stack effect), and imbalance between supply and exhaust air *systems*.

installed exterior lighting power: the power in watts of all site, landscape, and *building lighting systems* for exterior *luminaires*.

installed interior lighting power: the power in watts of all general, task, and furniture *lighting systems* for interior *luminaires*.

integrated energy efficiency ratio (IEER): a single-number figure of merit expressing cooling part-load *EER efficiency* for commercial 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.*I-P*): a single-number figure of merit based on part-load *EER*, , or *kW*/*kW* expressing part-load *efficiency* for air-conditioning and heat pump *equipment* on the basis of weighted operation at various load capacities for the *equipment*.

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

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

interior lighting power allowance: see *lighting power allowance*.

isolation devices: devices that isolate *HVAC zones* so that they can be operated independently of one another. *Isolation devices* include, but are not limited to, separate *systems*, isolation dampers, and *controls* providing shutoff at *terminal* boxes.

IT equipment energy: annual *energy* used for computer storage and network *equipment* along with supplemental *equipment* represented by the uninterruptible power supply (UPS) output calculated in accordance with industry-accepted standards (see Informative Appendix E).

J

joist, steel: any structural steel member of a *building* or structure made of hot-rolled or cold-rolled solid or open-web sections.

K

kilovolt-ampere (kVA): where the term *kilovolt-ampere* is used in this standard, it is the product of the line current (amperes) times the nominal *system* voltage (kilovolts) times 1.732 for three-phase currents. For single-phase applications, *kVA* is the product of the line current (amperes) times the nominal *system* voltage (kilovolts).

kilowatt (kW): the basic unit of electric power, equal to 1000 W.

L

labeled: *equipment* or materials to which a symbol or other identifying mark has been attached by the *manufacturer* indicating compliance with specified standards or performance in a specified manner.

lamp: a generic term for a man-made light source, often called a "bulb" or "tube."

> ***high-intensity discharge (HID) lamp:*** an electric discharge *lamp* in which light is produced when an electric arc is discharged through a vaporized metal such as mercury or sodium. Some *HID lamps* may also have a phosphor coating that contributes to the light produced or enhances the light color.

light-to-solar-gain ratio (LSG): the ratio of the center-of-glass *visible transmittance* to the center-of-glass *solar heat gain coefficient*.

lighting, decorative: lighting that is ornamental or installed for aesthetic effect. *Decorative lighting* shall not include *general lighting*.

lighting, general: 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.

lighting power allowance, exterior: the maximum lighting power in watts allowed for the exterior of a *building*.

lighting power allowance, interior: the maximum lighting power in watts allowed for the interior of a *building*.

lighting power density (LPD): the lighting power per unit area of a *building*, *space*, or outdoor area expressed in W/ft^2.

lighting system: a group of *luminaires* circuited or controlled to perform a specific function.

liner system (Ls): a continuous vapor barrier liner installed below the purlins and uninterrupted by framing members.

low-rise residential buildings: single-family houses, multifamily structures of three stories or fewer above *grade*, manufactured houses (mobile homes), and manufactured houses (modular).

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.

M

makeup air (dedicated replacement air): *outdoor air* deliberately brought into the *building* from the outside and supplied to the vicinity of an exhaust hood to replace air, vapor, and contaminants being exhausted. *Makeup air* is generally filtered and fan-forced, and it may be heated or cooled depending on the requirements of the application. *Makeup air* may be delivered through outlets integral to the exhaust hood or through outlets in the same room.

manual (nonautomatic): requiring personal intervention for *control*. *Nonautomatic* does not necessarily imply a *manual* controller, only that personal intervention is necessary. (See *automatic*.)

manufacturer: the company engaged in the original production and assembly of products or *equipment* or a company that purchases such products and *equipment* manufactured in accordance with company specifications.

mass floor: see *floor*.

mass wall: see *wall*.

mean temperature: one-half the sum of the minimum daily temperature and maximum daily temperature.

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

mechanical heating: raising the temperature of a gas or liquid by use of *fossil fuel* burners, *electric resistance* heaters, heat pumps, or other *systems* that require *energy* to operate.

metal building: a complete integrated set of mutually dependent components and assemblies that form a *building*, which consists of a steel-framed superstructure and metal skin.

metal building roof: see *roof*.

metal building wall: see *wall*.

metal framing: see *vertical fenestration*.

metering: instruments that measure electric voltage, current, power, etc.

moisture removal efficiency (MRE): a ratio of the moisture removal capacity in lb of moisture/h to the power input values in *kW* at any given set of standard rating conditions expressed in lb of moisture/kWh.

motor power, rated: the rated output power from the motor.

multilevel occupancy sensor: an occupancy sensor having an *automatic* OFF function that turns off all the lights, and either an *automatic* or a manually controlled ON function capable of activating between 30% and 70% of the lighting power. After that event occurs, the device shall be capable of all of the following actions when manually called to do so by the occupant:

a. Activating alternate sets of lights
b. Activating 100% of the lighting power
c. Deactivating all lights

multiscene control: a lighting *control device* or *system* that allows for two or more predefined lighting settings, in addition to all off, for two or more groups of *luminaires* to suit multiple activities in the *space*, and allows the *automatic* recall of those settings.

N

nameplate horsepower (hp): the nominal motor output power rating stamped on the motor nameplate.

nameplate rating: the design load operating conditions of a device as shown by the *manufacturer* on the nameplate or otherwise marked on the device.

NEMA Design A motor: a squirrel-cage motor that

a. is designed to withstand full-voltage starting and developing locked-rotor torque as shown in NEMA MG 1, paragraph 12.38.1;
b. has pull-up torque not less than the values shown in NEMA MG 1, paragraph 12.40.1;

c. has breakdown torque not less than the values shown in NEMA MG 1, paragraph 12.39.1;

d. has a locked-rotor current higher than the values shown in NEMA MG 1, paragraph 12.35.1, for 60 Hz, and NEMA MG 1, paragraph 12.35.2, for 50 Hz; and

e. has a slip at rated load of less than 5% for motors with fewer than 10 poles.

NEMA Design B motor: a squirrel-cage motor that is

a. designed to withstand full-voltage starting;

b. develops locked-rotor, breakdown, and pull-up torques adequate for general application as specified in NEMA MG1, paragraphs 12.38, 12.39, and 12.40;

c. draws locked-rotor current not to exceed the values shown in NEMA MG1, paragraph 12.35.1, for 60 Hz, and paragraph 12.35.2 for 50 Hz; and

d. has a slip at rated load of less than 5% for motors with fewer than 10 poles.

NEMA Design C motor: a squirrel-cage motor that

a. is designed to withstand full-voltage starting and developing locked-rotor torque for high-torque applications up to the values shown in NEMA MG1, paragraph 12.38.2 (incorporated by reference; see §431.15);

b. has pull-up torque not less than the values shown in NEMA MG1, paragraph 12.40.2;

c. has breakdown torque not less than the values shown in NEMA MG1, paragraph 12.39.2;

d. has a locked-rotor current not to exceed the values shown in NEMA MG1, paragraph 12.35.1, for 60 Hz, and paragraph 12.35.2 for 50 Hz; and

e. has a slip at rated load of less than 5%.

networked guest room control system: a *control system*, accessible from the hotel/motel front desk or other central location, that is capable of identifying ~~reserved~~ rented and unrented rooms according to a timed schedule, and is capable of controlling HVAC in each hotel/motel guest room separately.

nonautomatic: see *manual*.

nonmetal framing: see *vertical fenestration.*

nonrecirculating system: a domestic or ~~*service*~~service hot-water *distribution system* that is not a *recirculating system*.

nonrenewable energy: *energy* derived from a *fossil fuel* source.

nonresidential: all occupancies other than *residential*. (See *residential*.)

nonstandard part-load value (NPLV): a single-number part-load *efficiency* figure of merit calculated and referenced to conditions other than *IPLV.I-P* conditions, for units that are not designed to operate at AHRI standard rating conditions.

nonswinging door: see *door*.

nonweatherized space constrained single-package vertical unit: a *single-package vertical air conditioner* (*SPVAC*) or *single-package vertical heat pump* (*SPVHP*) that meets all of the following requirements:

a. Is for indoor use only

b. Has rated cooling capacities no greater than 36,000 Btu/h

c. Is a single-package unit requiring opening in an *exterior wall* or *semiexterior wall* with overall exterior dimensions that requires or uses an existing sleeve that meets one of the following criteria:

1. Has a width of less than 32 in. and height of less than 45 in.
2. Fits inside an existing 1310 in.^{2} opening

d. Is commonly installed in site-built commercial buildings

e. Is of a similar cooling capacity and, if a heat pump, similar heating capacity

f. Draws *outdoor air* for heat exchange directly through an existing opening, used for both inlet and outlet, in the *exterior wall* or *semiexterior wall*

g. Is restricted to applications where an existing air conditioner, heat pump, or gas/electric unit, installed in an existing *exterior wall* or *semiexterior wall* opening, is to be replaced

h. Bears a permanent "Replacement" marking, conspicuously placed, and clearly indicating that its application is limited to installations where an existing air conditioner or heat pump is to be replaced

north-oriented: facing within 45 degrees of true north in the northern hemisphere (however, facing within 45 degrees of true south in the southern hemisphere).

O

~~***occupant***~~ ***occupancy sensor:*** a device that detects the presence or absence of people within an area and causes lighting, *equipment*, or appliances to be regulated accordingly.

on-site renewable energy: *energy* generated from renewable sources produced at the *building* site.

opaque: all areas in the *building envelope*, except *fenestration* and *building service* openings such as vents and grilles. (See *building envelope* and *fenestration*.)

~~***operable:*** see *vertical fenestration.*~~

optimum start controls: *controls* that are designed to ~~automatically~~*automatically* adjust the start time of an *HVAC system* each day with the intention of bringing the *space* to desired occupied temperature levels immediately before scheduled occupancy.

orientation: the direction an *envelope* element faces, i.e., the direction of a vector perpendicular to and pointing away from the surface outside of the element.

outdoor (outside) air: air that is outside the *building envelope* or is taken from outside the *building* that has not been previously circulated through the *building*.

overcurrent: any current in excess of the rated current of *equipment* or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

P

packaged terminal air conditioner (PTAC): a factory-selected *wall* sleeve and separate unencased combination of heating and cooling components, assemblies, or sections. It may include heating capability by hot water, steam, or electricity and is intended for mounting through the *wall* to serve a single room or zone.

packaged terminal heat pump (PTHP): a *PTAC* capable of using the refrigerating *system* in a reverse cycle or heat pump mode to provide heat.

party wall: a fire *wall* on an interior lot line used or adapted for joint ~~*service*~~service between two buildings.

performance rating method: a calculation procedure that generates an index of merit for the performance of *building* designs that substantially exceeds the *energy efficiency* levels required by this standard or when using the *performance rating method* as an alternative path for minimum standard compliance in accordance with Section 4.2.1.1

permanently installed: *equipment* that is ~~*fixed*~~fixed in place and is not portable or movable.

photosensor: a device that detects the presence of visible light, infrared (IR) transmission, and/or ultraviolet (UV) *energy*.

piping: the pipes or tubes interconnecting the various parts of a fluid *distribution system*, including all elements that are in series with the fluid flow, such as pumps, valves, strainers, and air separators, but not including elements that are not in series with the fluid flow, such as expansion tanks, fill lines, chemical feeders, and drains.

plenum: a compartment or chamber to which one or more ducts are connected, that forms a part of the air *distribution system*, and that is not used for occupancy or storage. A *plenum* often is formed in part or in total by portions of the *building*.

pool: any structure, basin, or tank containing an artificial body of water for swimming, diving, or recreational bathing. The term includes, but is not limited to, swimming *pool*, whirlpool, spa, and hot tub.

power roof/wall ventilators (PRV): a fan consisting of a centrifugal or axial impeller with an integral *driver* in a weather-resistant housing and with a base designed to fit, usually by means of a curb, over a *wall* or *roof* opening.

power usage effectiveness (PUE): *computer room energy* divided by *IT equipment energy* calculated in accordance with industry-accepted standards (see Informative Appendix E).

power usage effectiveness—category 0 (PUE0): peak electric *demand* (*kW*) for the entire *computer room*, including IT *equipment* and supporting infrastructure, divided by peak electric *demand* (*kW*) of the IT *equipment*.

power usage effectiveness—category 1 (PUE1): annual *energy* consumption (kWh) for the entire *computer room*, including IT *equipment* and supporting infrastructure, divided by annual *energy* consumption (kWh) of the IT *equipment*.

primary sidelighted area: see *daylight area.*

process load: the load on a *building* resulting from the consumption or release of *process energy*.

projection factor (PF): the ratio of the horizontal depth of the external shading projection divided by the sum of the height of the *fenestration* and the distance from the top of the *fenestration* to the bottom of the farthest point of the external shading projection, in consistent units.

proposed building performance: the annual *energy* cost calculated for a *proposed design*.

proposed design: a computer representation of the actual proposed *building* design, or portion thereof, used as the basis for calculating the *design energy cost*.

public facility restroom: a restroom used by the transient public.

pump system power: the sum of the nominal power *demand* (*nameplate horsepower*) 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.

purchased energy: *energy* or power purchased for consumption and delivered to the *building* site.

purchased energy rates: costs for units of *energy* or power purchased at the *building* site. These costs may include *energy* costs as well as costs for power *demand* as determined by the *adopting authority*.

R

R-value: see *thermal resistance*.

radiant heating system: a heating *system* that transfers heat to objects and surfaces within the *heated space* primarily (greater than 50%) by infrared radiation.

rated motor power: see *motor power, rated*.

rated R-value of insulation: the *thermal resistance* of the insulation alone as specified by the *manufacturer* in units of $h \cdot ft^2 \cdot °F/Btu$ at a *mean temperature* of 75°F. Rated *R-value* refers to the *thermal resistance* of the added insulation in framing cavities or insulated sheathing only and does not include the *thermal resistance* of other *building materials* or air films. (See *thermal resistance*.)

rating authority: the organization or agency that adopts or sanctions use of Normative Appendix G when quantifying performance that exceeds requirements of this standard.

readily accessible: installed in a manner and location that allows it to be 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, chairs, etc. In public facilities, accessibility may be limited to certified personnel through locking covers or by placing *equipment* in locked rooms.

recirculating system: a domestic or ~~*service*~~service hot-water *distribution system* that includes a closed circulation circuit designed to maintain usage temperatures in hot-water pipes near *terminal* devices (e.g., lavatory faucets, shower heads) in order to reduce the time required to obtain hot water when the *terminal* device valve is opened. The motive force for circulation is either natural (due to water density variations with temperature) or mechanical (recirculation pump).

recool: to lower the temperature of air that has been previously heated by a mechanical heating *system*.

record ~~drawings~~documents: drawings and other documents that record the conditions of the project as constructed. These include any refinements of the *construction* or bid documents.

reflectance: the ratio of the light reflected by a surface to the light incident upon it.

refrigeration system, low-temperature: *system* for maintaining food products in their frozen state in refrigeration applications.

refrigeration system, medium-temperature: *system* for maintaining food products above their frozen state in refrigeration applications.

refrigerant dew point: the refrigerant vapor saturation temperature at a specified pressure.

regulated energy use: *energy* used by *building systems* and components with requirements prescribed in Sections 5 through 10. This includes *energy* used for HVAC, lighting, *service water heating*, motors, *transformers*, vertical transportation, refrigeration *equipment*, *computer-room* cooling *equipment*, and other *building systems*, components, and processes with requirements prescribed in Sections 5 through 10.

reheat: to raise the temperature of air that has been previously cooled either by mechanical refrigeration or an economizer *system*.

repair: the reconstruction or renewal of any part of an *existing building* for the purpose of its maintenance.

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

reset: *automatic* adjustment of the controller *set point* to a higher or lower value.

residential: *spaces* in buildings used primarily for living and sleeping. *Residential spaces* include, but are not limited to, *dwelling units*, hotel/motel guest rooms, dormitories, nursing homes, patient rooms in hospitals, lodging houses, fraternity/sorority houses, hostels, prisons, and fire stations.

resistance, electric: the property of an electric circuit or of any object used as part of an electric circuit that determines for a given circuit the rate at which electric *energy* is converted into heat or radiant *energy* and that has a value such that the product of the resistance and the square of the current gives the rate of conversion of *energy*.

roof: the upper portion of the *building envelope*, including *opaque* areas and *fenestration*, that is horizontal or tilted at an angle of less than 60 degrees from horizontal. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

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 *metal building roofs*.

metal building roof: a *roof* that

a. is constructed with a metal, structural, weathering surface;
b. has no ventilated cavity; and
c. 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:
    1. Metal roofing in direct contact with the steel framing members
    2. Metal roofing separated from the steel framing members by insulation
    3. Insulated metal roofing panels installed as described in subitems (a) or (b)

roof with insulation entirely above deck: a *roof* with all insulation

a. installed above (outside of) the *roof* structure and
b. continuous (i.e., uninterrupted by framing members).

single-rafter roof: a subcategory of attic *roofs* where the *roof* above and the ceiling below are both attached to the same wood rafter and where insulation is located in the *space* between these wood rafters.

roof area, gross: the area of the *roof* measured from the exterior faces of *walls* or from the centerline of *party walls*. (See *roof* and *wall*.)

roof covering: the topmost component of the *roof* assembly intended for weather resistance, fire classification, or appearance.

roof monitor: that part of a *building* that projects above the plane of the *roof* and whose *walls* contain *vertical fenestration* for lighting the interior.

roof recovering: the process of installing an additional *roof covering* over an existing *roof covering* without removing the existing *roof covering*.

room air conditioner: an encased assembly designed as a unit to be mounted in a window or through a *wall* or as a console. It is designed primarily to provide direct delivery of conditioned air to an *enclosed space*, room, or zone. It includes a prime source of refrigeration for cooling and dehumidification and a means for circulating and cleaning air. It may also include a means for ventilating and heating.

room cavity ratio (RCR): a factor that characterizes room configuration as a ratio between the *walls* and ceiling and is based upon room dimensions.

S

saturated condensing temperature: the saturation temperature corresponding to the measured refrigerant pressure at the condenser inlet for single component and azeotropic refrigerants, and the arithmetic average of the *refrigerant dew-point* temperature and the bubble-point temperature corresponding to the refrigerant pressure at the condenser entrance for zeotropic refrigerants.

seal class A: a *ductwork* sealing category that requires sealing all transverse joints, longitudinal seams, and duct wall penetrations. Duct wall penetrations are openings made by pipes, holes, conduit, tie rods, or wires. Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow.

seasonal coefficient of performance—cooling ($SCOP_C$): the total cooling output of an air conditioner during its normal annual usage period for cooling divided by the total electric *energy* input during the same period in consistent units (analogous to *SEER* but in I-P or other consistent units).

seasonal coefficient of performance—heating ($SCOP_H$): the total heating output of a heat pump during its normal annual usage period for heating divided by the total electric *energy* input during the same period in consistent units (analogous to *HSPF* but in I-P or other consistent units).

seasonal energy efficiency ratio (SEER): the total cooling output of an air conditioner during its normal annual usage period for cooling (Btu) divided by the total electric *energy* input during the same period (W).

secondary sidelighted area: see *daylight area.*

sectional garage door: see *door.*

~~an upward-acting, *nonswinging door* assembly made of two or more horizontal panels hinged together vertically.~~

semiexterior building envelope: see *building envelope*.

semiexterior wall: see *building envelope* and *wall*.

semiheated floor area: see *floor area, gross*.

semiheated space: see *space*.

sensible cooling panel: a panel designed for sensible cooling of an indoor *space* through heat transfer to the *thermally effective panel surfaces* from the occupants and/or indoor *space* by thermal radiation and natural convection.

sensible energy recovery ratio: change in the dry-bulb temperature of the *outdoor air* supply divided by the difference between the *outdoor air* and entering exhaust air dry-bulb temperatures, expressed as a percentage.

sensible heating panel: a panel designed for sensible heating of an indoor *space* through heat transfer from the *thermally effective panel surfaces* to the occupants and/or indoor *space* by thermal radiation and natural convection.

~~***service:*** the *equipment* for delivering *energy* from the supply or *distribution system* to the premises served.~~

service agency: an agency capable of providing calibration, testing, or manufacture of *equipment*, instrumentation, *metering*, or *control* apparatus, such as a contractor, laboratory, or *manufacturer*.

~~***service equipment:*** the necessary *equipment*, usually consisting of a *circuit breaker* or switch and fuses and accessories, located near the point of entrance of supply conductors to a *building* or other structure (or an otherwise defined area) and intended to constitute the main *control* and means of cutoff of the supply. *Service equipment* may consist of *circuit breakers* or fused switches provided to *disconnect* all under-grounded conductors in a *building* or other structure from the *service* entrance conductors.~~

setback: reduction of heating (by reducing the *set point*) or cooling (by increasing the *set point*) during hours when a *building* is unoccupied or during periods when lesser *demand* is acceptable.

set point: point at which the desired temperature (°F) of the heated or *cooled space* is set.

SHGC: see *solar heat gain coefficient*.

shading coefficient (SC): the ratio of solar heat gain at normal incidence through glazing to that occurring through 1/8 in. thick clear, double-strength glass. *SC* does not include interior, exterior, or integral shading devices.

sidelighting effective aperture: relationship of daylight transmitted through *vertical fenestration* to the *primary sidelighted areas*. The *sidelighting effective aperture* is calculated according to the following formula:

$$\text{Sidelighting Effective Aperture} = \frac{\sum \text{Vertical Fenestration Area} \times \text{Vertical Fenestration VT}}{\text{Area of Primary Sidelighted Area}}$$

where "*Vertical Fenestration VT*" is the *visible transmittance* of *vertical fenestration* as determined in accordance with Section 5.8.2.5.

simulation program: a computer program that is capable of simulating the *energy* performance of *building systems*.

single-line diagram: a simplified schematic drawing that shows the connection between two or more items. Common multiple connections are shown as one line.

single-package vertical air conditioner (SPVAC): a type of air-cooled small or large commercial package air-conditioning and heating *equipment*; factory assembled as a single package having its major components arranged vertically, which is an encased combination of cooling and optional heating components; is intended for exterior mounting on, adjacent interior to, or through an outside *wall* and is powered by single or three-phase current. It may contain separate indoor grilles, outdoor louvers, various *ventilation* options, or indoor free air discharge, *ductwork*, *wall plenum*, or sleeve. Heating components may include electrical resistance, steam, hot water, gas, or no heat, but may not include reverse-cycle refrigeration as a heating means.

single-package vertical heat pump (SPVHP): an *SPVAC* that utilizes reverse-cycle refrigeration as its primary heat source, with secondary supplemental heating by means of electrical resistance, steam, hot water, or gas.

single-rafter roof: see *roof*.

single-zone system: an *HVAC system* serving a single *HVAC zone*.

site-recovered energy: waste *energy* recovered at the *building* site that is used to offset consumption of purchased *fuel* or electrical *energy* supplies.

site-solar energy: thermal, chemical, or electrical *energy* derived from direct conversion of incident solar radiation at the *building* site and used to offset consumption of purchased *fuel* or electrical *energy* supplies. For the purposes of applying this standard, *site-solar energy* shall not include passive heat gain through *fenestration systems*.

skylight: a *fenestration* surface having a slope of less than 60 degrees from the horizontal plane. Other *fenestration*, even if mounted on the *roof* of a *building*, is considered *vertical fenestration*.

skylight effective aperture: the overall amount of *visible transmittance* of the *roof* via *skylights*. *Skylight effective aperture* is calculated according to the following formula:

$$\text{Skylight Effective Aperture} = \frac{0.85 \times \textbf{Skylight Area} \times \textbf{Skylight VT} \times \text{WF}}{\text{Daylight Area Under Skylights}}$$

where

skylight area = total *fenestration area* of *skylights*

skylight VT = area-weighted average *visible transmittance* of *skylights* as determined in accordance with Section 5.8.2.5.

WF = area-weighted average *skylight well* factor, where *skylight well* factor is 0.9 if *skylight well* depth is less than 2 ft, or 0.7 if *skylight well* depth is 2 ft or greater. *Skylight well* depth is measured vertically from the underside of the lowest point on the *skylight* glazing to the ceiling plane under the *skylight*.

skylight well: the shaft from the *skylight* to the ceiling.

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 in. below the final elevation of the nearest exterior *grade*.

heated slab-on-grade floor: a *slab-on-grade floor* with a heating source either within or below it.

unheated slab-on-grade floor: a *slab-on-grade floor* that is not a *heated slab-on-grade floor*.

Table 3.2 *Heated Space* Criteria

Climate Zone	Heating Output, Btu/h·ft^2
0	>5
1	>5
2	>5
3A, 3B	>9
3C	>7
4A, 4B	>10
4C	>8
5	>12

6	>14
7	>16
8	>19

small electric motor: a NEMA general purpose, alternating current, single-speed induction motor, built in a two-digit frame number series in accordance with NEMA Standards Publication MG1-1987, including IEC metric equivalent motors; constructed in the NEMA 42, 48, and 56 frame sizes or IEC metric equivalent.

solar energy source: source of thermal, chemical, or electrical *energy* derived from direct conversion of incident solar radiation at the *building* site.

solar heat gain coefficient (SHGC): the ratio of the solar heat gain entering the *space* through the *fenestration area* 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*. (See *fenestration area*.)

space: an *enclosed space* within a *building*. The classifications of *spaces* are as follows for the purpose of determining *building envelope* requirements:

conditioned space: a *cooled space*, *heated space*, or *indirectly conditioned space* defined as follows:

a. ***cooled space:*** an *enclosed space* within a *building* that is cooled by a cooling *system* whose sensible output capacity is ≥3.4 Btu/h·ft^2 of ~~*floor area*~~floor area.

b. ***heated space:*** an *enclosed space* within a *building* that is heated by a heating *system* whose output capacity relative to the ~~*floor area*~~floor area is greater than or equal to the criteria in Table 3.2.

c. ***indirectly conditioned space:*** an *enclosed space* within a *building* that is not a *heated space* or a *cooled space*, which is heated or cooled indirectly by being connected to adjacent *spaces*, provided:

1. the product of the *U-factors* and surface areas of the *space* adjacent to connected *spaces* exceeds the combined sum of the product of the *U-factor*s and surface areas of the *space* adjoining the outdoors, *unconditioned spaces*, and to or from *semiheated spaces* (e.g., corridors) or

2. that air from heated or *cooled spaces* is intentionally transferred (naturally or mechanically) into the *space* at a rate exceeding 3 ach (e.g., atria).

semiheated space: an *enclosed space* within a *building* that is heated by a heating *system* whose output capacity is greater than or equal to 3.4 Btu/h·ft^2 of ~~*floor area*~~floor area but is not a *conditioned space*.

unconditioned space: an *enclosed space* within a *building* that is not a *conditioned space* or a *semiheated space*. Crawlspaces, attics, and parking garages with natural or mechanical *ventilation* are not considered *enclosed spaces*.

space-conditioning category:

a. *nonresidential conditioned space* (See *nonresidential*.)

b. *residential conditioned space* (See *residential*.)

c. *nonresidential* and *residential semiheated space* (See *space*.)

steel-framed wall: see *wall*.

steel-joist floor: see *floor*.

story: portion of a *building* that is between one finished *floor* level and the next higher finished *floor* level or the *roof*, provided, however, that a basement or cellar shall not be considered a story.

substantial contact: a condition where adjacent *building materials* are placed so that proximal surfaces are contiguous, being installed and supported so they eliminate voids between materials without compressing or degrading the thermal performance of either product.

swinging door: see *door*.

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

T

task lighting: lighting directed to a specific surface or area that provides illumination for visual tasks.

temperature control throttling range: the number of degrees that room temperature must change in order to go from full heating to no heating or from full cooling to no cooling.

terminal: a device by which *energy* from a *system* is finally delivered, e.g., registers, diffusers, lighting *fixtures*, faucets, etc.

thermal block: a collection of one or more *HVAC zones* grouped together for simulation purposes. *Spaces* need not be contiguous to be combined within a single *thermal block.*

thermal conductance (C-factor): time rate of steady-state heat flow through unit area of a material or *construction*, induced by a unit temperature difference between the body surfaces (Btu/h·ft^2·°F). Note that the *C-factor* does not include soil or air films.

thermal resistance (R-value): the reciprocal of the time rate of heat flow through a unit area induced by a unit temperature difference between two defined surfaces of material or *construction* under steady-state conditions (h·ft^2·°F/Btu).

thermal transmittance (U-factor): heat transmission in unit time through unit area of a material or *construction* and the boundary air films, induced by unit temperature difference between the environments on each side (Btu/h·ft^2·°F).

thermally effective panel surface: any exterior surface of a panel that is intended to transfer heat between the panel and the occupants and/or the indoor *space*.

thermally ineffective panel surface: any exterior surface of a panel, which is not intended to transfer heat between the panel and the occupants and/or the indoor *space*.

thermostat: an *automatic control device* used to maintain temperature at a ~~*fixed*~~fixed or adjustable *set point*.

thermostatic control: an *automatic control device* or *system* used to maintain temperature at a ~~*fixed*~~fixed or adjustable *set point*.

tinted: (as applied to *fenestration*) bronze, green, blue, or gray coloring that is integral with the glazing material. Tinting does not include surface-applied films such as reflective coatings, applied either in the field or during the manufacturing process.

transfer air: air transferred from one room to another through openings in the room *envelope*, whether it is transferred intentionally or not. The driving force for *transfer air* is generally a small pressure differential between the rooms, although one or more fans may be used.

transformer: a piece of electrical *equipment* used to convert electric power from one voltage to another voltage.

dry-type transformer: a *transformer* in which the core and coils are in a gaseous or dry compound.

liquid-immersed transformer: a *transformer* in which the core and coils are immersed in an insulating liquid.

toplighting: lighting *building* interiors with daylight admitted through *fenestration*, such as *skylights* and *roof monitors*, located on the *roof*.

U

U-factor: see *thermal transmittance*.

unconditioned space: see *space*.

unenclosed space: a *space* that is not an *enclosed space*.

unitary cooling equipment: one or more factory-made assemblies that normally include an evaporator or cooling coil and a compressor and condenser combination. Units that perform a heating function are also included.

unitary heat pump: one or more factory-made assemblies that normally include an indoor conditioning coil, compressors, and an outdoor refrigerant-to-air coil or refrigerant-to-water heat exchanger. These units provide both heating and cooling functions.

unmet load hour: an hour in which one or more zones is outside of the *thermostat set point* plus or minus one half of the *temperature control throttling range*. Any hour with one or more zones with an unmet cooling load or unmet heating load is defined as an *unmet load hour*.

unregulated energy use: *energy* used by *building systems* and components that is not *regulated energy use*. (See *regulated energy use*.)

V

variable-air-volume (VAV) system: *HVAC system* that *controls* the dry-bulb temperature within a *space* by varying the volumetric flow of heated or cooled supply air to the *space*.

variable-refrigerant-flow (VRF) system: an engineered direct expansion (DX) multisplit *system* incorporating at least one variable capacity compressor distributing refrigerant through a *piping* network to multiple indoor fan-coil units, each capable of individual zone temperature *control*, through integral zone temperature *control devices* and common communications network. Variable refrigerant flow utilizes three or more steps of *control* on common, interconnecting *piping*.

vegetative roof system: vegetation, *growth media*, drainage *system*, and waterproofing over a *roof* deck.

vent damper: a device intended for installation in the venting *system* of an individual, ~~automatically~~*automatically* operated, fossil-*fuel*-fired appliance in the outlet or downstream of the appliance draft *control device*, which is designed to ~~automatically~~*automatically* open the venting *system* when the appliance is in operation and to ~~automatically~~*automatically* close off the venting *system* when the appliance is in a standby or shutdown condition.

ventilation: the process of supplying or removing air by natural or mechanical means to or from any *space*. Such air is not required to have been conditioned.

ventilation system motor nameplate horsepower (hp): the sum of the motor *nameplate horsepower* of all fans that are required to operate as part of the *system*.

vertical fenestration: all *fenestration* other than *skylights*. Trombe *wall* assemblies, where glazing is installed within 12 in. of a *mass wall*, are considered *walls*, not *fenestration*. For the purposes of determining *building envelope* requirements, the *vertical fenestration* classifications are defined as follows:

metal framing: products with *metal framing* with or without thermal break.

metal framing, entrance door: any doorway, set of *doors*, turnstile, vestibule, or other form of portal that is ordinarily used to gain access by its users and occupants to the *building* or to individual tenant *spaces* accessed from the exterior. (See *building entrance* and *door*.)

metal framing, fixed: all types of *vertical fenestration*, other than *entrance door* and ~~*operable*~~operable, including, but not limited to, curtain *walls*, window *walls*, *fixed* windows, picture windows, glass block *walls*, nonopenable clerestory windows, and nonopenable sidelights and transoms.

metal framing, operable: all *vertical fenestration* that opens, except *entrance doors*, including, but not limited to, casement windows, projecting windows, pivoting windows, horizontal sliding windows, vertical sliding windows, openable clerestory windows, openable sidelights and transoms, sliding glass *doors*, and *doors* that are not *entrance doors*.

nonmetal framing: all products with framing materials other than metal with or without metal reinforcing or cladding.

visible transmittance (VT): the ratio of visible radiation entering the *space* through the *fenestration* product to the incident visible radiation, determined as the spectral transmittance of the total *fenestration system*, weighted by the photopic response of the eye and integrated into a single dimensionless value.

voltage drop: a decrease in voltage caused by losses in the lines connecting the power source to the load.

VT: see *visible transmittance*.

W

walk-in cooler: an enclosed storage *space* of <3000 ft^2 that can be walked into and that is designed to maintain a *space* temperature of >32°F and ≤55°F.

walk-in freezer: an enclosed storage *space* of <3000 ft^2 that can be walked into that is designed to maintain a *space* temperature of ≤32°F.

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- and *below-grade walls*, between *floor* spandrels, peripheral edges of *floors*, and foundation *walls*. For the purposes of determining *building envelope* requirements, the classifications are defined as follows:

above-grade wall: a *wall* that is not a *below-grade wall*.

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.

mass wall: a *wall* with a *heat capacity* exceeding (1) 7 $Btu/ft^2 \cdot °F$ or (2) 5 $Btu/ft^2 \cdot °F$, provided that the *wall* has a material unit weight not greater than 120 lb/ft^3.

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*).

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*).

wood-framed and other walls: all other *wall* types, including wood stud *walls*.

wall area, gross: the area of the *wall* measured on the exterior face from the top of the *floor* to the bottom of the *roof*.

warm-up: increase in *space* temperature to occupied *set point* after a period of shutdown or *setback*.

water heater: vessel in which water is heated and is withdrawn for use external to the *system.*

wood-framed and other floors: see *floor*.

wood-framed and other walls: see *wall*.

…

4.1 General

4.1.1 Scope

4.1.1.1 New Buildings

New *buildings* shall comply with the standard as described in Section 4.2.

4.1.1.2 Additions to Existing Buildings

~~An extension or increase in the *floor* area or height of a *building* outside of the *existing building envelope* shall be considered additions to *existing buildings* and shall comply with the standard as described in Section 4.2.~~

Additions to *existing buildings* shall comply with the standard as described in Section 4.2.

4.1.1.3 Alterations of Existing Buildings

Alterations of *existing buildings* shall comply with the standard as described in Section 4.2.

…

4.2 Compliance

4.2.1 Compliance Paths

4.2.1.1 New Buildings

New *buildings* shall comply with Sections 4.2.2 through 4.2.5 and either the provisions of

a. Section 5, "*Building Envelope*"; Section 6, "Heating, Ventilating, and Air Conditioning"; Section 7, "*Service Water Heating*"; Section 8, "Power"; Section 9, "Lighting"; and Section 10, "Other *Equipment*," or

b. Section 11, "*Energy Cost Budget* Method," or

c. Normative Appendix G, "*Performance Rating Method*."

When using Appendix G, the Performance Cost Index (PCI) of new *buildings*, *additions* to *existing buildings* and/or *alterations* to *existing buildings* shall be less than or equal to the Performance Cost Index Target (PCI_t) when calculated in accordance with the following:

$$PCI_t = [BBUEC + (BPF \times BBREC)]/BBP$$

where

PCI = Performance Cost Index calculated in accordance with Section G1.2.

BBUEC = Baseline *Building* Unregulated *Energy* Cost, the portion of the annual *energy* cost of a *baseline building design* that is due to *unregulated energy use*.

BBREC = Baseline *Building* Regulated *Energy* Cost, the portion of the annual *energy* cost of a *baseline building design* that is due to *regulated energy use*.

BPF = *Building* Performance Factor from Table 4.2.1.1. For *building* area types

not listed in Table 4.2.1.1 use "All others." Where a *building* has multiple *building* area types, the required BPF shall be equal to the area-weighted average of the *building* area types.

BBP = Baseline Building Performance.

…

4.2.1.2 Additions to Existing Buildings

Additions to *existing buildings* shall comply with ~~either~~ the provisions of Sections 4.2.2 through 4.2.5 and one of the following:

a. Section 5,"Building Envelope"; Section 6, "Heating, Ventilating, and Air"; Section 7, "Service Water Heating"; Section 8, "Power"; Section 9, "Lighting"; and Section 10, "Other Equipment," or

b. Section 11, "Energy Cost Budget Method," or

c. Normative Appendix G, "Performance Rating Method" in accordance with Section 4.2.1.1.

4.2.1.2.1

When an ~~addition~~*addition* to an *existing building* cannot comply by itself, trade-offs will be allowed by modification to one or more of the existing components of the *existing building*. Modeling of the modified components of the *existing building* and ~~addition~~*addition* shall employ the procedures of Section 11 or Normative Appendix G; the ~~addition~~*addition* shall not increase the *energy* consumption of the *existing building* plus the ~~addition~~*addition* beyond the *energy* that would be consumed by the *existing building* plus the ~~addition~~*addition* if the ~~addition~~*addition* alone did comply.

4.2.1.3 Alterations of Existing Buildings

Alterations of *existing buildings* shall comply with the provisions of Sections 4.2.2 through 4.2.5 and one of the following:

a. Section~~s~~ 5, "Building Envelope"; Section 6, "Heating, Ventilating, and Air"; Section 7, "Service Water Heating"; Section 8, "Power"; Section 9, "Lighting"; and Section 10, "Other Equipment," or

b. Section 11, "Energy Cost Budget Method," or

c. Normative Appendix G, "Performance Rating Method" in accordance with Section 4.2.1.1.

Exception to 4.2.1.3

A *building* that has been specifically designated as historically significant by the *adopting authority* or is listed in The National Register of *Historic* Places or has been determined to be eligible for listing by the U.S. Secretary of the Interior need not comply with these requirements.

4.2.2 Compliance Documentation

4.2.2.1 Construction Details

Compliance documents shall show all the pertinent data and features of the *building*, *equipment*, and *systems* in sufficient detail to permit a determination of compliance by the *building official* and to indicate compliance with the requirements of this standard.

4.2.2.2 Supplemental Information

Supplemental information necessary to verify compliance with this standard, such as calculations, worksheets, compliance forms, vendor literature, or other data, shall be made available when required by the *building official*.

4.2.2.3 Manuals

Operating and maintenance information shall be provided to the *building* owner. This information shall include, but not be limited to, the information specified in Sections 5.7.3.2,~~6.7.2.2~~ 6.7.3.2, 7.7.3.2, ~~8.7.2~~8.7.3.2, ~~and~~ ~~9.7.2.2~~9.7.3.2, and 10.7.3.2.

4.2.3 Labeling of Material and Equipment

Materials and *equipment* shall be *labeled* in a manner that will allow for a determination of their compliance with the applicable provisions of this standard.

4.2.4 Inspections

All *building construction*, additions, or *alterations* work subject to the provisions of this standard shall remain accessible and exposed for inspection purposes until approved in accordance with the procedures specified by the *building official*.

…

5.2 Compliance Paths

The *building envelope* shall comply with Section 5.2.1 and Section 5.2.2.

5.2.1 Requirements for All Compliance Paths

~~For the appropriate climate, *space conditioning category*, and *class of construction*, t~~The *building envelope* shall comply with Section 5.1, "General"; Section 5.4, "Mandatory Provisions"; Section 5.7, "Submittals"; Section 5.8, "Product Information and Installation Requirements"; and Section 5.9, "Inspection and Verification";~~ and either~~

5.2.2 Additional Requirements to Comply with Section 5

The ~~building envelope~~*building envelope* shall comply with either of the following:

a. Section 5.5, "Prescriptive *Building Envelope* ~~Option~~Compliance Path," provided that the *fenestration area* does not exceed the maximum allowed by Section 5.5.4.2, or

b. Section 5.6, "*Building Envelope* Trade-Off ~~Option~~Compliance Path."

~~Projects using the *Energy Cost Budget* Method (see Section 11 of this standard) must comply with Section 5.4, the mandatory provisions of this section, as a portion of that compliance path.~~

5.3 Simplified Building Compliance Path (Not Used)

5.4 Mandatory Provisions

5.4.1 Insulation

Where insulation is required in Section 5.5 or Section 5.6, it shall comply with the requirements found in Section 5.8.1.

5.4.2 Fenestration and Doors

Procedures for determining *fenestration* and *door* performance are described in Section 5.8.2. Product samples used for determining *fenestration* performance shall be production line units or representative of units purchased by the consumer or contractor.

…

5.4.3.1.3 Testing, Acceptable Materials, and Assemblies

The *building* shall comply with whole-*building* pressurization testing in accordance with Section 5.4.3.1.3(a) or with the *continuous air barrier* requirements in Section 5.4.3.1.3(b) or 5.4.3.1.3(c).

a. Whole-*building* pressurization testing shall be conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air leakage rate of the *building envelope* shall not exceed 0.40 cfm/ft^2

under a pressure differential of 0.3 in. of water, with this air leakage rate normalized by the sum of the above and below-*grade building envelope* areas of the *conditioned* and *semiheated space*.

Exceptions to 5.4.3.1.3(a)

1. For *buildings* having over 50,000 ft^2 of *gross conditioned floor area*, air leakage testing shall be permitted to be conducted on less than the whole *building*, provided the following portions of the *building* are tested and their measured air leakage is area-weighted by the surface areas of the *building envelope*:
   a. The entire *floor* areafloor area of all stories that have any *spaces* directly under a *roof.*
   b. The entire *floor* areafloor area of all stories that have a *building entrance* or loading dock.
   c. Representative *above-grade wall* sections of the *building* totaling at least 25% of the *wall* area enclosing the remaining *conditioned space*; *floor* areafloor area tested per (a) and (b) shall not be included in the 25%.
2. Where the measured air leakage rate exceeds 0.40 cfm/ft^2 but does not exceed 0.60 cfm/ft^2, a diagnostic evaluation, such as a smoke tracer or infrared imaging shall be conducted while the *building* is pressurized, and any leaks noted shall be sealed if such sealing can be made without destruction of *existing building* components. In addition, a visual inspection of the air barrier shall be conducted, and any leaks noted shall be sealed if such sealing can be made without destruction of *existing building* components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the *code official* and the *building* owner and shall be deemed to satisfy the requirements of this section.

…

Vestibules

Building entrances that separate *conditioned space* from the exterior shall be protected with an enclosed vestibule, with all *doors* opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior *doors* to open at the same time. Interior and exterior *doors* shall have a minimum distance between them of not less than 7 ft when in the closed position. The ~~*floor area*~~floor area of each vestibule shall not exceed the greater of 50 ft^2 or 2% of the *gross conditioned floor area* for that level of the *building*. The exterior envelope of conditioned vestibules shall comply with the requirements for a *conditioned space*. The interior and exterior envelope of unconditioned vestibules shall comply with the requirements for a *semiheated space*.

Exceptions to 5.4.3.4

1. *Building entrances* with revolving *doors.*
2. *Doors* not intended to be used as a *building entrance.*
3. *Doors* opening directly from a *dwelling unit.*
4. *Building entrances* in *buildings* located in Climate Zone 1 or 2.
5. *Building entrances* in *buildings* that are located in Climate Zone 3, less than four stories above *grade*, and less than 10,000 ft^2 in *gross conditioned floor area.*
6. *Building entrances* in *buildings* that are located in Climate Zone 0, 4, 5, 6, 7, or 8 and are less than 1000 ft^2 in *gross conditioned floor area.*
7. *Doors* that open directly from a *space* that is less than 3000 ft^2 in area and is separate from the *building entrance.*
8. *Semiheated spaces*.
9. Enclosed elevator lobbies for *building entrances* directly from parking garages.

5.4.3.4.1

Where vestibules are required under Section 5.4.3.4, for *spaces* having a *gross conditioned floor area* for that level of the *building* of 40,000 ft^2 and greater, and when the *doors* opening into and out of the vestibule are equipped with *automatic*, electrically driven, self-closing devices, the interior and exterior *doors* shall have a minimum distance between them of not less than 16 ft.

5.5 Prescriptive Building Envelope ~~Option~~ Compliance Path

5.5.1 Exterior Building Envelope

For a *conditioned space*, the *exterior building envelope* shall comply with either the *nonresidential* or *residential* requirements in Tables 5.5-0 through 5.5-8 for the appropriate climate.

5.5.2 Semi-~~E~~exterior Building Envelope

If a *building* contains any *semiheated space* or *unconditioned space* then the *semiexterior building envelope* shall comply with the requirements for *semiheated space* in Tables 5.5-0 through 5.5-8 for the appropriate climate. (See Figure 5.5.2.)

…

Exceptions to 5.5.3.1.1

1. Ballasted *roofs* with a minimum stone ballast of 17 lb/ft^2 or 23 lb/ft^2 pavers.
2. *Vegetative roof systems* that contain a minimum thickness of 2.5 in. of growing medium and covering a minimum of 75% of the *roof* area with durable plantings.
3. *Roofs* where a minimum of 75% of the *roof* area
   a. is shaded during the peak sun angle on June 21 by permanent components or features of the *building*;
   b. is covered by offset photovoltaic arrays, *building*-integrated photovoltaic arrays, or solar air or water collectors; or
   c. is permitted to be interpolated using a combination of 1 and 2 above.
4. Steep-sloped *roofs*.
5. Low-sloped *metal building roofs* in Climate Zones 2 and 3.
6. *Roofs* over ventilated attics, *roofs* over *semiheated spaces*, or *roofs* over *conditioned spaces* that are not *cooled spaces*.
7. Asphaltic membranes in Climate Zones 2 and 3.

…

5.5.4.2 Fenestration Area

5.5.4.2.1 Vertical Fenestration Area

The total *vertical fenestration area* shall not be greater than that specified in Tables 5.5-0 through 5.5-8.

Exception to 5.5.4.2.1

Vertical fenestration complying with Exception (3) to Section 5.5.4.4.1.

5.5.4.2.2 Maximum Skylight Fenestration Area

The total *skylight* area shall not be greater than that specified in Tables 5.5-0 through 5.5-8.

Exception to 5.5.4.2.2

The total *skylight* area is permitted to be increased to no greater than 6% of the *gross roof area*, provided the *skylights* meet all of the criteria in Exception (1) to Section 5.5.4.4.2 and the total *daylight area under skylights* is a minimum of half the ~~*floor area*~~floor area of the *space*.

5.5.4.2.3 Minimum Skylight Fenestration Area

In any *enclosed space* in a *building* that is

a. 2500 ft^2 and greater;

b. directly under a *roof* with ceiling heights greater than 15 ft; and

c. one of the following *space* types: office, lobby, atrium, concourse, corridor, storage (including nonrefrigerated warehouse), gymnasium, fitness/exercise area, playing area, gymnasium seating area, convention exhibit/event space, courtroom, automotive service, fire station engine room, manufacturing corridor/transition and bay areas, retail, library reading and stack areas, distribution/sorting area, transportation baggage and seating areas, or workshop,

the total *daylight area under skylights* shall be a minimum of half the ~~*floor area*~~floor area and either

a. provide a minimum *skylight* area to *daylight area under skylights* of 3% with a *skylight VT* of at least 0.40 or

b. provide a minimum *skylight effective aperture* of at least 1%.

These *skylights* shall have a glazing material or diffuser with a measured haze value greater than 90% when tested according to ASTM D1003. *General lighting* in the *daylight area* shall be controlled as described in Section 9.4.1.1(f).

Exceptions to Section 5.5.4.2.3

1. *Enclosed spaces* in Climate Zones 6 through 8
2. *Enclosed spaces* where it is documented that existing structures or natural objects block direct-beam sunlight on at least half of the *roof* over the *enclosed space* for more than 1500 daytime hours per year between 8 a.m. and 4 p.m.
3. *Enclosed spaces* where the *daylight area under roof monitors* is greater than 50% of the *enclosed space* ~~*floor area*~~floor area.
4. *Enclosed spaces* where it is documented that 90% of the *skylight* area is shaded on June 21 in the Northern Hemisphere (December 21 in the Southern Hemisphere) at noon by permanent architectural features of the *building.*
5. *Enclosed spaces* where the total area minus the *primary sidelighted area* and *secondary sidelighted area* is less than 2500 ft^2 and where the lighting is controlled according to sidelighting requirements described in Section 9.4.1.1(e).

5.5.4.3 Fenestration U-Factor

Fenestration shall have a *U-factor* not greater than that specified in Tables 5.5-0 through 5.5-8.

Exception to 5.5.4.3

The *U-factor* for *skylights* is permitted to be increased to no greater than 0.90 Btu/h·ft^2·°F in Climate Zones 0 through 3 and 0.75 Btu/h·ft^2·°F in Climate Zones 4 through 8, provided the *skylights* meet all of the criteria in Exception (1) to Section 5.5.4.4.2.

5.5.4.4 Fenestration Solar Heat Gain Coefficient (SHGC)

5.5.4.4.1 SHGC of Vertical Fenestration

Vertical fenestration shall have an *SHGC* not greater than that specified in Tables 5.5-0 through 5.5-8.

Exceptions to Section 5.5.4.4.1

1. For demonstrating compliance for south-, east-, or west-oriented *vertical fenestration* shaded by opaque permanent projections that will last as long as the *building* itself, the *SHGC* of the shaded *vertical fenestration* in the *proposed design* is permitted to be reduced by using the multipliers in Table 5.5.4.4.1. Permanent

projections consisting of open louvers shall be considered to provide shading, provided that no sun penetrates the louvers during the peak sun angle on June 21.

2. For demonstrating compliance for south-, east-, or west-oriented *vertical fenestration* shaded by partially opaque permanent projections (e.g., framing with glass or perforated metal) that will last as long as the *building* itself, the *projection factor* (*PF*) shall be reduced by multiplying it by a factor of O_s, which is derived as follows:

Table 5.5.4.4.1 *SHGC* Multipliers for Permanent Projections

Projection Factor	*SHGC* Multiplier (South, East, and West Orientations)
0 to 0.10	1.00
>0.10 to 0.20	0.91
>0.20 to 0.30	0.82
>0.30 to 0.40	0.74
>0.40 to 0.50	0.67
>0.50 to 0.60	0.61
>0.60 to 0.70	0.56
>0.70 to 0.80	0.51
>0.80 to 0.90	0.47
>0.90 to 1.00	0.44

$$O_s = (A_i \times O_i) + (A_f \times O_f)$$

where

O_s = percent opacity of the shading device

A_i = percent of the area of the shading device that is a partially ~~*opaque* infill~~opaque infill

O_i = percent opacity of the infill for glass $O_i = (100\% - T_s)$, where T_s is the solar transmittance as determined in accordance with NFRC 300; for perforated or decorative metal panels, O_i = percentage of solid material

A_f = percent of the area of the shading device that represents the framing members

O_f = percent opacity of the framing members; if solid then 100%

The *SHGC* of the shaded *vertical fenestration* in the proposed *building* is permitted to then be reduced by using the multipliers in Table 5.5.4.4.1 for each *fenestration* product.

3. *Vertical fenestration* that is located on the street side of the street-level story only, provided that

   a. the street side of the street-level story does not exceed 20 ft in height,

   b. the *fenestration* has a continuous overhang with a weighted average *PF* greater than 0.5, and

   c. the *fenestration area* for the street side of the street-level story is less than 75% of the *gross wall area* for the street side of the street-level story.

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. No credit shall be given here or elsewhere in the *building* for not fully utilizing the *fenestration area* allowed.

4. For *dynamic glazing*, the minimum *SHGC* shall be used to demonstrate compliance with this section. *Dynamic glazing* shall be considered separately from other *vertical fenestration*, and area-weighted averaging with other *vertical fenestration* that is not *dynamic glazing* shall not be permitted.
5. *Vertical fenestration* that is *north oriented* shall be permitted to have an *SHGC* equal to or less than the area-weighted average *SHGC* of the south-, east-, and west-oriented *vertical fenestration* before any reductions made for permanent projections in Exceptions 1 and 2 of Section 5.5.4.4.1.

…

5.5.4.6 Visible Transmittance/SHGC Ratio

Where *automatic* daylighting *controls* are required in accordance with 9.4.1.1(e) or (f), *fenestration* shall have a ratio of *VT* divided by *SHGC* not less than that specified in Tables 5.5-0 through 5.5-8 for the appropriate *fenestration area*.

Exceptions to Section 5.5.4.6

1. A *light-to-solar-gain ratio* (*LSG*) of not less than 1.25 is allowed to be used as an alternative to *VT*/*SHGC*. When using this option, the center-of-glass *VT* and the center-of-glass *SHGC* shall be determined in accordance with NFRC 300 and NFRC 301, determined by an independent laboratory or included in a database published by a government agency, and certified by the *manufacturer*.
2. *Fenestration* not covered in the scope of the NFRC 200.
3. *Enclosed spaces* where the *daylight area under roof monitors* is greater than 50% of the *enclosed space* ~~*floor area*~~floor area.
4. *Enclosed spaces* with *skylights* that comply with Section 5.5.4.2.3.
5. *Enclosed spaces* where the *sidelighting effective aperture* is greater than or equal to 0.15.
6. For *dynamic glazing*, the *VT*/*SHGC* ratio and the *LSG* 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.

5.6 Building Envelope Trade-Off ~~Option~~Compliance Path

5.6.1

The *building envelope* complies with the standard if

a. the *proposed design* satisfies the provisions of Sections 5.1, 5.4, 5.7, 5.8, and 5.9 and
b. the *proposed envelope performance factor* of the *proposed design* is less than or equal to the *proposed envelope performance factor* of the *base design*.

5.6.1.1

All components of the *building envelope* shown on architectural drawings or installed in *existing buildings* shall be modeled in the *proposed design*. The *simulation program* model *fenestration* and *opaque building envelope* types and area shall be consistent with the *construction documents*. Any *building envelope* assembly that covers less than 5% of the total area of that assembly type (e.g., *exterior walls*) need not be separately described, provided it is similar to an assembly being modeled. If not separately described, the area of a *building envelope* assembly shall be added to the area of an assembly of that same type with the same *orientation* and thermal properties.

…

5.7.1 General

~~The *authority having jurisdiction* may require submittal of c~~Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

5.7.2 Permit Application Documentation

Application documents shall include, at a minimum, the type and *rated R-value of insulation* for each product; *opaque door* schedule showing the *U-factor* for each *opaque door* product as determined in accordance with Section 5.8.2; *fenestration* schedule showing the manufacturer, model number, orientation, area, *U-factor*, *SHGC*, and *VT* for each *fenestration* product as determined in accordance with Section 5.8.2; and air leakage details in accordance with Section 5.4.3. In addition, the following shall apply:

~~**5.7.2 Submittal Document Labeling of Space-Conditioning Categories**~~

a. Labeling of *Space-Conditioning Categories*~~.~~: For *buildings* that contain *spaces* that will be only *semiheated space* or *unconditioned space*, and compliance is sought using the *semiheated space building envelope* criteria, such *spaces* shall be clearly indicated on the *floor* plans ~~that are submitted for review~~.

~~**5.7.3 Visible Transmittance**~~

~~Test results required in Section 5.8.2.5 for *skylight* glazing or diffusers shall be included with *construction documents* submitted with each application for a permit.~~

~~**5.7.4 Submittal Documentation of Daylight Areas**~~

b. Labeling of *Daylight Areas*~~.~~: Daylighting documentation shall identify *daylight areas* on *floor* plans, including the *primary sidelighted areas*, *secondary sidelighted areas*, *daylight area under skylights*, and *daylight area under roof monitor*.

5.7.3 Completion Requirements

5.7.3.1 Record Documents

Construction documents shall require that, within 90 days after the date of *building envelope* acceptance, *record documents* be provided to the building owner or the designated representative of the building owner. *Record document* shall include, a~~s~~t a minimum, those items listed in Section 5.7.2~~,~~ and the following:

a. A report providing the results of air leakage verification of the ~~building envelope~~*building envelope* in accordance with Section 5.9.2.

b. Insulation documentation in accordance with 5.8.1.11.

5.7.3.2 Manuals.

Construction documents shall require that an operating manual and a maintenance manual be provided to the *building* owner or the designated representative of the *building* owner within 90 days after the date of *building envelope* acceptance. These manuals shall be in accordance with industry-accepted standards (see Informative Appendix E) and shall include, at a minimum, the following:

a. Operation manuals and maintenance manuals for each component of the *building envelope* requiring maintenance, except components not furnished as part of the project. Required routine maintenance actions shall be clearly identified.

5.8 Product Information and Installation Requirements

5.8.1 Insulation

5.8.1.1 Labeling of Building Envelope Insulation

The *rated R-value of insulation* shall be clearly identified by an identification mark applied by the *manufacturer* to each piece of *building envelope* insulation.

Exception to 5.8.1.1

When insulation does not have such an identification mark, the *rated R-value of insulation* and the additional information specified below shall be identified by the *manufacturer* on each package, shipping container, or bundle of insulation. Insulation documentation shall be provided in accordance with Section 5.8.1.11 and the following: ~~the installer of such insulation shall provide a signed and dated certification for the installed insulation listing the type of insulation, the *manufacturer*, the rated *R-value of insulation*, and, where appropriate, the initial installed thickness, the settled thickness, and the coverage area.~~

1. For batts and blankets of any type: the *rated R-value of insulation*, length, width, thickness.
2. For boardstock: the *rated R-value of insulation*, length, width, and thickness of the boards in the package.
3. For all loose-fill insulation: the minimum settled thickness, initial installed thickness, maximum net coverage area, number of bags per 1000 ft^2 (100 m^2) and minimum weight per ft^2 (m^2) at *R-values* of 13, 19, 30, 38, and 49 (per m^2 at *R-values* of 2.3, 3.4, 5.3, 6.7, and 8.6). The package shall also state the minimum net weight of the insulation in the package.

~~1.~~4. For spray-applied polyurethane foam: the *R-value* for the insulation~~:~~ at a 1 in. (25 mm) thickness and additional inch (mm) increments up to the maximum thickness allowed.

5.8.1.2 Manufacturer's Installation Instructions~~Compliance with Manufacturers' Requirements~~

Insulation materials shall be installed in accordance with *manufacturers*' recommendations and in such a manner as to achieve the *rated R-value of insulation*.

~~**Exception to 5.8.1.2**~~

~~Where *metal building roof* and *metal building wall* insulation is compressed between the *roof* or *wall* skin and the structure.~~

Exceptions to 5.8.1.2

1. The R-value of compressed cavity insulation is determined in accordance with Table A9.4.2.
2. Where metal building roof or wall insulation is compressed between the steel structure and the metal roof or wall panels, the overall assembly *U-factor* is determined in accordance with Section A2.3, Section A3.2, or Section A9.4.5.

5.8.1.3 Loose-Fill Insulation Limitation

Open-blown or poured loose-fill insulation shall not be used in attic *roof spaces* when the slope of the ceiling is more than three in twelve.

…

5.8.1.10 Joints in Rigid Insulation

Where two or more layers of rigid insulation board are used in a *construction* assembly, the edge joints between each layer of boards shall be staggered.

5.8.1.11 Insulation Installation Documentation

The insulation installer shall provide a signed and dated document for the installed insulation listing the type of insulation, the manufacturer, the manufacturer's *rated R-value of insulation*, and where appropriate, the initial installed thickness, the settled thickness, and the coverage area. The insulation documentation shall be included in the *record documents*.

…

Inspection of Opaque Building Envelope Air Tightness Requirements

Opaque roof, *above-grade walls* and *below-grade walls*, and *floors*, shall be subject to the following inspections during *construction*:

a. Use of compliant materials and assemblies as indicated in Section 5.4.3.1.3.

b. Integration with adjoining *fenestration* and *continuous air barrier* elements.

5.9.1.4 Fenestration Inspections

Fenestration shall be subject to the following inspections during *construction*:

a. *Skylights* size and location in relation to the designed *primary sidelighted area* and *secondary sidelighted area* below.

b. *Roof monitor* size and location in relation to the designed *primary sidelighted area* and *secondary sidelighted area* ~~areas~~ below.

c. *Dynamic glazing* compliance with *SHGC* and *U-factor* in accordance with Sections 5.5.4.4.1 and 5.5.4.4.2, and testing of the operation for conformance with the *manufacturer*'s instructions.

***Permanent* fenestration *projections installation and performance in accordance with Section 5.5.4.4.1 and the* construction documents.**

…

6.1.1.2 Additions to Existing Buildings

Mechanical *equipment* and *systems* serving the heating, cooling, ventilating, or refrigeration needs of additions to *existing buildings* shall comply with the requirements of this section as described in Section 6.2.

Exception to 6.1.1.2

When HVACR to an ~~addition~~*addition* is provided by existing HVACR *systems* and *equipment*, such *existing systems* and *equipment* shall not be required to comply with this standard. However, any new *systems* or *equipment* installed must comply with specific requirements applicable to those *systems* and *equipment*.

…

6.2 Compliance Paths

Mechanical equipment and systems providing heating, cooling, ventilating, or refrigeration shall comply with Section 6.2.1 and Section 6.2.2.

6.2.1 Requirements for All Compliance Paths

~~Compliance with Section 6 shall be achieved by meeting all requirements for~~ Mechanical equipment and systems shall comply with Section~~s~~ 6.2~~=~~1, "General"; Section 6.4, "Mandatory Provisions"; Section 6.7, "Submittals"; and Section 6.8, "Minimum *Equipment Efficiency* Tables"; ~~and~~

6.2.2 Additional Requirements to Comply with Section 6

Mechanical equipment and systems shall comply with one of the following:

a. Section 6.3, "Simplified Approach ~~Option~~ Building Compliance Path for *HVAC Systems*"

b. ~~Sections 6.4, "Mandatory Provisions" and~~ Section 6.5, "Prescriptive Compliance Path"

c. ~~Sections 6.4, "Mandatory Provisions" and~~ Section 6.6, "Alternative Compliance Path"

Exception to 6.2.2: When compliance is shown using Section 6.2.2(a), compliance with Section 6.4 is not required.

~~Projects using the *Energy Cost Budget* Method (see Section 11 of this standard) must comply with Section 6.4, the mandatory provisions of this section, as a portion of that compliance path.~~

6.3 Simplified Approach ~~Option~~ Building Compliance Path for HVAC Systems

6.3.1 Scope

The simplified approach is an optional path for compliance when the following conditions are met:

a. The *building* is two stories or fewer in height.

b. *Gross floor area* is less than 25,000 ft^2.

c. Each *HVAC system* in the *building* complies with the requirements listed in Section 6.3.2.

6.3.2 Criteria

The *HVAC system* must meet all of the following criteria:

a. The *system* serves a single *HVAC zone*.

b. The *equipment* must meet the variable flow requirements of Section 6.5.3.2.1.

c. Cooling (if any) shall be provided by a unitary packaged or split-*system* air conditioner that is either air cooled or evaporatively cooled, with *efficiency* meeting the requirements shown in Table 6.8.1-1 (air conditioners), Table 6.8.1-2 (heat pumps), or Table 6.8.1-4 (packaged *terminal* and *room air conditioners* and heat pumps) for the applicable *equipment* category.

d. The *system* shall have an *air economizer* meeting the requirements of Sections 6.5.1 and 6.4.3.12.

e. Heating (if any) shall be provided by a unitary packaged or split-*system* heat pump that meets the applicable *efficiency* requirements shown in Table 6.8.1-2 (heat pumps) or Table 6.8.1-4 (packaged *terminal* and *room air conditioners* and heat pumps), a *fuel*-fired furnace that meets the applicable *efficiency* requirements shown in Table 6.8.1-5 (furnaces, duct furnaces, and unit heaters), an *electric resistance* heater, or a baseboard *system* connected to a *boiler* that meets the applicable *efficiency* requirements shown in Table 6.8.1-6 (*boilers*).

f. The *system* shall meet the exhaust air *energy* recovery requirements of Section 6.5.6.1.

g. The *system* shall be controlled by a *manual* changeover or dual *set-point thermostat*.

h. If a heat pump equipped with auxiliary internal *electric resistance* heaters is installed, *controls* shall be provided that prevent supplemental heater operation when the heating load can be met by the heat pump alone during both steady-state operation and *setback* recovery. Supplemental heater operation is permitted during outdoor coil defrost cycles. The heat pump must be controlled by either (1) a digital or electronic *thermostat* designed for heat pump use that energizes auxiliary heat only when the heat pump has insufficient capacity to maintain *set point* or to warm up the *space* at a sufficient rate or (2) a multistage *space thermostat* and an *outdoor air thermostat* wired to energize auxiliary heat only on the last stage of the *space thermostat* and when *outdoor air* temperature is less than 40°F.

Exception to 6.3.2(h)

Heat pumps that comply with the following:

1. Have a minimum *efficiency* regulated by NAECA.
2. Meet the requirements in Table 6.8.1-2.
3. Include all usage of internal *electric resistance* heating.

i. The *system controls* shall not permit *reheat* or any other form of simultaneous heating and cooling for humidity *control*.

j. *Systems* serving *spaces* other than hotel/motel guest rooms, and other than those requiring continuous operation, which have both a cooling or heating capacity greater than 15,000 Btu/h and a supply fan motor power greater than 0.75 hp, shall be provided with a time clock that (1) can start and stop the *system* under different schedules for seven different day types per week, (2) is capable of retaining programming and time setting during a loss of power for a period of at least ten hours, (3) includes an accessible *manual* override that allows temporary operation of the *system* for up to two hours, (4) is capable of and configured with temperature *setback* down to 55°F during off hours, and (5) is capable of capable of and configured with temperature setup to 90°F during off hours.

k. *Systems* serving hotel/motel guest rooms shall comply with Section 6.4.3.3.5.

l. Except for *piping* within *manufacturers*' units, HVAC *piping* shall be insulated in accordance with Tables 6.8.3-1 and 6.8.3-2. Insulation exposed to weather shall be suitable for outdoor ~~*service*~~service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation.

m. *Ductwork* and plenums shall be insulated in accordance with Table 6.8.2 and shall be sealed in accordance with Section 6.4.4.2.1.

n. *Construction documents* shall require a ducted *system* to be air balanced in accordance with industry accepted procedures.

o. *Outdoor air* intake and exhaust *systems* shall meet the requirements of Section 6.4.3.4.

p. Where separate heating and cooling *equipment* serves the same temperature zone, *thermostats* shall be interlocked to prevent simultaneous heating and cooling.

q. *Systems* with a design supply air capacity greater than 10,000 cfm shall have *optimum start controls*.

r. The *system* shall comply with the *demand control ventilation* requirements in Section 6.4.3.8 and the *ventilation* design requirements in Section 6.5.3.7.

s. The *system* complies with the *door* switch requirements in Section 6.5.10.

…

6.4.3.3.1 Automatic Shutdown

HVAC systems shall be equipped with at least one of the following:

a. *Controls* that can start and stop the *system* under different time schedules for seven different day types per week, are capable of retaining programming and time setting during loss of power for a period of at least ten hours, and include an accessible *manual* override or equivalent function that allows temporary operation of the *system* for up to two hours.

b. An ~~*occupant*~~ *occupancy sensor* that is capable of shutting the *system* off when no occupant is sensed for a period of up to 30 minutes.

c. A manually operated timer capable of being adjusted to operate the *system* for up to two hours.

d. An interlock to a security *system* that shuts the *system* off when the security *system* is activated.

Exception to 6.4.3.3.1

Residential occupancies may use *controls* that can start and stop the *system* under two different time schedules per week.

6.4.3.3.2 Setback Controls

Heating *systems* shall be equipped with *controls* capable of and configured to ~~automatically~~*automatically* restart and temporarily operate the *system* as required to maintain zone temperatures above an adjustable heating *set point* at least 10°F below the occupied heating *set point*. Cooling *systems* shall be equipped with *controls* capable of and configured to ~~automatically~~*automatically* restart and temporarily operate the *mechanical cooling system* as required to maintain zone temperatures below an adjustable cooling *set point* at least 5°F above the occupied cooling *set point* or to prevent high *space* humidity levels.

Exception to 6.4.3.3.2

Radiant heating systems capable of and configured with a *setback* heating *set point* at least 4°F below the occupied heating *set point*.

6.4.3.3.3 Optimum Start Controls

Individual heating and cooling *systems* with *setback controls* and *DDC* shall have *optimum start controls*. The *control* algorithm shall, as a minimum, be a function of the difference between *space* temperature and occupied *set point*, the outdoor temperature, and the amount of time prior to scheduled occupancy. Mass radiant *floor* slab *systems* shall incorporate *floor* temperature into the optimum start algorithm.

6.4.3.3.4 Zone Isolation

HVAC systems serving zones that are intended to operate or be occupied nonsimultaneously shall be divided into isolation areas. Zones may be grouped into a single isolation area provided it does not exceed 25,000 ft^2 of *conditioned floor area* nor include more than one floor. Each isolation area shall be equipped with *isolation devices* capable of and configured to ~~automatically~~*automatically* shut off the supply of conditioned air and *outdoor air* to and exhaust air from the area. Each isolation area shall be controlled independently by a device meeting the requirements of Section 6.4.3.3.1. For central *systems* and plants, *controls* and devices shall be provided to allow stable *system* and *equipment* operation for any length of time while serving only the smallest isolation area served by the *system* or plant.

Exceptions to 6.4.3.3.4

Isolation devices and *controls* are not required for

1. exhaust air and *outdoor air* connections to isolation zones when the fan *system* to which they connect is 5000 cfm and smaller;
2. exhaust airflow from a single isolation zone of less than 10% of the design airflow of the exhaust *system* to which it connects; or
3. zones intended to operate continuously or intended to be inoperative only when all other zones are inoperative.

6.4.3.3.5 Automatic Control of HVAC in Hotel/Motel Guest Rooms

Hotels and motels with greater than 50 guest rooms shall be provided with *automatic controls* for the HVAC *equipment* serving each guest room capable of and configured according to the requirements in the following subsection.

6.4.3.3.5.1 Guest Room HVAC Set-Point Control

~~a.~~ HVAC *Systems* serving hotel guest rooms shall be capable of and configured with three modes of temperature *control.*

a. **Rented and unoccupied.** Within ~~30~~20 minutes of all occupants leaving the guest room, HVAC *set points* shall be ~~automatically~~*automatically* raised by at least 4°F from the occupant *set point* in the cooling mode and ~~automatically~~*automatically* lowered by at least 4°F from the occupant *set point* in the heating mode.

b **Unrented and unoccupied.** HVAC *set points* shall be ~~automatically~~*automatically reset* to 80°F or higher in the cooling mode and to 60°F or lower in the heating mode. The HVAC set points in the unrented and unoccupied guest room modes shall be initiated within 16 hours of the guest room being continuously unoccupied or within 20 minutes of the guest room being continuously unoccupied where a *networked guest room control system* indicates the guest room is unrented~~, and~~.

c. **Occupied**. HVAC *set points* shall return to their occupied *set points* once occupancy is sensed.

~~When the guest room is unrented **and unoccupied**, HVAC *set points* shall be automatically *reset* to 80°F or higher in the cooling mode and to 60°F or lower in the heating mode. Unrented and unoccupied guest rooms shall be determined by either of the following:~~

~~a. The guest room has been continuously unoccupied for up to 16 hours.~~

~~b. A *networked guest room control system* indicates the guest room is unrented and the guest room is unoccupied for no more than 30 minutes.~~

Exceptions to 6.4.3.3.5.1

1. A *networked guest room control system* shall be permitted to return the *thermostat set points* to their default occupied *set points* 60 minutes prior to the time the room is scheduled to be occupied.
2. Cooling for humidity *control* shall be permitted during rented and unoccupied or unrented and unoccupied periods.

6.4.3.3.5.2 Guest Room Ventilation Control

Within 20 ~~30~~ minutes of all occupants leaving the guest room, *ventilation* and exhaust fans shall ~~automatically~~*automatically* be turned off, or *isolation devices* serving each guest room shall ~~automatically~~*automatically* shut off the supply of *outdoor air* to the guest room and shut off exhaust air from the guest room.

Exception to 6.4.3.3.5.2

Guest room *ventilation systems* shall be permitted to have an *automatic* daily preoccupancy purge cycle that provides daily *outdoor air ventilation* during unrented periods at the design *ventilation* rate for 60 minutes or at a rate and duration equivalent to one air change.

6.4.3.3.5.3 Automatic Control

~~Captive~~ Card key ~~card *systems*~~ controls shall be permitted to be used to indicate occupancy ~~comply with Section 6.4.3.3.5~~.

Table 6.4.3.4.3 Maximum Damper Leakage, cfm per ft² at 1.0 in. wc

Climate Zone		*Ventilation* Air Intake		Exhaust/Relief	
		Nonmotorized[a]	Motorized	Nonmotorized[a]	Motorized
0, 1, 2					
Any height		20	4	20	4
3					

Any height		20	10	20	10
4, 5B, 5C					
Fewer than three stories		NA	10	20	10
Three or more stories		NA	10	NA	10
5A, 6, 7, 8					
Fewer than three stories		NA	4	20	4
Three or more stories		NA	4	NA	4

Non-motorized dampers smaller than 24 in. in either dimension may have leakage of 40 cfm/ft^2.
NA = Not allowed

Table 6.4.3.4.3 Maximum Damper Leakage, L/s per m^2 at 250 Pa wc (SI)

		***Ventilation* Air Intake**		**Exhaust/Relief**	
Climate Zone		**Nonmotorized[a]**	**Motorized**	**Nonmotorized[a]**	**Motorized**
0, 1, 2					
Any height		100	20	100	20
3					
Any height		100	50	100	50
4, 5B, 5C					
Fewer than three stories		NA	50	100	50
Three or more stories		NA	50	NA	50
5A, 6, 7, 8					
Fewer than three stories		NA	20	100	20
Three or more stories		NA	20	NA	20

a. Non-motorized dampers smaller than 600 mm in either dimension may have leakage of 200 L/s per m^2.
NA = Not allowed

6.4.3.4 Ventilation System Controls

6.4.3.4.1 Stair and Shaft Vents

Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of and configured to ~~automatically~~*automatically* close during normal *building* operation and are interlocked to open as required by fire and smoke detection *systems*.

6.4.3.4.2 Shutoff Damper Controls

All *outdoor air* intake and exhaust *systems* shall be equipped with motorized dampers that will ~~automatically~~*automatically* shut when the *systems* or *spaces* served are not in use. *Ventilation outdoor air* and exhaust/relief dampers shall be capable of and configured to ~~automatically~~*automatically* shut off during preoccupancy *building warm-up*, *cooldown*, and *setback*, except when *ventilation* reduces *energy* costs or when *ventilation* must be supplied to meet code requirements.

…

6.4.3.4.5 Enclosed Parking Garage Ventilation

Enclosed parking garage *ventilation systems* shall ~~automatically~~*automatically* detect contaminant levels and stage fans or modulate fan airflow rates to 50% or less of *design capacity*, provided acceptable contaminant levels are maintained.

…

6.4.3.6 Humidification and Dehumidification Control

6.4.3.6.1 Dehumidification

Humidistatic controls shall not use *mechanical cooling* to reduce the humidity below the lower of a dew point of 55°F (13°C) or relative humidity of 60% in the coldest zone served by the *system*.

Informative Note: Lower humidity is permitted when operating *mechanical cooling* for temperature control.

6.4.3.6.2 Humidification

Humidistatic controls shall not use *fossil fuel* or electricity to produce relative humidity above 30% in the warmest zone served by the *system*.

6.4.3.6.3 Control Interlock

~~Humidity *control* shall prevent the use of *fossil fuel* or electricity to produce relative humidity above 30% in the warmest zone served by the humidification *system* and to reduce relative humidity below 60% in the coldest zone served by the dehumidification *system*.~~ Where a zone is served by a *system* or *systems* with both humidification and dehumidification capability, means (such as limit switches, mechanical stops, or, for *DDC systems*, software programming) shall be provided capable of and configured to prevent simultaneous operation of humidification and dehumidification *equipment*.

Exceptions to 6.4.3.6.1 and 6.4.3.6.2

~~1. Zones served by desiccant *systems*, used with direct evaporative cooling in series.~~

Systems serving zones where specific humidity levels are required, such as museums and hospitals, and approved by the *authority having jurisdiction* or required by accreditation standards, and ~~humidity~~ *humidistatic controls* are capable of and configured to maintain a *dead band* of at least 10% relative humidity where no active humidification or dehumidification takes place.

Exceptions to 6.4.3.6.1, 6.4.3.6.2 and 6.4.3.4.3

~~3.~~ *Systems* serving zones where humidity levels are required to be maintained with precision of not more than ±5% relative humidity to comply with applicable codes or accreditation standards or as approved by the *authority having jurisdiction*.

…

6.4.3.8 Ventilation Controls for High-Occupancy Areas

Demand control ventilation (*DCV*) is required for *spaces* larger than 500 ft^2 and with a design occupancy for *ventilation* of ≥25 people per 1000 ft^2 of ~~*floor area*~~floor area and served by *systems* with one or more of the following:

a. *Air economizer*.
b. *Automatic* modulating *control* of *outdoor air* damper.
c. Design outdoor airflow greater than 3000 cfm.

Exceptions to 6.4.3.8

1. *Systems* with exhaust air *energy* recovery complying with Section 6.5.6.1.

2. Multiple-zone *systems* without *DDC* of individual zones communicating with a central *control* panel.
3. *Systems* with a design outdoor airflow less than 750 cfm.
4. *Spaces* where >75% of the *space* design outdoor airflow is required for *makeup air* that is exhausted from the *space* or *transfer air* that is required for *makeup air* that is exhausted from other *spaces*.
5. *Spaces* with one of the following occupancy categories as defined in ASHRAE Standard 62.1: correctional cells, daycare sickrooms, science labs, barbers, beauty and nail salons, and bowling alley seating.

...

6.4.3.10 Direct Digital Control (DDC) Requirements

Direct digital control shall be required as follows.

6.4.3.10.1 DDC Applications

DDC shall be provided in the applications and qualifications listed in Table 6.4.3.10.1.

Exception to 6.4.3.10.1

DDC is not required for *systems* using the simplified approach to compliance in accordance with Section 6.3.

6.4.3.10.2 DDC Controls

Where *DDC* is required by Section 6.4.3.10.1, the *DDC system* shall be capable of and configured with all of the following, as required, to provide the *control* logic required in Section 6.5:

a. Monitoring zone and *system demand* for fan pressure, pump pressure, heating, and cooling.

b. Transferring zone and *system demand* information from zones to air *distribution system* controllers and from air *distribution systems* to heating and cooling plant controllers.

c. *Automatically* detecting those zones and *systems* that may be excessively driving the *reset* logic and generate an alarm or other indication to the *system* operator

Table 6.4.3.10.1 *DDC* Applications and Qualifications

***Building* Status**	**Application**	**Qualifications**
New *building*	Air-handling *system* and all zones served by the *system*	Individual *systems* supplying more than three zones and with fan *system* bhp of 10 hp and larger
	Chilled-water plant and all coils and *terminal* units served by the *system*	Individual plants supplying more than three zones and with design cooling capacity of 300,000 Btu/h and larger
	Hot-water plant and all coils and *terminal* units served by the *system*	Individual plants supplying more than three zones and with design heating capacity of 300,000 Btu/h and larger
Alteration or ~~addition~~*addition*	Zone *terminal* unit such as *VAV* box	Where existing zones served by the same air-handling, chilled-water, or hot-water *system* have *DDC*
	Air-handling *system* or fan coil	Where existing air-handling *systems* and fan coils served by the same chilled- or hot-water plant have *DDC*
	New air-handling *system* and all new zones served by the *system*	Individual *systems* with fan *system* bhp of 10 hp and larger and supplying more than three zones and more than 75% of zones are new

	New or upgraded chilled-water plant	Where all chillers are new and plant design cooling capacity is 300,000 Btu/h and larger
	New or upgraded hot-water plant	Where all *boilers* are new and plant design heating capacity is 300,000 Btu/h and larger

…

6.4.3.12 Economizer Fault Detection and Diagnostics (FDD)

Air-cooled direct-expansion cooling units listed in Tables 6.8.1-1 and 6.8.1-2, where an *air economizer* is installed in accordance with Section 6.5.1, shall include a fault detection and diagnostics (FDD) *system* complying with the following:

a. The following temperature sensors shall be *permanently installed* to monitor *system* operation:
   1. *Outdoor air*
   2. Supply air
   3. Return air, where required for economizer *control*

b. The *system* shall have the capability of displaying the value of each sensor.

c. The FDD *system* or unit *controls* shall be capable of and configured to provide *system* status by indicating the following:
   1. Free cooling available
   2. Economizer enabled
   3. Compressor enabled
   4. Heating enabled
   5. Mixed-air low-limit cycle active

d. The FDD *system* or unit *controls* shall have provisions to manually initiate each operating mode so that the operation of compressors, economizers, fans, and the heating *system* can be independently tested and verified.

e. The FDD *system* shall be capable of and configured to detect the following faults:
   1. Air temperature sensor failure/fault
   2. Not economizing when the unit should be economizing
   3. Economizing when the unit should not be economizing
   4. Damper not modulating
   5. Excess *outdoor air*

f. The FDD *system* shall be capable of and configured to report faults to a fault management application or *DDC system* accessible by operating or ~~*service*~~service personnel, or annunciated locally on zone *thermostats*.

…

6.4.4.1 Insulation

6.4.4.1.1 General

Insulation required by this section shall be installed in accordance with industry-accepted standards (see Informative Appendix E). These requirements do not apply to HVAC *equipment*. Insulation shall be protected from damage, including that due to sunlight, moisture, *equipment* maintenance and wind, but not limited to the following:

a. Insulation exposed to weather shall be suitable for outdoor ~~*service*~~service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic

cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

…

Exception to 6.4.5(c)
Glazed portions of *doors* or structural members.

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

e. Evaporator fan motors that are less than 1 hp and less than 460 V shall use electronically commutated motors (brushless direct-current motors) or three-phase motors.

f. Lights shall use light sources with an *efficacy* of 40 lm/W or more, including ~~ballast~~*ballast* losses (if any). Light sources with lower 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.

…

6.4.6 Refrigerated Display Case

a. All refrigerated display cases shall conform to Section 6.4.1.1 and Tables 6.8.1-12 and 6.8.1-13.

b. Lighting in refrigerated display cases and glass *doors* installed on *walk-in coolers* and *walk-in freezers* shall be controlled by one of the following:

1. *Automatic* time-switch *controls* to turn off lights during nonbusiness hours: Timed overrides for display cases or *walk-in coolers* and *walk-in freezers* may be used to turn the lights on for up to one hour and shall ~~automatically~~*automatically* time out to turn the lights off.

2. Motion sensor *controls* on each display case or walk-in *door* section that reduce lighting power by at least 50% within three minutes after the area within the sensor range is vacated.

c. All low-temperature display cases shall incorporate temperature-based defrost termination *control* with a time-limit default. The defrost cycle shall terminate first on an upper temperature limit breach and second on a time limit breach.

d. Antisweat heater *controls* shall reduce the *energy* use of the antisweat heater as a function of the relative humidity in the air outside the *door* or to the condensation on the inner glass pane.

…

Table 6.5.1.1.3 High-Limit Shutoff *Control* Settings for *Air Economizers*[b]

***Control* Type**	**Allowed Only in Climate Zone at Listed *Set Point***	**Required High-Limit *Set Points* (Economizer Off when):**	
		Equation	**Description**
~~*Fixed*~~Fixed dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	T_{OA} > 75°F	*Outdoor air* temperature exceeds 75°F
	5A, 6A	T_{OA} > 70°F	*Outdoor air* temperature exceeds 70°F
	0A, 1A, 2A, 3A, 4A,	T_{OA} > 65°F	*Outdoor air* temperature exceeds 65°F
Differential dry-bulb temperature	0B, 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*~~Fixed enthalpy	All	h_{OA} > 28 Btu/lb [a]	*Outdoor air* enthalpy exceeds 28 Btu/lb [a] of

with ~~*fixed*~~fixed dry-bulb temperature		or T_{OA} > 75°F	dry air[a] or *outdoor air* temperature exceeds 75°F
Differential enthalpy with ~~*fixed*~~fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or T_{OA} > 75°F	*Outdoor air* enthalpy exceeds return air enthalpy or *outdoor air* temperature exceeds 75°F

a. At altitudes substantially different than sea level, the ~~*fixed*~~fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50% rh. As an example, at approximately 6000 ft elevation, the ~~*fixed*~~fixed enthalpy limit is approximately 30.7 Btu/lb.

b. Devices with selectable rather than adjustable *set points* shall be capable of being set to within 2°F and 2 Btu/lb of the *set point* listed.

6.5.1.1.3 High-Limit Shutoff

All *air economizers* shall be capable of and configured to ~~automatically~~*automatically* reduce *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will no longer reduce cooling *energy* use. High-limit shutoff *control* types and associated *set points* for specific climate zones shall be chosen from Table 6.5.1.1.3.

…

…

6.5.3.2.3 VAV Set-Point Reset

For multiple-zone *VAV systems* having a total *fan system motor nameplate horsepower* exceeding 5 hp with *DDC* of individual zones reporting to the central *control* panel, static pressure *set point* shall be *reset* based on the zone requiring the most pressure; i.e., the *set point* is *reset* lower until one zone damper is nearly wide open. *Controls* shall provide the following:

a. Monitor zone damper positions or other indicator of need for static pressure.

b. ~~Automatically~~*Automatically* detect those zones that may be excessively driving the *reset* logic and generate an alarm to the *system* operator.

c. Readily allow operator removal of zones from the *reset* algorithm.

…

6.5.3.3 Multiple-Zone VAV System Ventilation Optimization Control

Multiple-zone *VAV systems* with *DDC* of individual zone boxes reporting to a central *control* panel shall include means to ~~automatically~~*automatically* reduce *outdoor air* intake flow below design rates in response to changes in *system ventilation efficiency* as defined by Appendix A of ASHRAE Standard 62.1.

…

6.5.3.5 Supply Air Temperature Reset Controls

Multiple zone *HVAC systems* must include *controls* that ~~automatically~~*automatically* *reset* the supply air temperature in response to representative *building* loads, or to *outdoor air* temperature. The *controls* shall *reset* the supply air temperature at least 25% of the difference between the design supply air temperature and the design room air temperature. *Controls* that adjust the *reset* based on zone humidity are allowed. Zones that are expected to experience relatively constant loads, such as electronic *equipment* rooms, shall be designed for the fully *reset* supply temperature.

…

…

6.5.5.2 Fan Speed Control

6.5.5.2.1

The fan *system* on a heat-rejection device powered by an individual motor or an array of motors with a connected power, including the motor ~~*service*~~service factor, totaling 5 hp or more shall have *controls* and/or devices (such as variable-speed *control*) that shall result in fan motor *demand* of no more than 30% of design wattage at 50% of the design airflow and that shall ~~automatically~~*automatically* modulate the fan speed to *control* the leaving fluid temperature or condensing temperature/pressure of the heat-rejection device.

…

6.5.6.1 Exhaust Air Energy Recovery

Each fan *system* shall have an *energy* recovery *system* when the design supply fan airflow rate exceeds the value listed in Tables 6.5.6.1-1 and 6.5.6.1-2, based on the climate zone and percentage of *outdoor air* at design airflow conditions. Table 6.5.6.1-1 shall be used for all *ventilation systems* that operate less than 8000 hours per year, and Table 6.5.6.1-2 shall be used for all *ventilation systems* that operate 8000 or more hours per year.

Energy recovery *systems* required by this section shall result in an *enthalpy recovery ratio* of at least 50%. A 50% *enthalpy recovery ratio* shall mean a change in the enthalpy of the *outdoor air* supply equal to 50% of the difference between the *outdoor air* and entering exhaust air enthalpies at *design conditions*. Provision shall be made to bypass or *control* the *energy* recovery *system* to permit *air economizer* operation as required by Section 6.5.1.1

Exceptions to 6.5.6.1

1. Laboratory *systems* meeting Section 6.5.7.3.
2. *Systems* serving *spaces* that are not cooled and that are heated to less than 60°F.
3. Where more than 60% of the *outdoor air* heating *energy* is provided from *site-recovered energy* or *site-solar energy*.
4. Heating *energy* recovery in Climate Zones 0, 1, and 2.
5. Cooling *energy* recovery in Climate Zones 3C, 4C, 5B, 5C, 6B, 7, and 8.
6. Where the sum of the airflow rates exhausted and relieved within 20 ft of each other is less than 75% of the design outdoor airflow rate, excluding exhaust air that is
   a. used for another *energy* recovery *system*,
   b. not allowed by ASHRAE Standard 170 for use in *energy* recovery *systems* with leakage potential, or
   c. of Class 4 as defined in ASHRAE Standard 62.1.
7. *Systems* requiring dehumidification that employ *energy* recovery in series with the cooling coil.
8. *Systems* expected to operate less than 20 hours per week at the *outdoor air* percentage covered by Table 6.5.6.1-1.

~~8.~~ 9 *Indoor pool dehumidifiers* meeting the requirements of Section 6.5.6.4.

…

6.5.6.2 Heat Recovery for Service Water Heating

6.5.6.2.1

Condenser heat recovery *systems* shall be installed for heating or preheating of ~~*service*~~service hot water provided all of the following are true:

a. The facility operates 24 hours a day.

b. The total installed heat-rejection capacity of the water-cooled *systems* exceeds 6,000,000 Btu/h of heat rejection.

c. The design *service water-heating* load exceeds 1,000,000 Btu/h.

6.5.6.2.2

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

a. 60% of the peak heat-rejection load at *design conditions* or

b. preheat of the peak ~~*service*~~service hot-water draw to 85°F.

…

Indoor Pool Dehumidifier Energy Recovery

An *indoor pool dehumidifier* serving a natatorium with a heated indoor *pool* over 500 ft^2 in size shall include one of the following:

a. an exhaust air sensible *energy* recovery *system* with a *sensible energy recovery ratio* of at least 50%,

b. a condenser heat recovery system capable of and configured to use 100% of the heat generated through dehumidification to heat the *pool* water when there is a *pool* water heating load, or

c. an exhaust air *energy* recovery *system* that results in an *enthalpy recovery ratio* of at least 50%.

Exceptions to 6.5.6.4

Natatoriums heated by *on-site renewable energy* or *site recovered energy* capable of and configured to provide at least 60% of the annual heating energy required.

…

Table 6.5.7.2.2 Maximum Net Exhaust Flow Rate, cfm per Linear Foot of Hood Length

Type of Hood	Light-Duty *Equipment*	Medium-Duty *Equipment*	Heavy-Duty *Equipment*	Extra-Heavy-Duty *Equipment*
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island (per side)	175	210	280	385
Eyebrow	175	175	NA	NA
Backshelf/pass-over	210	210	280	NA

NA = Not allowed

…

6.7.1 General

~~The *authority having jurisdiction* may require submittal of c~~Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

6.7.2 Permit Application Documentation (not used)

~~**6.7.2**~~ **6.7.3 Completion Requirements**

~~The following requirements are mandatory provisions and are necessary for compliance with the standard.~~

~~**6.7.2.1**~~ **6.7.3.1 ~~Drawings~~Record Documents**

Construction documents shall require that, within 90 days after the date of *system* acceptance, *record* ~~drawings of the actual installation~~*documents* be provided to the *building*

owner or the designated representative of the *building* owner. *Record* ~~*drawings*~~ *documents* shall include, as a minimum, the location and performance data on each piece of *equipment*; general configuration of the duct and pipe *distribution system*, including sizes; and the *terminal* air or water design flow rates.

~~6.7.2.2~~ 6.7.3.2 Manuals

Construction documents shall require that an operating manual and a maintenance manual be provided to the *building* owner or the designated representative of the *building* owner within 90 days after the date of *system* acceptance. These manuals shall be in accordance with industry-accepted standards (see Informative Appendix E) and shall include, at a minimum, the following:

a. Submittal data stating *equipment* size and selected options for each piece of *equipment* requiring maintenance.

b. Operation manuals and maintenance manuals for each piece of *equipment* and *system* requiring maintenance, except *equipment* not furnished as part of the project. Required routine maintenance actions shall be clearly identified.

c. Names and addresses of at least one ~~*service*~~service *agency*.

d. HVAC *controls system* maintenance and calibration information, including wiring diagrams, schematics, and *control* sequence descriptions. Desired or field-determined *set points* shall be permanently recorded on *control* drawings at *control devices* or, for digital *control systems*, in programming comments.

e. A complete narrative of how each *system* is intended to operate, including suggested *set points*.

~~6.7.2.3~~ 6.7.3.3 System Balancing

~~6.7.2.3.1~~ 6.7.3.3.1 General

Construction documents shall require that all *HVAC systems* be balanced in accordance with *generally accepted engineering standards* (see Informative Appendix E). *Construction documents* shall require that a written balance report be provided to the *building* owner or the designated representative of the *building* owner for *HVAC systems* serving zones with a total conditioned area exceeding 5000 ft^2.

~~6.7.2.3.2~~ 6.7.3.3.2 Air System Balancing

Air *systems* shall be balanced in a manner to first minimize throttling losses. Then, for fans with fan *system* power greater than 1 hp, fan speed shall be adjusted to meet design flow conditions.

~~6.7.2.3.3~~ 6.7.3.3.3 Hydronic System Balancing

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.

Exceptions to 6.7.~~2~~3.3

Impellers need not be trimmed nor pump speed adjusted

1. for pumps with pump motors of 10 hp or less or
2. when throttling results in no greater than 5% of the *nameplate horsepower* draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed.

~~6.7.2.4~~ 6.7.3.4 System Commissioning

HVAC *control systems* shall be tested to ensure that *control* elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft^2 conditioned area, except warehouses and *semiheated spaces*, detailed instructions for commissioning

HVAC systems (see Informative Appendix E) shall be provided by the designer in plans and specifications.

…

Table 6.8.1-4 Electrically Operated *Packaged Terminal Air Conditioners*, *Packaged Terminal Heat Pumps*, *Single-Package Vertical Air Conditioners*, *Single-Package Vertical Heat Pumps*, *Room Air Conditioners*, and Room Air Conditioner Heat Pumps—Minimum *Efficiency* Requirements *(Continued)*

***Equipment* Type**	**Size Category (Input)**	**Subcategory or Rating Condition**	**Minimum *Efficiency***	**Test Procedure[a]**
PTAC (cooling mode) standard size	All capacities	95°F db *outdoor air*	13.8 – (0.300 × Cap/1000)[c] (before 1/1/2015) 14.0 – (0.300 × Cap/1000)[c] (as of 1/1/2015)	AHRI 310/380
PTAC (cooling mode) nonstandard size[a]	All capacities	95°F db *outdoor air*	10.9 – (0.213 × Cap/1000)[c] *EER*	AHRI 310/380
PTHP (cooling mode) standard size	All capacities	95°F db *outdoor air*	14.0 – (0.300 × Cap/1000)[c]	AHRI 310/380
PTHP (cooling mode) nonstandard size[b]	All capacities	95°F db *outdoor air*	10.8 – (0.213 × Cap/1000)[c] *EER*	AHRI 310/380
PTHP (heating mode) standard size	All capacities		3.7 – (0.052 × Cap/1000)[c] COP_H	AHRI 310/380
PTHP (heating mode) nonstandard size[b]	All capacities		2.9 – (0.026 × Cap/1000)[c] COP_H	AHRI 310/380
SPVAC (cooling mode)	<65,000 Btu/h	95°F db/75°F wb *outdoor air*	10.0 *EER*	AHRI 390
	≥65,000 Btu/h and <135,000 Btu/h		10.0 *EER*	
	≥135,000 Btu/h and <240,000 Btu/h		10.0 *EER*	
SPVHP (cooling mode)	<65,000 Btu/h	95°F db/75°F wb *outdoor air*	10.0 *EER*	AHRI 390
	≥65,000 Btu/h and <135,000 Btu/h		10.0 *EER*	
	≥135,000 Btu/h and <240,000 Btu/h		10.0 *EER*	
SPVHP (heating mode)	<65,000 Btu/h	47°F db/43°F wb *outdoor air*	3.0 COP_H	AHRI 390
	≥65,000 Btu/h and <135,000 Btu/h		3.0 COP_H	
	≥135,000 Btu/h and <240,000 Btu/h		3.0 COP_H	
Room air conditioners with louvered sides	<6000 Btu/h		9.7 *SEER*	ANSI/AHAM RAC-1
	≥6000 Btu/h and <8000 Btu/h		9.7 *SEER*	
	≥8000 Btu/h and <14,000 Btu/h		9.8 *EER*	
	≥14,000 Btu/h and <20,000 Btu/h		9.7 *SEER*	
	≥20,000 Btu/h		8.5 *EER*	
SPVAC (cooling mode), nonweatherized ~~*space*~~space constrained	≤30,000 Btu/h	95°F db/75°F wb *outdoor air*	9.2 *EER*	AHRI 390
	>30,000 Btu/h and≤36,000 Btu/h		9.0 *EER*	

SPVHP (cooling mode), nonweatherized ~~*space*~~space constrained	≤30,000 Btu/h	95°F db/75°F wb *outdoor air*	9.2 *EER*	AHRI 390
	>30,000 Btu/h and ≤36,000 Btu/h		9.0 *EER*	
SPVHP (heating mode), nonweatherized ~~*space*~~space constrained<	≤30,000 Btu/h	47°F db/43°F wb *outdoor air*	3.0 COP_H	AHRI 390
	>30,000 Btu/h and ≤36,000 Btu/h		3.0 COP_H	
Room air conditioners without louvered sides	<8000 Btu/h		9.0 *EER*	ANSI/AHAM RAC-1
	≥8000 Btu/h and <20,000 Btu/h		8.5 *EER*	
	≥20,000 Btu/h		8.5 *EER*	
Room air conditioner heat pumps with louvered sides	<20,000 Btu/h		9.0 *EER*	ANSI/AHAM RAC-1
	≥20,000 Btu/h		8.5 *EER*	
Room air conditioner heat pumps without louvered sides	<14,000 Btu/h		8.5 *EER*	ANSI/AHAM RAC-1
	≥14,000 Btu/h		8.0 *EER*	
Room air conditioner, casement only	All capacities		8.7 *EER*	ANSI/AHAM RAC-1
Room air conditioner, casement slider	All capacities		9.5 *EER*	ANSI/AHAM RAC-1

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Nonstandard size units must be factory *labeled* as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW STANDARD PROJECTS." Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external *wall* opening of less than 16 in. high or less than 42 in. wide and having a cross-sectional area less than 670 in^2.
c. "Cap" means 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 calculation.

. . .

Table 6.8.1-13 Commercial Refrigeration—Minimum Efficiency Requirements

***Equipment* Type**					
***Equipment* Class**[a]	**Family Code**	**Operating Mode**	**Rating Temperature**	***Energy* Use Limits**[b,c]**, kWh/day**	**Test Procedure**
VOP.RC.M	Vertical open	Remote condensing	Medium temperature	0.82 × TDA + 4.07	AHRI 1200
SVO.RC.M	Semivertical open	Remote condensing	Medium temperature	0.83 × TDA + 3.18	AHRI 1200
HZO.RC.M	Horizontal open	Remote condensing	Medium temperature	0.35 × TDA + 2.88	AHRI 1200
VOP.RC.L	Vertical open	Remote condensing	Low temperature	2.27 × TDA + 6.85	AHRI 1200
HZO.RC.L	Horizontal open	Remote condensing	Low temperature	0.57 × TDA + 6.88	AHRI 1200
VCT.RC.M	Vertical transparent *door*	Remote condensing	Medium temperature	0.22 × TDA + 1.95	AHRI 1200
VCT.RC.L	Vertical transparent *door*	Remote condensing	Low temperature	0.56 × TDA + 2.61	AHRI 1200
SOC.RC.M	~~*Service*~~Service over counter	Remote condensing	Medium temperature	0.51 × TDA + 0.11	AHRI 1200
VOP.*SC*.M	Vertical open	Self contained	Medium temperature	1.74 × TDA + 4.71	AHRI 1200
SVO.*SC*.M	Semivertical open	Self contained	Medium temperature	1.73 × TDA + 4.59	AHRI 1200
HZO.*SC*.M	Horizontal open	Self contained	Medium temperature	0.77 × TDA + 5.55	AHRI 1200
HZO.*SC*.L	Horizontal open	Self contained	Low temperature	1.92 × TDA + 7.08	AHRI 1200
VCT.*SC*.I	Vertical transparent *door*	Self contained	Ice cream	0.67 × TDA + 3.29	AHRI 1200
VCS.*SC*.I	Vertical solid *door*	Self contained	Ice cream	0.38 × *V* + 0.88	AHRI 1200
HCT.*SC*.I	Horizontal transparent	Self contained	Ice cream	0.56 × TDA + 0.43	AHRI 1200

	door				
SVO.RC.L	Semivertical open	Remote condensing	Low temperature	2.27 × TDA + 6.85	AHRI 1200
VOP.RC.I	Vertical open	Remote condensing	Ice cream	2.89 × TDA + 8.7	AHRI 1200
SVO.RC.I	Semivertical open	Remote condensing	Ice cream	2.89 × TDA + 8.7	AHRI 1200
HZO.RC.I	Horizontal open	Remote condensing	Ice cream	0.72 × TDA + 8.74	AHRI 1200
VCT.RC.I	Vertical transparent *door*	Remote condensing	Ice cream	0.66 × TDA + 3.05	AHRI 1200
HCT.RC.M	Horizontal transparent *door*	Remote condensing	Medium temperature	0.16 × TDA + 0.13	AHRI 1200
HCT.RC.L	Horizontal transparent *door*	Remote condensing	Low temperature	0.34 × TDA + 0.26	AHRI 1200
HCT.RC.I	Horizontal transparent *door*	Remote condensing	Ice cream	0.4 × TDA + 0.31	AHRI 1200
VCS.RC.M	Vertical solid *door*	Remote condensing	Medium temperature	0.11 × *V* + 0.26	AHRI 1200
VCS.RC.L	Vertical solid *door*	Remote condensing	Low temperature	0.23 × *V* + 0.54	AHRI 1200
VCS.RC.I	Vertical solid *door*	Remote condensing	Ice cream	0.27 × *V* + 0.63	AHRI 1200
HCS.RC.M	Horizontal solid *door*	Remote condensing	Medium temperature	0.11 × *V* + 0.26	AHRI 1200
HCS.RC.L	Horizontal solid *door*	Remote condensing	Low temperature	0.23 × *V* + 0.54	AHRI 1200
HCS.RC.I	Horizontal solid *door*	Remote condensing	Ice cream	0.27 × *V* + 0.63	AHRI 1200
HCS.RC.I	Horizontal solid *door*	Remote condensing	Ice cream	0.27 × *V* + 0.63	AHRI 1200
SOC.RC.L	~~*Service*~~Service over counter	Remote condensing	Low temperature	1.08 × TDA + 0.22	AHRI 1200
SOC.RC.I	~~*Service*~~Service over counter	Remote condensing	Ice cream	1.26 × TDA + 0.26	AHRI 1200
VOP.*SC*.L	Vertical open	Self contained	Low temperature	4.37 × TDA + 11.82	AHRI 1200
VOP.*SC*.I	Vertical open	Self contained	Ice cream	5.55 × TDA + 15.02	AHRI 1200
SVO.*SC*.L	Semivertical open	Self contained	Low temperature	4.34 × TDA + 11.51	AHRI 1200
SVO.*SC*.I	Semivertical open	Self contained	Ice cream	5.52 × TDA + 14.63	AHRI 1200
HZO.*SC*.I	Horizontal open	Self contained	Ice cream	2.44 × TDA + 9.0	AHRI 1200
SOC.*SC*.I	~~*Service*~~Service over counter	Self contained	Ice cream	1.76 × TDA + 0.36	AHRI 1200
HCS.*SC*.I	Horizontal solid *door*	Self contained	Ice cream	0.38 × *V* + 0.88	AHRI 1200

a. *Equipment* class designations consist of a combination (in sequential order separated by periods (AAA).(BB).(C)) of the following:
(AAA)—An *equipment* family code (VOP = vertical open, SVO = semivertical open, HZO = horizontal open, VCT = vertical transparent *doors*, VCS = vertical solid *doors*, HCT = horizontal transparent *doors*, HCS = horizontal solid *doors*, and SOC = ~~*service*~~service over counter); (BB)—An operating mode code (RC = remote condensing and *SC* = self contained); and (C)—A rating temperature code (M = medium temperature [38°F], L = low temperature [0°F], or I = ice cream temperature [15°F]). For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" *equipment* class.
b. *V* is the volume of the case (ft) as measured in AHRI Standard 1200, Appendix C.
c. TDA is the total display area of the case (ft) as measured in AHRI Standard 1200, Appendix D.

…

7.1.1.2 Additions to Existing Buildings

Service water-heating systems and *equipment* shall comply with the requirements of this section.

Exception to 7.1.1.2

When the *service water heating* to an ~~addition~~*addition* is provided by existing *service water-heating systems* and *equipment*, such *systems* and *equipment* shall not be required to comply with

this standard. However, any new *systems* or *equipment* installed must comply with specific requirements applicable to those *systems* and *equipment*.

…

7.2 Compliance Paths

Service water heating systems and *equipment* shall comply with Sections 7.2.1 and ~~Section~~ 7.2.2.

7.2.1 Requirements for All Compliance Paths

~~Compliance shall be achieved by meeting the requirements of~~ Service water heating systems and equipment shall comply with Section 7.1, "General"; Section 7.4, "Mandatory Provisions"; ~~Section 7.5, "Prescriptive Path";~~ Section 7.7, "Submittals"; and Section 7.8, "Product Information."

7.2.2 Additional Requirements to Comply with Section 7

Service water heating systems and equipment shall comply with Section 7.5, "Prescriptive Compliance Path".

~~Projects using the *Energy Cost Budget* Method (Section 11) for demonstrating compliance with the standard shall meet the requirements of Section 7.4, "Mandatory Provisions," in conjunction with Section 11, "*Energy Cost Budget* Method."~~

7.3 Simplified/~~Small~~ Building ~~Option~~ Compliance Path (Not Used)

…

7.5 Prescriptive Compliance Path

…

7.5.3 Buildings with High-Capacity Service Water-Heating Systems

New *buildings* with gas *service water-heating systems* with a total installed gas water-heating input capacity of 1,000,000 Btu/h or greater, shall have gas ~~*service*~~service water-heating *equipment* with a minimum thermal *efficiency* (E_t) of 90%. Multiple units of gas water-heating *equipment* are allowed to meet this requirement if the water-heating input provided by *equipment* with thermal *efficiency* (E_t) above and below 90% provides an input capacity-weighted average thermal *efficiency* of at least 90%.

…

7.7.1

~~The *authority having jurisdiction* may require submittal of c~~Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

7.7.2 Permit Application Documentation (not used)

7.7.3 Completion Requirements

7.7.3.1 Record Documents

Construction documents shall require that, within 90 days after the date of *building envelope* acceptance, *record documents* be provided to the building owner or the designated representative of the building owner.

7.7.3.2 Manuals

Construction documents shall require that an operating manual and a maintenance manual be provided to the *building* owner or the designated representative of the *building* owner within 90 days after the date of *system* acceptance. These manuals shall be in accordance with industry-accepted standards~~,~~ and shall include, at a minimum, the following:

a. Operation manuals and maintenance manuals for each component of the *system* requiring maintenance, except components not furnished as part of the project. Required routine maintenance actions shall be clearly identified.

…

8.2 Compliance Paths

Power distribution systems and equipment shall comply with Section 8.2.1 and Section 8.2.2.

8.2.1 Requirements for All Compliance Paths

Power *distribution systems* and equipment ~~in all projects~~ shall comply with ~~the requirements of~~ Section 8.1, "General"; Section 8.4, "Mandatory Provisions"; and Section 8.7, "Submittals."

8.2.2 Additional Requirements to Comply with Section 8 (Not Used)

8.3 Simplified/~~Small~~ Building Compliance Path~~Option~~ (Not Used)

8.4 Mandatory Provisions

8.4.1 Voltage Drop

The *feeder conductors* and *branch circuits* combined shall be sized for a maximum of 5% *voltage drop* total.

8.4.2 Automatic Receptacle Control

The following shall be ~~automatically~~*automatically* controlled:

a. At least 50% of all 125 V, 15 and 20 amp receptacles in all private offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, classrooms, and individual workstations.

b. At least 25% of *branch circuit* feeders installed for modular furniture not shown on the *construction documents.*

This *control* shall function on

a. a scheduled basis using a time-of-day operated *control device* that turns receptacles off at specific programmed times—an independent program schedule shall be provided for controlled areas of no more than 5000 ft^2 and not more than one *floor* (the occupant shall be able to manually override the *control device* for up to two hours);

b. an ~~*occupant*~~ *occupancy sensor* that shall turn receptacles off within 20 minutes of all occupants leaving a *space*; or

c. an automated signal from another *control* or alarm *system* that shall turn receptacles off within 20 minutes after determining that the area is unoccupied.

All controlled receptacles shall be permanently marked to visually differentiate them from uncontrolled receptacles and are to be uniformly distributed throughout the *space*. Plug-in devices shall not be used to comply with Section 8.4.2.

…

Exception to 8.4.4

Transformers that meet any of the following exclusions of the Energy Policy Act of 2005 based on 10 CFR 431 definition:

1. Special purpose applications.
2. Not likely to be used in general purpose applications.
3. *Transformers* with multiple voltage taps, where the highest tap is at least 20% more than the lowest tap.
4. Drive *transformer*.
5. Rectifier *transformer*.
6. Auto-*transformer*.
7. Uninterruptible power *system transformer*.

8. Impedance *transformer*.
9. Regulating *transformer*.
10. Sealed and nonventilating *transformer*.
11. Machine tool *transformer*.
12. Welding *transformer*.
13. Grounding *transformer*.
14. Testing *transformer*.

8.5 Prescriptive Path (Not Used)

8.6 Alternative Compliance Path (Not Used)

8.7 Submittals

8.7.1 General

Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

8.7.2 Permit Application Documentation (not used)

8.7.3 Completion Requirements

~~**8.7.1**~~ **8.7.3.1 ~~Drawings~~Record Documents**

Construction documents shall require that within 30 days after the date of *system* acceptance, *record* ~~*drawings of the actual installation*~~*documents* shall be provided to the *building* owner, including

a. a *single-line diagram* of the *building* electrical *distribution system* and
b. *floor* plans indicating location and area served for all distribution.

~~**8.7.2**~~ **8.7.3.2 Manuals**

Construction documents shall require that an operating ~~*manual*~~manual and maintenance ~~*manual*~~manual be provided to the *building* owner. The manuals shall include, at a minimum, the following:

a. Submittal data stating *equipment* rating and selected options for each piece of *equipment* requiring maintenance.
b. Operation manuals and maintenance manuals for each piece of *equipment* requiring maintenance. Required routine maintenance actions shall be clearly identified.
c. Names and addresses of at least one qualified *service agency*.
d. A complete narrative of how each *system* is intended to operate.

(Enforcement agencies should only check to ensure that the *construction documents* require this information to be transmitted to the owner and should not expect copies of any of the materials.)

…

9.1.1 Scope

This section shall apply to the following:

a. Interior *spaces* of *buildings*.
b. Exterior lighting that is powered through the *building*'s electrical *service*.

Exception to 9.1.1

1. Emergency lighting that is ~~automatically~~*automatically* off during normal *building* operation.
2. Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation.
3. Decorative gas *lighting systems*.

…

9.1.4 Interior and Exterior Luminaire Wattage

~~*Luminaire*~~ The wattage of lighting *equipment*, when used to calculate either *installed interior lighting power* or *installed exterior lighting power*, shall be determined in accordance with the following criteria:

a. The wattage of ~~line voltage *luminaires*~~ lighting *equipment* connected to line voltage ~~not containing *permanently installed ballasts, transformers,* or similar devices~~ shall be the *manufacturers*' *labeled* maximum wattage ~~of the *luminaire*~~.

b. The wattage of line voltage ~~*luminaires*~~ lighting *equipment* with ~~*permanently installed* or~~ remote *ballasts*/*drivers*, ~~*transformers*,~~ or similar devices shall be the total ~~operating~~ input wattage of ~~the maximum *lamp*/auxiliary combination based on values from the auxiliary *manufacturers*' literature or recognized testing laboratories or shall be the maximum *labeled* wattage of the *luminaire*~~ all line voltage components in the *system*.

Exception to 9.1.4(b)

Lighting power calculations for *ballasts* with adjustable *ballast* factors shall be based on the *ballast* factor that will be used in the *space*, provided that the *ballast* factor is not user changeable.

c. For line-voltage lighting track and plug-in busway designed to allow the addition and/or relocation of ~~*luminaires*~~ lighting *equipment* without altering the wiring of the *system*, the wattage shall be

1. the specified wattage of the ~~*luminaires*~~ lighting *equipment* included in the *system* with a minimum of 30 W/lin ft,
2. the wattage limit of the *system*'s *circuit breaker*, or
3. the wattage limit of other permanent current-limiting devices on the *system*.

d. The wattage of low-voltage lighting track, cable conductor, rail conductor, and other flexible *lighting systems* that allow the addition and/or relocation of ~~*luminaires*~~ lighting *equipment* without altering the wiring of the *system* shall be the specified wattage of the *ballast/driver* or *transformer* supplying the *system*.

e. The wattage of a DC low-voltage lighting *system* that employs flexible cabling for plug-in connection of the lighting *equipment* and a remote power supply~~,~~ shall be labeled maximum wattage of the *system* power supply. For *systems* that also provide power to *equipment* other than lighting, the wattage shall be labeled maximum wattage of the *system* power supply reduced by the wattage of the non-lighting *equipment* connected to the *system*.

~~e.~~ f. The wattage of all other miscellaneous lighting *equipment* shall be the specified wattage of the lighting *equipment*.

9.1.5 Climate

Climate zones shall be determined in accordance with Section 5.1.4.

9.2 Compliance Paths

~~Compliance Paths~~

Lighting systems and equipment shall comply with Section 9.2.1 and Section 9.2.2.

9.2.1 Requirements for All Compliance Paths

Lighting systems and equipment shall comply with Section 9.1, "General"; Section 9.4, "Mandatory Provisions"; and Section 9.7, "Submittals".~~;~~

Additional Requirements to Comply with Section 9

Lighting systems and equipment shall comply with:

a. Section 9.5, "Building Area Method Compliance Path," or

b. Section 9.6, "Alternative Compliance Path: Space-by-Space Method."

…

9.2.2.3

The following lighting *equipment* and applications shall not be considered when determining the *interior lighting power allowance* developed in accordance with Section 9.5 or 9.6, nor shall the wattage for such lighting be included in the *installed interior lighting power* identified in accordance with Section 9.1.3. However, any such lighting shall not be exempt unless it is an addition to *general lighting* and is controlled by an independent *control device*.

1. Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments.
2. Lighting that is integral to *equipment* or instrumentation and is installed by its *manufacturer*.
3. Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical *equipment*.
4. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.
5. Lighting integral to food warming and food preparation *equipment*.
6. Lighting specifically designed for the life support of nonhuman life forms.
7. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
8. Lighting in interior *spaces* that have been specifically designated as a registered interior *historic* landmark.
9. Lighting that is an integral part of advertising or directional signage.
10. Exit signs.
11. Lighting that is for sale or lighting educational demonstration *systems*.
12. Lighting for theatrical purposes, including performance, stage, and film and video production.
13. Lighting for television broadcasting in sporting activity areas.
14. Casino gaming areas.
15. Furniture-mounted supplemental *task lighting* that is controlled by *automatic* shutoff and complies with Section 9.4.1.3(c).
16. Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas.
17. Parking garage transition lighting—lighting for covered vehicle entrances and exits from *buildings* and parking structures—that complies with

Section 9.4.1.2(a) and 9.4.1.2(c); each transition zone shall not exceed a depth of 66 ft inside the structure and a width of 50 ft.

…

9.4 Mandatory Provisions

9.4.1 Lighting Control

Building lighting *controls* shall be installed to meet the provisions of Sections 9.4.1.1, 9.4.1.2, 9.4.1.3 and 9.4.1.4.

9.4.1.1 Interior Lighting Controls

For each *space* in the *building*, all of the lighting *control* functions indicated in Table 9.6.1, for the appropriate *space* type in the first column, and as described below, shall be implemented. All *control* functions ~~*labeled* with an~~ indicated as "REQ" are mandatory and shall be implemented. If a *space* type has *control* functions ~~*labeled*~~ indicated as "ADD1," then at least one of those functions shall be implemented. If a *space* type has *control* functions ~~*labeled*~~ indicated as "ADD2," then at least one of those functions shall be implemented. For *space* types not listed, select a reasonably equivalent type.

If using the Space-by-Space Method, the *space* type used for determining *control* requirements shall be the same *space* type that is used for determining the *LPD* allowance.

a. *Local control:* There shall be one or more *manual* lighting *controls* in the *space* that *controls* all of the lighting in the *space*. Each *control device* shall *control* an area (1) no larger than 2500 ft^2 if the *space* is ≤10,000 ft^2 and (2) no larger than 10,000 ft^2 otherwise. The device installed to comply with this provision shall be *readily accessible* and located so that the occupants can see the controlled lighting when using the *control device*.

Exception to 9.4.1.1(a)

Remote location of this local *control device* or devices shall be permitted for reasons of safety or security when each remote *control device* has an indicator pilot light as part of or next to the *control device* and the light is clearly *labeled* to identify the controlled lighting.

b. *Restricted to manual* ON*:* None of the lighting shall be ~~automatically~~*automatically* turned on.

Exception to 9.4.1.1(b)

Manual ON is not required where *manual* ON operation of the *general lighting* would endanger the safety or security of the room or *building* occupants.

c. *Restricted to partial automatic ON:* No more than 50% of the lighting power for the *general lighting* shall be allowed to be ~~automatically~~*automatically* turned on, and none of the remaining lighting shall be ~~automatically~~*automatically* turned on.

Exception to 9.4.1.1(c)

Lighting in open-plan office *spaces* shall be allowed to turn on ~~automatically~~*automatically* to more than 50%, provided the *control* zone is no larger than 600 ft^2.

…

Exception to9.4.1.1(f)

The following areas are exempted from Section 9.4.1.1(f):

1. *Daylight area under skylights* where it is documented that existing adjacent structures or natural objects block direct sunlight for more than 1500 daytime hours per year between 8 a.m. and 4 p.m.
2. *Daylight area under skylights* where the overall *skylight effective aperture* for the *enclosed space* is less than 0.006.

3. In each *space* within *buildings* in Climate Zone 8 where the input power of the *general lighting* within *daylight areas* is less than 200 W.

g. *Automatic partial OFF (full OFF complies):* The *general lighting* power in the *space* shall be ~~automatically~~*automatically* reduced by at least 50% within 20 minutes of all occupants leaving the *space*.

Exception to 9.4.1.1(g)

This requirement does not have to be complied with in *spaces* that meet all three of the following requirements:

1. The *space* has an installed *LPD* of no more than 0.80 W/ft^2.
2. The *space* is lighted by *HID lamp*.
3. The *general lighting* power in the *space* is ~~automatically~~*automatically* reduced by at least 30% within 20 minutes of all occupants leaving the *space*.
4. Lighting load does not exceed 0.02 W/ft^2 multiplied by the *gross lighted floor area* of the *building*.

h. *Automatic full OFF:* All lighting, including lighting connected to emergency circuits, shall be ~~automatically~~*automatically* shut off within 20 minutes of all occupants leaving the *space*. A *control device* meeting this requirement shall *control* no more than 5000 ft^2.

Exception to 9.4.1.1(h)

The following lighting is not required to be ~~automatically~~*automatically* shut off:

1. *General lighting* and *task lighting* in shop and laboratory classrooms.
2. *General lighting* and *task lighting* in *spaces* where *automatic* shutoff would endanger the safety or security of room or *building* occupants.
3. Lighting required for 24/7 operation.

~~3.~~4. Lighting load not exceeding 0.02 W/ft^2 (0.22 W/m^2) multiplied by the *gross lighted area* of the *building*.

i. *Scheduled shutoff:* All lighting in the *space*, including lighting connected to emergency circuits, shall be ~~automatically~~*automatically* shut off during periods when the *space* is scheduled to be unoccupied using either (1) a time-of-day operated *control device* that ~~automatically~~*automatically* turns the lighting off at specific programmed times or (2) a signal from another *automatic control device* or alarm/security *system*. The *control device* or *system* shall provide independent *control* sequences that (1) *control* the lighting for an area of no more than 25,000 ft^2, (2) include no more than one *floor*, and (3) shall be programmed to account for weekends and holidays. Any *manual control* installed to provide override of the scheduled shutoff *control* shall not turn the lighting on for more than two hours per activation during scheduled off periods and shall not *control* more than 5000 ft^2.

Exception to 9.4.1.1(i)

The following lighting is not required to be on scheduled shutoff:

1. Lighting in *spaces* where lighting is required for 24/7 continuous operation.
2. Lighting in *spaces* where patient care is rendered.
3. Lighting in *spaces* where *automatic* shutoff would endanger the safety or security of the room or *building* occupants.
4. Lighting load not exceeding 0.02 W/ft^2 multiplied by the *gross lighted floor area* of the *building*.

9.4.1.2 Parking Garage Lighting Control

Lighting for parking garages shall comply with the following requirements:

a. Parking garage lighting shall have *automatic* lighting shutoff per Section 9.4.1.1(i).

b. Lighting power of each *luminaire* shall be ~~automatically~~*automatically* reduced by a minimum of 30% when there is no activity detected within a lighting zone for 20 minutes. Lighting zones for this requirement shall be no larger than 3600 ft^2.

c. Lighting for covered vehicle entrances and exits from *buildings* and parking structures shall be separately controlled by a device that ~~automatically~~*automatically* reduces the lighting by at least 50% from sunset to sunrise.

d. The power to *luminaires* within 20 ft of any perimeter *wall* structure that has a net opening-to-*wall* ratio of at least 40% and no exterior obstructions within 20 ft, shall be ~~automatically~~*automatically* reduced in response to daylight by at least 50%.

Exception to 9.4.1.2(d)

Lighting in the following areas is exempt:

1. Lighting in daylight transitions zones and ramps without parking.

9.4.1.3 Special Applications

a. The following lighting shall be separately controlled from the *general lighting* in all *spaces*:

1. Display or accent lighting.
2. Lighting in display cases.
3. Nonvisual lighting, such as for plant growth or food warming.
4. Lighting *equipment* that is for sale or used for demonstrations in lighting education.

b. Guestrooms

1. All lighting and all switched receptacles in guestrooms and suites in hotels, motels, boarding houses, or similar *buildings* shall be ~~automatically~~*automatically* controlled such that the power to the lighting and switched receptacles in each *enclosed space* will be turned off within 20 minutes after all occupants leave that *space*.

Exception to 9.4.1.3(b)(1)

Enclosed spaces where the lighting and switched receptacles are controlled by ~~captive~~ card key ~~*systems*~~ *controls* and bathrooms are exempt.

2. Bathrooms shall have a separate *control device* installed to ~~automatically~~*automatically* turn off the bathroom lighting within 30 minutes after all occupants have left the bathroom.

Exception to 9.4.1.3(b)(2)

Night lighting of up to 5 W per bathroom is exempt.

c. All supplemental *task lighting*, including *permanently installed* undershelf or undercabinet lighting, shall be controlled from either (1) a *control device* integral to the *luminaires* or (2) by a *wall*-mounted *control device* that is *readily accessible* and located so that the occupant can see the controlled lighting.

9.4.1.4 Exterior Lighting Control

Lighting for exterior applications not exempted in Section 9.1 shall meet the following requirements:

a. Lighting shall be controlled by a device that ~~automatically~~*automatically* turns off the lighting when sufficient daylight is available.

b. All *building* façade and landscape lighting shall be ~~automatically~~*automatically* shut off between midnight or business closing, whichever is later, and 6 a.m. or business opening, whichever comes first, or between times established by the *authority having jurisdiction*.

c. Lighting not specified in Section 9.4.1.4(b) and lighting for signage shall be controlled by a device that ~~automatically~~*automatically* reduces the connected lighting power by at least 50% for at least one of the following conditions:

1. From 12 midnight or within one hour of the end of business operations, whichever is later, until 6 a.m. or business opening, whichever is earlier.

2. During any period when no activity has been detected for a time of no longer than 15 minutes.

d. *Luminaires* serving outdoor parking areas and having a rated input wattage of greater than 78 W and a mounting height of 24 ft or less above the ground shall be controlled to ~~automatically~~*automatically* reduce the power of each *luminaire* by a minimum of 50% when no activity has been detected in the area illuminated by the controlled *luminaires* for a time of no longer than 15 minutes. No more than 1500 W of lighting power shall be controlled together.

All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least ten hours.

…

Table 9.4.2-2 Individual Lighting Power Allowances for *Building* Exteriors

	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.)					
	No allowance	350 W	400 W	500 W	900 W
Tradable Surfaces (*LPD* allowances for uncovered parking areas, *building* grounds, *building entrances*, exits and loading docks, canopies and overhangs, and outdoor sales areas may be traded.)					
Uncovered Parking Areas					
Parking areas and drives	No allowance	0.03 W/ft^2	0.04 W/ft^2	0.06 W/ft^2	0.08 W/ft^2
***Building* Grounds**					
Walkways/ramps less than 10 ft wide	No allowance	0.5 W/linear foot	0.5 W/linear foot	0.6 W/linear foot	0.7 W/linear foot
Walkways/ramps 10 ft wide or greater Plaza areas Special feature areas	No allowance	0.10 W/ft^2	0.10 W/ft^2	0.11 W/ft^2	0.14 W/ft^2
Dining areas	No allowance	0.65 W/ft^2	0.65 W/ft^2	0.75 W/ft^2	0.95 W/ft^2
Stairways	No allowance	0.6 W/ft^2	0.7 W/ft^2	0.7 W/ft^2	0.7 W/ft^2
Pedestrian tunnels	No allowance	0.12 W/ft^2	0.12 W/ft^2	0.14 W/ft^2	0.21 W/ft^2
Landscaping	No allowance	0.03 W/ft^2	0.04 W/ft^2	0.04 W/ft^2	0.04 W/ft^2
***Building Entrances*, Exits, and Loading Docks**					
Pedestrian and vehicular entrances and exits	No allowance	14 W/lin ft of opening	14 W/lin ft of opening	21 W/lin ft of opening	21 W/lin ft of opening

Entry canopies	No allowance	0.20 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
Loading docks	No allowance	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2
Sales Canopies					
Free standing and attached	No allowance	0.4 W/ft^2	0.4 W/ft^2	0.6 W/ft^2	0.7 W/ft^2
Outdoor Sales					
Open areas (including vehicle sales lots)	No allowance	0.2 W/ft^2	0.2 W/ft^2	0.35 W/ft^2	0.5 W/ft^2
Street frontage for vehicle sales lots in addition to “open area” allowance	No allowance	No allowance	7 W/linear foot	7 W/linear foot	21 W/linear foot
Nontradable Surfaces (*LPD* allowances 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 (The allowance for each illuminated facade *orientation* shall be calculated by multiplying the allowable value by the entire façade area or facade length for that *orientation*.)	No allowance	No allowance	0.1 W/ft^2 of *façade area* or 2.5 W/linear foot of façade length	0.15 W/ft^2 of *façade area* or 3.75 W/linear foot of façade length	0.2 W/ft^2 of *façade area* or 5.0 W/linear foot of façade length
Automated teller machines and night depositories	No allowance	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location
Uncovered entrances and gatehouse inspection stations at guarded facilities	No allowance	0.5 W/ft^2	0.5 W/ft^2	0.5 W/ft^2	0.5 W/ft^2
Uncovered loading areas for law enforcement, fire, ambulance, and other emergency ~~*service*~~service vehicles	No allowance	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2
Drive-through windows/*doors*	No allowance	200 W per drive-through	200 W per drive-through	200 W per drive-through	200 W per drive-through
Parking near 24-hour retail entrances	No allowance	400 W per main entry	400 W per main entry	400 W per main entry	400 W per main entry
Roadway/parking entry, trail head, and toilet facility, or other locations approved by the *authority having jurisdiction*.	A single *luminaire* of 25 W or less	No additional allowance	No additional allowance	No additional allowance	No additional allowance

…

9.4.3 Functional Testing

Lighting *control devices* and *control systems* shall be tested to 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.

When *occupant* *occupancy* *sensors*, time switches, programmable schedule *controls*, or *photosensors* are installed, at a minimum, the following procedures shall be performed:

a. Occupant *Occupancy Sensors*

1. Certify that the sensor has been located and aimed in accordance with *manufacturer* recommendations.
2. For projects with up to seven (7) ~~occupancy sensors~~*occupancy sensors*, all ~~occupancy sensors~~*occupancy sensors* shall be tested.
3. For projects with more than seven (7) ~~occupancy sensors~~*occupancy sensors*, testing shall be done for each unique combination of sensor type and *space* geometry.
   (a) For each sensor to be tested, verify the following:
   (1) Status indicator (as applicable) operates correctly.
   (2) Controlled lights turn off or down to the permitted level within the required time.
   (3) For auto-ON *occupant* *occupancy* *sensors*, the lights turn on to the permitted level when someone enters the *space*.
   (4) For *manual*-ON sensors, the lights turn on only when manually activated.
   (5) The lights are not incorrectly turned on by movement in nearby areas or by HVAC operation.

…

9.5 Building Area Method Compliance Path

9.5.1 Building Area Method of Calculating Interior Lighting Power Allowance

Use the following steps to determine the *interior lighting power allowance* by the *Building* Area Method:

a. Determine the appropriate *building* area type from Table 9.5.1 and the corresponding *LPD* allowance. For *building* area types not listed, selection of a reasonably equivalent type shall be permitted.

b. Determine the *gross lighted floor area* in ft^2 of the *building* area type.

c. Multiply the *gross lighted floor areas* of the *building* area types times the *LPD*.

d. The *interior lighting power allowance* for the *building* is the sum of the lighting power allowances of all *building* area types. Trade-offs among *building* area types are permitted, provided that the total *installed interior lighting power* does not exceed the *interior lighting power allowance*.

…

9.6 Alternative Compliance Path: Space-by-Space Method

9.6.1 Space-by-Space Method of Calculating Interior Lighting Power Allowance

Use the following steps to determine the *interior lighting power allowance* by the Space-by-Space Method:

a. For each *space* enclosed by partitions that are 80% of the ceiling height or taller, determine the appropriate *space* type and the corresponding

LPD allowance from Table 9.6.1. If a *space* has multiple functions, where more than one *space* type is applicable, that *space* shall be broken up into smaller subspaces, each using its own *space* type from Table 9.6.1. Any of these subspaces that are smaller in ~~*floor area*~~floor area than 20% of the original *space* and less than 1000 ft^2 need not be broken out separately. Include the ~~*floor area*~~floor area of balconies and other projections in this calculation.

b. In calculating the area of each *space* and subspace, the limits of the area are defined by the centerline of interior walls, the dividing line between subspaces, and the outside surface of *exterior walls* or *semiexterior walls*. For the purposes of this section, *semiexterior walls* that separate *semiheated space* from *conditioned space* shall be considered interior walls.

c. Based on the *space* type selected for each *space* or subspace, determine the lighting power allowance of each *space* or subspace by multiplying the calculated area of the *space* or subspace by the appropriate *LPD* allowance determined in Section 9.6.1(a). For *space* types not listed, selection of a reasonable equivalent category shall be permitted.

d. The *interior lighting power allowance* is the sum of lighting power allowances of all *spaces* and subspaces. Trade-offs among *spaces* and subspaces are permitted, provided that the total *installed interior lighting power* does not exceed the *interior lighting power allowance*.

...

***Building* Type Specific/*Space* Types[1]**	***LPD* W/ft²**	***RCR* Threshold**	**a**	**b**	**c**	**d**	**e**	**f**
Retail Facilities								
Dressing/fitting room	0.5	8	REQ	ADD1	ADD1	REQ		REQ
Mall concourse	0.9	4	REQ	ADD1	ADD1	REQ	REQ	REQ
Sports Arena—Playing Area[8]								
Class I facility	2.47	4	REQ	ADD1	ADD1	REQ	REQ	REQ
Class II facility	1.96	4	REQ	ADD1	ADD1	REQ	REQ	REQ
Class III facility	1.70	4	REQ	ADD1	ADD1	REQ	REQ	REQ
Class IV facility	1.13	4	REQ	ADD1	ADD1	REQ	REQ	REQ
Transportation Facility								
Baggage/carousel area	0.45	4	REQ	ADD1	ADD1		REQ	REQ
Airport concourse	0.31	4	REQ	ADD1	ADD1		REQ	REQ
~~*Terminal t*~~Ticket counter	0.62	4	REQ	ADD1	ADD1	REQ	REQ	REQ
Warehouse—Storage Area								
Medium to bulky, palletized items	0.35	4	REQ	ADD1	ADD1	REQ	REQ	REQ
Smaller, hand-carried items[5]	0.69	6	REQ	ADD1	ADD1	REQ	REQ	REQ

1. In cases where both a common *space* type and a *building* area specific *space* type are listed, the *building* area specific *space* type shall apply
2. In corridors, the extra *lighting power density* allowance is permitted when the width of the corridor is less than 8 ft and is not based on the *RCR*.
3. A "Facility for the Visually Impaired" is a facility that can be documented as being designed to comply with the light levels in ANSI/IES RP-28 and is licensed or will be licensed by local
daycare, senior support and/or people with special visual needs.
4. For accent lighting, see Section 9.6.2(b).
5. Sometimes referred to as a "Picking Area."
6. *Automatic* daylight responsive *controls* are mandatory only if the requirements of the specified sections are present.
7. An additional 0.52 W/ft² shall be allowed, provided that the additional lighting is controlled separately from the base allowance of 0.43 W/ft². The additional 0.52 W/ft² allowance shall not
8. Class of play as defined by IES RP-6.

...

9.6.2 Additional Interior Lighting Power

When using the Space-by-Space Method, an increase in the *interior lighting power allowance* is allowed for specific lighting functions. Additional power shall be allowed only if the specified lighting is installed and ~~automatically~~*automatically* controlled, separately from the *general lighting*, to be turned off during nonbusiness hours. This additional power shall be used only for the specified *luminaires* and shall not be used for any other purpose unless otherwise indicated.

An increase in the *interior lighting power allowance* is permitted in the following cases:

a. For *spaces* in which lighting is specified to be installed in addition to the *general lighting* for the purpose of decorative appearance or for highlighting art or exhibits not exempted in Section 9.2.2.3, Exception 1, provided that the additional lighting power shall not exceed 0.75 W/ft^2 of such *spaces.*

b. For lighting *equipment* installed in sales areas and specifically designed and directed to highlight merchandise, calculate the additional lighting power as follows:

Additional *Interior Lighting Power Allowance* =
1000 W + (Retail Area 1 × 0.45 W/ft^2) + (Retail Area 2 × 0.45 W/ft^2)
+ (Retail Area 3 × 1.05 W/ft^2) + (Retail Area 4 × 1.88 W/ft^2)

where

Retail Area 1 = the ~~*floor area*~~floor area for all products not listed in Retail Areas 2, 3, or 4

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

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

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

Exception to 9.6.2

Other merchandise categories may 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*.

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Table 9.6.3 *Control* Factors Used in Calculating Additional *Interior Lighting Power Allowance*

Additional *Control* Method (in Addition to Mandatory Requirements)	***Space* Type**				
	Open Office	**Private Office**	**Conference Room, Meeting Room, Classroom (Lecture/ Training)**	**Retail Sales Area**	**Lobby, Atrium, Dining Area, Corridors/ Stairways, Gym/*Pool*, Mall Concourse, Parking Garage**
Manual, continuous dimming *control* or programmable multilevel dimming *control*	0.05	0.05	0.10	0.10	0
Programmable multilevel dimming *control* using programmable time scheduling	0.05	0.05	0.10	0.10	0.10

~~Occupancy sensors~~*Occupancy sensors* controlling the downlight component of workstation specific *luminaires* with continuous dimming to off capabilities	0.25[a]	0	0	0	0
~~Occupancy sensors~~*Occupancy sensors* controlling the downlight component of workstation specific *luminaires* with continuous dimming to off operation, in combination with personal continuous dimming *control* of downlight illumination by workstation occupant	0.30[a,b]	0	0	0	0
Automatic continuous daylight dimming in *secondary sidelighted areas*	0.10[c]	0.10[c]	0.10[c]	0.10[c]	0.10[c]

a. *Control* factor is limited to workstation-specific *luminaires* in partitioned single occupant work *spaces* contained within an open office environment (i.e. direct-indirect *luminaires* with separately controlled downlight and uplight components, with the downward component providing illumination to a single occupant in an open plan workstation). Within 30 minutes of the occupant leaving the *space*, the downward component shall continuously dim to off over a minimum of two minutes. Upon the occupant entering the *space*, the downward component shall turn on at the minimum level and continuously raise the illumination to a preset level over a minimum of 30 seconds. The uplight component of workstation specific *luminaire* shall comply with Section 9.4.1.1(h) (*automatic* full off).

b. In addition to the requirements described in footnote (a), the *control* shall allow the occupant to select their preferred light level via a personal computer, handheld device, or similarly accessible device located within the workstation.

c. *Control* factors may not be used if *controls* are used to satisfy exceptions to Section 5.5.4.2.3

…

9.7 Submittals

9.7.1 General

~~Where required by the *authority having jurisdiction*, the submittal of c~~Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2.

~~**9.7.2**~~ **9.7.2 Permit Application Documentation** (not used)

~~**9.7.2**~~ **9.7.3 Completion Requirements**

~~The following requirements are mandatory provisions and are necessary for compliance with this standard.~~

~~**9.7.2.1**~~ **9.7.3.1 ~~Drawings~~Records Documents**

Construction documents shall require that within 90 days after the date of *system* acceptance, *record* ~~*drawings of the actual installation*~~*documents* be provided to the *building* owner or the designated representative of the *building* owner. *Record* ~~*drawings*~~ *documents* shall include, as a minimum, the location, *luminaire* identifier, *control*, and circuiting for each piece of lighting *equipment*.

~~**9.7.2.2**~~ **9.7.3.2 Manuals**

Construction documents shall require for all lighting *equipment* and lighting *controls* that an operating ~~*manual*~~manual and maintenance ~~*manual*~~manual be provided to the *building* owner or the designated representative of the *building* owner within 90 days after the date of *system* acceptance. These manuals shall include, at a minimum, the following:

a. Submittal data indicating all selected options for each piece of lighting *equipment*, including but not limited to *lamps*, *ballasts*, *drivers*, and lighting *controls*.

b. Operation and maintenance manuals for each piece of lighting *equipment* and lighting *controls* with routine maintenance clearly identified including, as a minimum, a recommended relamping/cleaning program and a schedule for inspecting and recalibrating all lighting *controls*.

c. A complete narrative of how each lighting *control system* is intended to operate, including recommended settings.

~~9.7.2.3~~ 9.7.3.3 Daylighting Documentation

The design documents shall identify all *luminaires* for *general lighting* that are located within *daylight areas under skylights*, *daylight areas under roof monitors*, and *primary sidelighted area* and *secondary sidelighted areas*.

…

10.2 Compliance Paths

Other equipment shall comply with Section 10.2.1 and Section 10.2.2.

10.2.1 Requirements for All Compliance Paths

~~Compliance with Section 10 shall be achieved by meeting all requirements of~~ Other equipment shall comply with Section 10.1, "General"; Section 10.4, "Mandatory Provisions"; and Section 10.8, "Product Information."

10.2.2 Additional Requirements to Comply with Section 10 (Not Used)

~~Projects using the *Energy Cost Budget* Method (Section 11 of this standard) must comply with Section 10.4, the mandatory provisions of this section, as a portion of that compliance path.~~

10.3 Simplified~~/Small~~ Building ~~Option~~ Compliance Path (Not Used)

10.4 Mandatory Provisions

10.4.1 Electric Motors

Electric motors manufactured alone or as a component of another piece of *equipment* with a *rated motor power* of 1 hp or more, and less than or equal to 200 hp, shall comply with the requirements shown in Table 10.8-1 for *NEMA Design A motors*, *NEMA Design B motors*, and *IEC Design N motors*, and Table 10.8-2 for *NEMA Design C motors* and *IEC Design H motors*.

General purpose *small electric motors* with an *rated motor power* of 0.25 hp or more, and less than or equal to 3 hp, shall have a minimum average full-load *efficiency* that is not less than as shown in Table 10.8-3 for polyphase *small electric motors* and Table 10.8-4 for capacitor-start capacitor-run *small electric motors* and capacitor-start induction-run *small electric motors*.

Fire pump electric motors shall have a minimum nominal full-load *efficiency* that is not less than that shown in Table 10.8-5.

Exception to 10.4.1

The standards in this section do not apply to the following exempt electric motors:

1. Air-over electric motors.
2. Component sets of an electric motor.
3. Liquid-cooled electric motors.
4. Submersible electric motors.
5. Inverter-only electric motors.

10.4.2 Service Water Pressure-Booster Systems

~~*Service*~~Service water pressure-booster *systems* shall be designed such that the following apply:

a. One or more pressure sensors shall be used to vary pump speed and/or start and stop pumps. The sensors shall either be located

near the critical *fixtures* that determine the pressure required, or logic shall be employed that adjusts the *set point* to simulate operation of remote sensors.

b. No devices shall be installed for the purpose of reducing the pressure of all of the water supplied by any booster *system* pump or booster *system*, except for safety devices.

c. No booster *system* pumps shall operate when there is no ~~*service*~~service water flow.

…

10.4.4 Escalators and Moving Walks

Escalators and moving walks shall ~~automatically~~*automatically* slow to the minimum permitted speed in accordance with ASME A17.1/CSA B44 or applicable local code when not conveying passengers.

…

10.4.5.1 Monitoring

Measurement devices shall be installed to monitor the *building* use of the following types of *energy* supplied by a utility, *energy* provider, or plant that is not within the *building*:

a. Natural gas.

b. *Fuel* oil.

c. Propane.

d. Steam.

~~e.~~ f. Chilled water.

f. Hot water.

…

10.7 Submittals ~~(Not Used)~~

10.7.1 General

Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

10.7.2 Permit Application Documentation (not used)

10.7.3 Completion Requirements

10.7.3.1 Record Documents

Construction documents shall require that within 90 days after the date of *system* acceptance, *record documents* shall be provided to the *building* owner.

10.7.3.2 Manuals (not used)

…

11.2 Compliance

~~Compliance with Section 11 will be achieved if~~The proposed building design shall comply with all of the following:

a. ~~all requirements of~~ Sections 5.2.1, 6.2.1, 7.2.1., 8.2.1, 9.2.1, and 10.2.1~~5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 are met~~; ~~and~~

b. ~~the A~~a *design energy cost*, as calculated in Section 11.5, that does not exceed the *energy cost budget* as calculated by the *simulation program* described in Section 11.4; and

~~the~~ ~~T~~the *energy efficiency* level of installed components and systems ~~specified in the *building* design~~that meets or exceeds the *efficiency* levels used to calculate the *design energy cost*.

Informative Note

The energy cost budget and the design energy cost calculations are applicable only for determining compliance with this standard. They are not predictions of actual energy consumption or costs of the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this standard, changes in energy rates between design of the building and occupancy, and precision of the calculation tool.

11.3 Simplified Option (Not Used)

…

Submittals~~Documentation Requirements~~

11.7.1 General

Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

11.7.2 Permit Application Documentation

Compliance shall be documented and submitted to the *building official~~authority having jurisdiction~~*. The information submitted shall include the following:

a. The *energy cost budget* for the *budget building design* and the *design energy cost* for the *proposed design*.

b. A list of the *energy*-related features that are included in the design and on which compliance with the provisions of Section 11 is based. This list shall document all *energy* features that differ between the models used in the *energy cost budget* and the *design energy cost* calculations.

c. The input and output reports from the *simulation program*, including a breakdown of *energy* usage by at least the following components: lights, internal *equipment* loads, *service water-heating equipment*, *space*-heating *equipment*, *space* cooling and heat-rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of time any loads are not met by the *HVAC system* for both the *proposed design* and *budget building design*.

d. An explanation of any error messages noted in the *simulation program* output.

~~e.~~ f. The reduction in *design energy cost* associated with *on-site renewable energy*.

11.7.3 Completion Requirements

Completion requirements shall be in compliance with Section 5.7.3, 6.7.3, 7.7.3, 8.7.3, 9.7.3, and 10.7.3.

11.8 Product Information (Not Used)

Table 11.5.1 Modeling Requirements for Calculating *Design Energy Cost* and *Energy Cost Budget*

Proposed Design **(Column A)** ***Design Energy Cost*** **(DEC)**	***Budget Building Design*** **(Column B)** ***Energy Cost Budget*** **(ECB)**

1. Design Model	
a. The simulation model of the *proposed design* shall be consistent with the design documents, including proper accounting of *fenestration* and *opaque envelope* types and area; interior lighting power and *controls*; *HVAC system* types, sizes, and *controls*; and *service water-heating systems* and *controls*. b. All *conditioned spaces* in the *proposed design* shall be simulated as being both heated and cooled, even if no cooling or heating *system* is being installed. Temperature and humidity *control set points* and schedules, as well as *temperature control throttling range*, shall be the same for *proposed design* and *baseline building design*. c. When the *Energy Cost Budget* Method is applied to *buildings* in which *energy*-related features have not yet been designed (e.g., a *lighting system*), those yet-to-be-designed features shall be described in the *proposed design* so that they minimally comply with applicable mandatory and prescriptive requirements from Sections 5 through 10. Where the *space* classification for a *building* is not known, the *building* shall be categorized as an office *building*.	The *budget building design* shall be developed by modifying the *proposed design* as described in this table. Except as specifically instructed in this table, all *building systems* and *equipment* shall be modeled identically in the *budget building design* and *proposed design*.
2. Additions and *Alterations*	
It is acceptable to demonstrate compliance using *building* models that exclude parts of the *existing building*, provided all of the following conditions are met: a. Work to be performed under the current permit application in excluded parts of the *building* shall meet the requirements of Sections 5 through 10. b. Excluded parts of the *building* are served by *HVAC systems* that are entirely separate from those serving parts of the *building* that are included in the *building* model. c. Design *space* temperature and *HVAC system* operating *set points* and schedules on either side of the boundary between included and excluded parts of the *building* are identical. d. If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the *building* are on the same utility meter, the rate shall reflect the utility block or rate for the *building* plus the ~~addition~~addition.	Same as *proposed design*.
3. *Space* Use Classification	
The *building* area type or *space* type classifications shall be chosen in accordance with Section 9.5.1 or 9.6.1. The user or designer shall specify the *space* use classifications using either the *building* area type or *space* type categories but shall not combine the two types of categories within a single permit application. More than one *building* area type category may be used for a *building* if it is a mixed-use facility.	Same as *proposed design*.
4. Schedules	
The schedule types listed in Section 11.4.1.1(b) shall be required	Same as *proposed design*.

input. The schedules shall be typical of the *proposed design* as determined by the designer and approved by the *authority having jurisdiction*. Required schedules shall be identical for the *proposed design* and *budget building design*.

5. *Building Envelope*	
All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as installed for *existing building envelopes*. **Exceptions:** The following *building* elements are permitted to differ from architectural drawings. 1. Any *building envelope* assembly that covers less than 5% of the total area of that assembly type (e.g., *exterior walls*) need not be separately described. If not separately described, the area of a *building envelope* assembly must be added to the area of the adjacent assembly of that same type. 2. Exterior surfaces whose azimuth *orientation* and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers. 3. The exterior *roof* surface shall be modeled using the aged solar *reflectance* and thermal *emittance* determined in accordance with Section 5.5.3.1.1(a). Where aged test data are unavailable, the *roof* surface shall be modeled with a solar *reflectance* of 0.30 and a thermal *emittance* of 0.90. 4. Manually operated *fenestration* shading devices, such as blinds or shades, shall not be modeled. Permanent shading devices, such as fins, overhangs, and lightshelves, shall be modeled.	The *budget building design* shall have identical conditioned floor area and identical exterior dimensions and orientations as the *proposed design*, except as follows: a. *Opaque* assemblies, such as *roof*, *floors*, *doors*, and *walls*, shall be modeled as having the same *heat capacity* as the *proposed design* but with the minimum *U-factor* required in Section 5.5 for new *buildings* or additions and Section 5.1.3 for *alterations*. b. The exterior *roof* surfaces shall be modeled with a solar *reflectance* and thermal *emittance* as required in Section 5.5.3.1.1(a). All other *roofs*, including *roofs* exempted from the requirements in Section 5.5.3.1.1, shall be modeled the same as the *proposed design*. c. No shading projections are to be modeled; *fenestration* shall be assumed to be flush with the *wall* or *roof*. If the *fenestration area* for new *buildings* or additions exceeds the maximum allowed by Section 5.5.4.2, the area shall be reduced proportionally along each exposure until the limit set in Section 5.5.4.2 is met. If the *vertical fenestration area* facing west or east of the *proposed design* exceeds the area limit set in Section 5.5.4.5 then the *energy cost budget* shall be generated by simulating the *budget building design* with its actual *orientation* and again after rotating the entire *budget building design* 90, 180, and 270 degrees and then averaging the results. *Fenestration U-factor* shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate, and the *SHGC* shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate. For portions of those tables where there are no *SHGC* requirements, the *SHGC* shall be equal to that determined in accordance with Section C3.6(c). The *VT* shall be equal to that determined in accordance with Section C3.6(c). The *fenestration* model for *building envelope alterations* shall reflect the limitations on area, *U-factor*, and *SHGC* as described in Section 5.1.3. **Exceptions:** When trade-offs are made between an ~~addition~~addition and an *existing building*, as described in the exception to Section 4.2.1.2, the *building envelope* assumptions for the *existing building* in the

	budget building design shall reflect existing conditions prior to any revisions that are part of this permit.
6. Lighting	
Lighting power in the *proposed design* shall be determined as follows: a. Where a complete *lighting system* exists, the actual lighting power for each *thermal block* shall be used in the model. b. Where a *lighting system* has been designed, lighting power shall be determined in accordance with Sections 9.1.3 and 9.1.4. c. Where no lighting exists or is specified, lighting power shall be determined in accordance with the *Building* Area Method for the appropriate *building area type*. d. *Lighting system* power shall include all *lighting system* components shown or provided for on plans (including *lamps*, *ballasts*, task *fixtures*, and furniture-mounted *fixtures*). e. The lighting schedules in the *proposed design* shall reflect the mandatory *automatic* lighting *control* requirements in Section 9.4.1 (e.g., programmable *controls* or ~~occupancy sensors~~*occupancy sensors*). **Exception:** *Automatic* daylighting *controls* required by Section 9.4.1 shall be modeled directly in the *proposed design* or through schedule adjustments determined by a daylighting analysis approved by the *building official*. f. *Automatic* lighting *controls* included in the *proposed design* but not required by Section 9.4.1 may be modeled directly in the *building* simulation or be modeled in the *building* simulation through schedule adjustments determined by a separate analysis approved by the *authority having jurisdiction*. As an alternative to modeling such lighting *controls*, the *proposed design* lighting power may be reduced for each *luminaire* under *control* by dividing the rated lighting power of the *luminaire* by the factor (1 + ∑ CF), where ∑ CF indicates the sum of all applicable *control* factors (CF) per Section 9.6.3 and Table 9.6.3.	a. Lighting power in the *budget building design* shall be determined using the same categorization procedure (*Building* Area Method or Space-by-Space Method) and categories as the *proposed design* with lighting power set equal to the maximum allowed for the corresponding method and category in Section 9.2. Additional interior lighting power for nonmandatory *controls* allowed under Section 9.6.3 shall not be included in the *budget building design*. b. Power for *fixtures* not included in the lighting power calculation shall be modeled identically in the *proposed design* and *budget building design*. c. Mandatory *automatic* lighting *controls* required by Section 9.4.1 shall be modeled the same as the *proposed design*.
7. *Thermal Blocks—HVAC Zones* Designed	
Where *HVAC zones* are defined on HVAC design drawings, each *HVAC zone* shall be modeled as a separate *thermal block*. **Exceptions:** Different *HVAC zones* may be combined to create a single *thermal block* or identical *thermal blocks* to which multipliers are applied, provided all of the following conditions are met: 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* and glazed *semiexterior walls* face the same *orientation* or their orientations are within 45 degrees of each other. 3. All of the zones are served by the same *HVAC system* or by the same kind of *HVAC system*.	Same as *proposed design*.

8. *Thermal Blocks—HVAC Zones* Not Designed	
Where the *HVAC zones* and *systems* have not yet been designed, *thermal blocks* shall be defined based on similar internal load densities, occupancy, lighting, thermal and *space* temperature schedules, and in combination with the following: a. Separate *thermal blocks* shall be assumed for interior and perimeter *spaces*. Interior *spaces* shall be those located more than 15 ft from an *exterior wall* or *semiexterior wall*. Perimeter *spaces* shall be those located closer than 15 ft from an *exterior wall* or *semiexterior wall*. A separate thermal zone does not need to be modeled for areas adjacent to *semiexterior walls* that separate *semiheated space* from *conditioned space*. b. Separate *thermal blocks* shall be assumed for *spaces* adjacent to glazed *exterior walls* or glazed *semiexterior walls*; a separate zone shall be provided for each *orientation*, except that orientations that differ by no more than 45 degrees may be considered to be the same *orientation*. Each zone shall include all ~~*floor area*~~floor area that is 15 ft or less from a glazed perimeter *wall*, except that ~~*floor area*~~floor area within 15 ft of glazed perimeter *walls* having more than one *orientation* shall be divided proportionately between zones. c. 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. d. Separate *thermal blocks* shall be assumed for *spaces* having *roof* assemblies from zones that do not share these features.	Same as *proposed design*.

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A5.4 Wood-Framed and Other Floors

A5.4.1 General

For the purpose of Section A1.2, the base assembly is a *floor* attached directly to the top of the wood joist with insulation located directly below the *floor* and ventilated ~~air *space*~~air space below the insulation. The heat flow path through the joist is calculated to be the same depth as the insulation. The *U-factors* include R-0.92 for interior air film, heat flow down; R-1.23 for carpet and pad; R-0.94 for 0.75 in. wood subfloor; and R-0.46 for semiexterior air film. The weighting factors are 91% insulated cavity and 9% framing.

A5.4.2 Rated R-Value of Insulation for Wood-Framed and Other Floors

A5.4.2.1

The first *rated R-value of insulation* is for uncompressed insulation installed in the cavity between wood joists.

A5.4.2.2

It is acceptable for this insulation to also be *continuous insulation* uninterrupted by framing. All *continuous insulation* shall be installed either on the interior above the *floor* structure or below a framing cavity completely filled with insulation.

A5.4.3 U-Factors for Wood-Framed Floors

A5.4.3.1

The *U-factors* for wood-framed *floors* shall be taken from Table A5.4.3.1.

A5.4.3.2

It is not acceptable to use these *U-factors* if the framing is not wood.

A6 SLAB-ON-GRADE FLOORS

A6.1 General

For the purpose of Section A1.2, the base assembly is a *slab-on-grade floor* of 6 in. concrete poured directly on to the earth, the bottom of the slab is at *grade* line, and soil conductivity is 0.75 Btu/h·ft·°F. In contrast to the *U-factor* for *floors*, the *F-factor* for *slab-on-grade floors* is expressed per linear foot of *building* perimeter. *F-factors* are provided for unheated slabs and for heated slabs. *Unheated slab-on-grade floors* do not have heating elements, and *heated slab-on-grade floors* do have heating elements within or beneath the slab. *F-factors* are provided for three insulation configurations:

a. Horizontal Insulation: *Continuous insulation* is applied directly to the underside of the slab and extends inward horizontally from the perimeter for the distance specified, or *continuous insulation* is applied downward from the top of the slab and then extends horizontally to the interior or the exterior from the perimeter for the distance specified.

b. Vertical Insulation: *Continuous insulation* is applied directly to the slab exterior, extending downward from the top of the slab for the distance specified.

c. Fully Insulated Slab: *Continuous insulation* extends downward from the top of the slab and along the entire perimeter and completely covers the entire area under the slab.

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Table A8.1-1 Assembly *U-Factors* for Unlabeled *Skylights*

Product Type		Sloped Installation						
		Unlabeled *Skylight* with Curb (Includes Glass/Plastic, Flat/Domed, ~~*Fixed*~~Fixed/~~*Operable*~~Operable)				Unlabeled *Skylight* without Curb (Includes Glass/Plastic, Flat/Domed, ~~*Fixed*~~Fixed/~~*Operable*~~Operable)		
Frame Type		Aluminum without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Aluminum without Thermal Break	Aluminum with Thermal Break	Structural Glazing
ID	Glazing Type							
	Single Glazing							
1	1/8 in. glass	1.98	1.89	1.75	1.47	1.36	1.25	1.25
2	1/4 in. acrylic/polycarb	1.82	1.73	1.60	1.31	1.21	1.10	1.10
3	1/8 in. acrylic/polycarb	1.90	1.81	1.68	1.39	1.29	1.18	1.18
	Double Glazing							
4	1/4 in. air space	1.31	1.11	1.05	0.84	0.82	0.70	0.66
5	1/2 in. air space	1.30	1.10	1.04	0.84	0.81	0.69	0.65
6	1/4 in. argon space	1.27	1.07	1.00	0.80	0.77	0.66	0.62
7	1/2 in. argon space	1.27	1.07	1.00	0.80	0.77	0.66	0.62
	Double Glazing, *e* = 0.60 on surface 2 or 3							
8	1/4 in. air space	1.27	1.08	1.01	0.81	0.78	0.67	0.63
9	1/2 in. air ~~*space*~~space	1.27	1.07	1.00	0.80	0.77	0.66	0.62
10	1/4 in. argon ~~*space*~~space	1.23	1.03	0.97	0.76	0.74	0.63	0.58
11	1/2 in. argon ~~*space*~~space	1.23	1.03	0.97	0.76	0.74	0.63	0.58
	Double Glazing, *e* = 0.40 on surface 2 or 3							
12	1/4 in. air ~~*space*~~space	1.25	1.05	0.99	0.78	0.76	0.64	0.60
13	1/2 in. air ~~*space*~~space	1.24	1.04	0.98	0.77	0.75	0.64	0.59
14	1/4 in. argon ~~*space*~~space	1.18	0.99	0.92	0.72	0.70	0.58	0.54
15	1/2 in. argon ~~*space*~~space	1.20	1.00	0.94	0.74	0.71	0.60	0.56
	Double Glazing, *e* = 0.20 on surface 2 or 3							
16	1/4 in. air ~~*space*~~space	1.20	1.00	0.94	0.74	0.71	0.60	0.56
17	1/2 in. air ~~*space*~~space	1.20	1.00	0.94	0.74	0.71	0.60	0.56
18	1/4 in. argon ~~*space*~~space	1.14	0.94	0.88	0.68	0.65	0.54	0.50
19	1/2 in. argon ~~*space*~~space	1.15	0.95	0.89	0.68	0.66	0.55	0.51
	Double Glazing, *e* = 0.10 on surface 2 or 3							
20	1/4 in. air ~~*space*~~space	1.18	0.99	0.92	0.72	0.70	0.58	0.54
21	1/2 in. air ~~*space*~~space	1.18	0.99	0.92	0.72	0.70	0.58	0.54
22	1/4 in. argon ~~*space*~~space	1.11	0.91	0.85	0.65	0.63	0.52	0.47
23	1/2 in. argon ~~*space*~~space	1.13	0.93	0.87	0.67	0.65	0.53	0.49
	Double Glazing, *e* = 0.05 on surface 2 or 3							
24	1/4 in. air ~~*space*~~space	1.17	0.97	0.91	0.70	0.68	0.57	0.52
25	1/2 in. air ~~*space*~~space	1.17	0.98	0.91	0.71	0.69	0.58	0.53
26	1/4 in. argon ~~*space*~~space	1.09	0.89	0.83	0.63	0.61	0.50	0.45
27	1/2 in. argon ~~*space*~~space	1.11	0.91	0.85	0.65	0.63	0.52	0.47
	Triple Glazing							
28	1/4 in. air spaces	1.12	0.89	0.84	0.64	0.64	0.53	0.48
29	1/2 in. air spaces	1.10	0.87	0.81	0.61	0.62	0.51	0.45
30	1/4 in. argon spaces	1.09	0.86	0.80	0.60	0.61	0.50	0.44
31	1/2 in. argon spaces	1.07	0.84	0.79	0.59	0.59	0.48	0.42
	Triple Glazing, *e* = 0.20 on surface 2,3,4, or 5							

32	1/4 in. air ~~space~~space	1.08	0.85	0.79	0.59	0.60	0.49	0.43
33	1/2 in. air ~~space~~space	1.05	0.82	0.77	0.57	0.57	0.46	0.41
34	1/4 in. argon ~~space~~space	1.02	0.79	0.74	0.54	0.55	0.44	0.38
35	1/2 in. argon ~~space~~space	1.01	0.78	0.73	0.53	0.54	0.43	0.37
	Triple Glazing, *e* = 0.20 on surfaces 2 or 3 and 4 or 5							
36	1/4 in. air ~~space~~space	1.03	0.80	0.75	0.55	0.56	0.45	0.39
37	1/2 in. air ~~space~~space	1.01	0.78	0.73	0.53	0.54	0.43	0.37
38	1/4 in. argon ~~space~~space	0.99	0.75	0.70	0.50	0.51	0.40	0.35
39	1/2 in. argon ~~space~~space	0.97	0.74	0.69	0.49	0.50	0.39	0.33
	Triple Glazing, *e* = 0.10 on surfaces 2 or 3 and 4 or 5							
40	1/4 in. air ~~space~~space	1.01	0.78	0.73	0.53	0.54	0.43	0.37
41	1/2 in. air ~~space~~space	0.99	0.76	0.71	0.51	0.52	0.41	0.36
42	1/4 in. argon ~~space~~space	0.96	0.73	0.68	0.48	0.49	0.38	0.32
43	1/2 in. argon ~~space~~space	0.95	0.72	0.67	0.47	0.48	0.37	0.31
	Quadruple Glazing, *e* = 0.10 on surfaces 2 or 3 and 4 or 5							
44	1/4 in. air ~~space~~space	0.97	0.74	0.69	0.49	0.50	0.39	0.33
45	1/2 in. air ~~space~~space	0.94	0.71	0.66	0.46	0.47	0.36	0.30
46	1/4 in. argon ~~space~~space	0.93	0.70	0.65	0.45	0.46	0.35	0.30
47	1/2 in. argon ~~space~~space	0.91	0.68	0.63	0.43	0.44	0.33	0.28
48	1/4 in. krypton ~~space~~spaces	0.88	0.65	0.60	0.40	0.42	0.31	0.25

Table A8.1-2 Assembly *SHGCs* and Assembly Visible Transmittances (*VTs*) for Unlabeled *Skylights*

Glass Type	Glazing Type: Number of Glazing Layers Number and Emissivity of Coatings (Glazing is Glass Except where Noted)	Unlabeled *Skylights* (Includes Glass/Plastic, Flat/Domed, ~~Fixed~~Fixed/~~Operable~~Operable)					
		Frame:	Metal without Thermal Break		Metal with Thermal Break		Wood/Vinyl/ Fiberglass	
		Characteristic:	SHGC	VT	SHGC	VT	SHGC	VT
Clear	Single glazing, 1/8 in. glass		0.82	0.76	0.78	0.76	0.73	0.73
	Single glazing, 1/4 in. glass		0.78	0.75	0.74	0.75	0.69	0.72
	Single glazing, acrylic/polycarbonate		0.83	0.92	0.83	0.92	0.83	0.92
	Double glazing		0.68	0.66	0.64	0.66	0.59	0.64
	Double glazing, *e* = 0.40 on surface 2 or 3		0.71	0.65	0.67	0.65	0.62	0.63
	Double glazing, *e* = 0.20 on surface 2 or 3		0.66	0.61	0.62	0.61	0.57	0.59
	Double glazing, *e* = 0.10 on surface 2 or 3		0.59	0.63	0.55	0.63	0.51	0.61
	Double glazing, acrylic/polycarbonate		0.77	0.89	0.77	0.89	0.77	0.89
	Triple glazing		0.60	0.59	0.56	0.59	0.52	0.57
	Triple glazing, *e* = 0.40 on surface 2, 3, 4, or 5		0.64	0.60	0.60	0.60	0.56	0.57
	Triple glazing, *e* = 0.20 on surface 2, 3, 4, or 5		0.59	0.55	0.55	0.55	0.51	0.53
	Triple glazing, *e* = 0.10 on surface 2, 3, 4, or 5		0.54	0.56	0.50	0.56	0.46	0.54
	Triple glazing, *e* = 0.40 on surfaces 3 and 5		0.62	0.57	0.58	0.57	0.53	0.55
	Triple glazing, *e* = 0.20 on surfaces 3 and 5		0.56	0.51	0.52	0.51	0.48	0.49
	Triple glazing, *e* = 0.10 on surfaces 3 and 5		0.47	0.54	0.43	0.54	0.40	0.52
	Triple glazing, acrylic/polycarbonate		0.71	0.85	0.71	0.85	0.71	0.85

	Quadruple glazing, *e* = 0.10 on surfaces 3 and 5	0.41	0.48	0.37	0.48	0.33	0.46
	Quadruple glazing, acrylic/polycarbonate	0.65	0.81	0.65	0.81	0.65	0.81
Tinted	Single glazing, 1/8 in. glass	0.70	0.58	0.66	0.58	0.62	0.56
	Single glazing, 1/4 in. glass	0.61	0.45	0.56	0.45	0.52	0.44
	Single glazing, acrylic/polycarbonate	0.46	0.27	0.46	0.27	0.46	0.27
	Double glazing	0.50	0.40	0.46	0.40	0.42	0.39
	Double glazing, *e* = 0.40 on surface 2 or 3	0.59	0.50	0.55	0.50	0.50	0.48
	Double glazing, *e* = 0.20 on surface 2 or 3	0.47	0.37	0.43	0.37	0.39	0.36
	Double glazing, *e* = 0.10 on surface 2 or 3	0.43	0.38	0.39	0.38	0.35	0.37
	Double glazing, acrylic/polycarbonate	0.37	0.25	0.37	0.25	0.37	0.25
	Triple glazing	0.42	0.22	0.37	0.22	0.34	0.21
	Triple glazing, *e* = 0.40 on surface 2, 3, 4, or 5	0.53	0.45	0.49	0.45	0.45	0.44
	Triple glazing, *e* = 0.20 on surface 2, 3, 4, or 5	0.42	0.33	0.38	0.33	0.35	0.32
	Triple glazing, *e* = 0.10 on surface 2, 3, 4, or 5	0.39	0.34	0.35	0.34	0.31	0.33
	Triple glazing, *e* = 0.40 on surfaces 3 and 5	0.51	0.43	0.47	0.43	0.43	0.42
	Triple glazing, *e* = 0.20 on surfaces 3 and 5	0.40	0.31	0.36	0.31	0.32	0.29
	Triple glazing, *e* = 0.10 on surfaces 3 and 5	0.34	0.32	0.30	0.32	0.27	0.31
	Triple glazing, acrylic/polycarbonate	0.30	0.23	0.30	0.23	0.30	0.23
	Quadruple glazing, *e* = 0.10 on surfaces 3 and 5	0.30	0.29	0.26	0.29	0.23	0.28
	Quadruple glazing, acrylic/polycarbonate	0.27	0.25	0.27	0.25	0.27	0.25

A8.2 Unlabeled Vertical Fenestration

Unlabeled *vertical fenestration*, both ~~*operable*~~operable and ~~*fixed*~~fixed, shall be assigned the *U-factors*, *SHGCs*, and *VTs* in Table A8.2.

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Table A9.2-2 Effective Insulation/Framing Layer *R-Values* for *Wall* Insulation Installed Between Steel Framing

Nominal Depth of Cavity, in.	Actual Depth of Cavity, in.	Rated *R-Value* of Air ~~*Space*~~Space or Insulation	Effective Framing/Cavity *R-Value* at 16 in. on Center	Effective Framing/Cavity *R-Value* at 24 in. on Center
Empty Cavity, No Insulation				
4	3.5	R-0.91	0.79	0.91
Insulated Cavity				
4	3.5	R-11	5.5	6.6
4	3.5	R-13	6.0	7.2
4	3.5	R-15	6.4	7.8
6	6.0	R-19	7.1	8.6
6	6.0	R-21	7.4	9.0
8	8.0	R-25	7.8	9.6

...

A9.4 Calculation Procedures and Assumptions

The following procedures and assumptions shall be used for all calculations. *R-values* for air films, air ~~*spaces*~~spaces, insulation, and *building materials* shall be taken from Sections A9.4.1 through A9.4.4, respectively. In addition, the appropriate assumptions listed in Sections A2 through A8, including framing factors, shall be used.

A9.4.1 Air Films

Prescribed *R-values* for air films shall be as follows:

R-Value	**Condition**
0.17	All exterior surfaces
0.46	All semiexterior surfaces
0.61	Interior horizontal surfaces, heat flow up
0.92	Interior horizontal surfaces, heat flow down
0.68	Interior vertical surfaces

A9.4.1.1

Exterior surfaces are areas exposed to the wind.

A9.4.1.2

Semiexterior surfaces are protected surfaces that face attics, crawlspaces, and parking garages with natural or mechanical *ventilation*.

A9.4.1.3

Interior surfaces are surfaces within *enclosed spaces*.

A9.4.2 Air ~~*Spaces*~~Spaces

The *R-value* for air ~~*spaces*~~spaces shall be taken from Table A9.4.2-1 based on the effective *emittance* of the surfaces facing the air ~~*space*~~space from Table A9.4.2-2, provided the following criteria are satisfied:

a. The air ~~*space*~~space shall be an enclosed and unventilated cavity designed to minimize airflow into and out of the enclosed air ~~*space*~~space. Airflow shall be deemed minimized when the enclosed air ~~*space*~~space is located on the interior of the *continuous air barrier* and bounded on all sides by *building* components.

Table A9.4.2-1 Values for Cavity Air Spaces[a]

Component	Air ~~*Space*~~Space Thickness, in.	Climate Zone 1 Effective *Emittance*				Climate Zone 2 Effective *Emittance*				Climate Zone 3 Effective *Emittance*			
		0.05	0.20	0.50	0.82	0.05	0.20	0.50	0.82	0.05	0.20	0.50	0.82
Roof	0.50	2.5	1.9	1.2	0.9	2.4	1.8	1.2	0.9	2.2	1.7	1.1	0.9
	0.75	3.5	2.4	1.4	1.0	3.2	2.2	1.4	1.0	2.8	2.0	1.3	0.9
	1.50	5.6	3.1	1.7	1.1	4.9	2.9	1.6	1.1	4.2	2.5	1.5	1.0
	3.50	8.0	3.8	1.9	1.2	7.0	3.4	1.7	1.1	5.9	3.0	1.6	1.1
Wall	0.50	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9
	0.75	2.8	2.0	1.3	0.9	2.8	2.0	1.3	0.9	2.8	2.0	1.3	0.9
	1.50	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9
	3.50	2.6	1.9	1.3	0.9	2.6	1.9	1.3	0.9	2.6	1.9	1.3	0.9
Floor	0.50	1.6	1.3	1.0	0.8	1.8	1.4	1.0	0.8	1.9	1.5	1.1	0.8

	0.75	1.7	1.4	1.0	0.8	2.0	1.5	1.1	0.8	2.4	1.7	1.2	0.9
	1.50	1.9	1.5	1.1	0.8	2.5	1.8	1.2	0.9	3.2	2.1	1.3	0.9
	3.50	2.1	1.6	1.1	0.8	3.2	2.0	1.2	0.9	4.3	2.4	1.4	1.0
Component	**Air ~~*Space*~~Space Thickness, in.**	**Climate Zone 4 Effective *Emittance***				**Climate Zone 5 Effective *Emittance***				**Climate Zone 6 Effective *Emittance***			
		0.05	**0.20**	**0.50**	**0.82**	**0.05**	**0.20**	**0.50**	**0.82**	**0.05**	**0.20**	**0.50**	**0.82**
Roof	0.50	2.0	1.6	1.1	0.8	1.9	1.5	1.1	0.8	1.8	1.4	1.0	0.8
	0.75	2.5	1.8	1.2	0.9	2.3	1.7	1.1	0.9	2.1	1.6	1.1	0.8
	1.50	3.5	2.2	1.3	0.9	3.1	2.0	1.3	0.9	2.8	1.9	1.2	0.9
	3.50	4.7	2.6	1.4	1.0	4.1	2.4	1.4	1.0	3.6	2.2	1.3	0.9
Wall	0.50	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9
	0.75	2.8	2.0	1.3	0.9	2.8	2.0	1.3	0.9	2.8	2.0	1.3	0.9
	1.50	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9
	3.50	2.6	1.9	1.3	0.9	2.6	1.9	1.3	0.9	2.6	1.9	1.3	0.9
Floor	0.50	2.1	1.6	1.1	0.8	2.2	1.7	1.1	0.9	2.3	1.7	1.2	0.9
	0.75	2.7	1.9	1.2	0.9	2.9	2.0	1.3	0.9	3.1	2.1	1.3	1.0
	1.50	3.9	2.4	1.4	1.0	4.3	2.6	1.5	1.0	4.7	2.7	1.5	1.1
	3.50	5.5	2.9	1.5	1.1	6.0	3.1	1.6	1.1	6.6	3.3	1.7	1.1
Component	**Air ~~*Space*~~Space Thickness, in.**	**Climate Zone 7 Effective *Emittance***				**Climate Zone 8 Effective *Emittance***							
		0.05	**0.20**	**0.50**	**0.82**	**0.05**	**0.20**	**0.50**	**0.82**				
Roof	0.50	1.8	1.4	1.0	0.8	1.6	1.3	1.0	0.8				
	0.75	2.0	1.6	1.1	0.8	1.8	1.4	1.0	0.8				
	1.50	2.6	1.8	1.2	0.9	2.1	1.6	1.1	0.8				
	3.50	3.2	2.0	1.3	0.9	2.4	1.7	1.2	0.9				
Wall	0.50	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9				
	0.75	2.8	2.0	1.3	0.9	2.8	2.0	1.3	0.9				
	1.50	2.5	1.8	1.2	0.9	2.5	1.8	1.2	0.9				
	3.50	2.6	1.9	1.3	0.9	2.6	1.9	1.3	0.9				
Floor	0.50	2.3	1.8	1.2	0.9	2.5	1.8	1.2	0.9				
	0.75	3.2	2.2	1.4	1.0	3.4	2.3	1.4	1.0				
	1.50	4.9	2.8	1.6	1.1	5.4	3.1	1.7	1.1				
	3.50	6.9	3.4	1.7	1.1	7.7	3.7	1.8	1.2				

a. Interpolation shall be permitted to be used for effective *emittance* values and air ~~*space*~~space thicknesses between those listed. Extrapolation below an effective *emittance* of 0.05 is not permitted.

Table A9.4.2-2 *Emittance* Values of Various Surfaces and Effective *Emittances* of Air ~~*Spaces*~~Spaces

Surface	**Average Emissivity *e***	**Effective Emissivity of Air Space**	
		One Surface *e*; Other, 0.9	**Both Surfaces Emissivity *e***
Aluminum foil, bright	0.05	0.05	0.03[a]
Metalized film, tested[b]	0.05	0.05	0.03[a]
Aluminum sheet	0.12	0.12	0.06
Aluminum coated paper, polished	0.20	0.20	0.11
Steel, galv., bright	0.25	0.24	0.14
Aluminum paint	0.50	0.47	0.32
Building materials: wood, paper, masonry,	0.90	0.82	0.82

nonmetallic paints			
Regular glass	0.84	0.77	0.72

a. When referencing Table A9.4.2-1, use an effective *emittance* of 0.05.
b. Tested *emittance* in accordance with ASTM C1224 at 0.05 or less.

b. Reflective insulation as defined in ASTM C1224, where used, shall be fitted closely around all non-heat-producing components and taped or otherwise sealed to eliminate gaps or voids through which air, dust, or water vapor has the potential to pass.

c. Nonparallel *spaces* shall use the average distance to determine the thickness of the air ~~*space*~~space.

d. Air ~~*spaces*~~spaces less than 0.5 in. thickness shall have no *R-value*.

e. The *R-value* for 3.5 in. air ~~*spaces*~~spaces shall be used for air ~~*spaces*~~spaces of that thickness or greater, provided that air ~~*space*~~space does not exceed 12 in. between the surfaces at any point.

For material emissivity properties not listed in Table A9.4.2-2, Equation A9.4-1 shall be permitted to calculate the effective emissivity for the air ~~*space*~~space.

$$1/e_{\text{eff}} = 1/e_1 + 1/e_2 - 1 \qquad \text{(A9.4-1)}$$

where

e_{eff} = effective *emittance* for the air ~~*space*~~space
e_1 = surface 1 *emittance*
e_2 = surface 2 *emittance*

...

A9.4.6.3 Single-Layer in Cavity and Double-Layer Walls

The *U-factor* of *metal building walls* that are insulated with a single-layer in cavity or multiple layers of mineral fiber insulation (see Figure A9.4.6.3) shall be calculated using the procedure outlined in this section. For double-layer *walls*, the procedure assumes that the outer layer of insulation is compressed between the *wall* panel and girt. There may also be a thermal spacer block or *continuous insulation* present. Air ~~*spaces*~~spaces may also exist depending on the specific drape profiles.

There are nine steps in the calculation process:

Step 1—Characterize the thermal conductivity of the mineral fiber insulation.
Step 2—Define the parabolic profiles for each insulation layer.
Step 3—Calculate the *R-values* for insulation and air ~~*spaces*~~spaces in cavity both outside and inside insulation layers, including air films.
Step 4—Calculate the *R-value* inside the girt and adjacent to the web.
Step 5—Calculate the *R-value* outside the girt.
Step 6—Add the *R-values* inside and outside the girt, including air films.
Step 7—Calculate the overall insulation assembly using the *R-values* in Steps 3 and 6.
Step 8—Calculate the *U-factor* from the finite element analysis results.
Step 9—Calculate the *U-factor* for any *continuous insulation* if present.

Step 1: The thermal conductivity of the mineral fiber insulation is represented by a thermal curve of the form in Equation A9.4-22:

$$k = A + B\frac{\rho_o \delta_o}{y} + C\frac{y}{\rho_o \delta_o} \quad \text{(A9.4-22)}$$

where

k = thermal conductivity, Btu·ft/h·ft²·°F
ρ_o = nominal density, lb/ft³
δ_o = nominal thickness, ft
y = thickness of insulation, ft
A = 0.014917
B = 0.0004377
C = 0.0005689

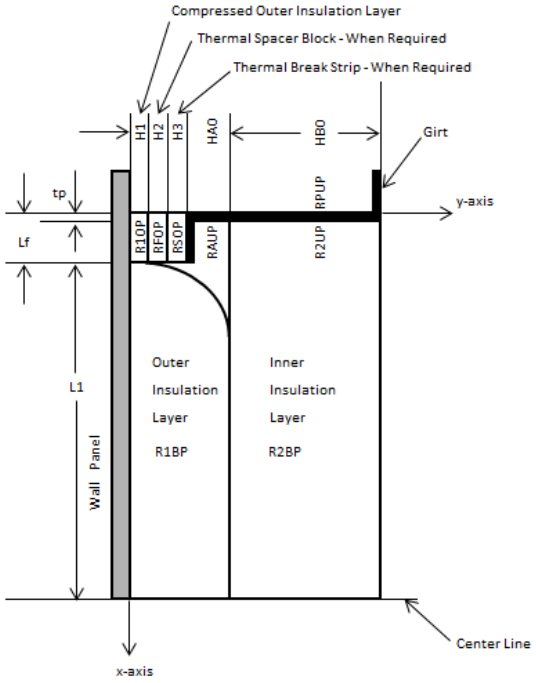

Figure A9.4.6.3 Geometry of single cavity layer or double-layer *wall*.

Step 2: Assume that each layer of mineral fiber has a parabolic profile defined by Equation A9.4-23:

$$\frac{y - Y_o}{Y_m - Y_o} = \frac{x}{x_m}\left(2 - \frac{x}{x_m}\right) \quad \text{(A9.4-23)}$$

where

x = distance from edge of girt, ft
y = distance from edge of *wall* panel, ft
Y_o = insulation thickness at $x = 0$, ft
Y_m = insulation thickness at $x = X_m$, ft

Step 3: Calculate *R-values* for the insulation and air ~~*spaces*~~spaces in the cavity both inside and outside insulation layers, including air films.

Because the configuration can possibly consist of both mineral fiber insulation and an air ~~*space*~~space, the composite is given by Equation A9.4-24:

$$R = \frac{1}{x_a}\int_0^{x_a}\left(\frac{y}{k_a} + \frac{Y_m - y}{k}\right)dx + \frac{Y_m}{k(Y_m)} \quad \text{(A9.4-24)}$$

where k_a is the thermal conductivity of air in Btu·ft/h·ft^2·°F.

The trapezoidal integration method is used to evaluate the integral and calculate *R* and is given by Equation A9.4-25:

$$\int_a^b f(x)dx \approx \frac{1}{2}\sum_{k=1}^{N}(x_{k+1} - x_k)(y_k + y_{k+1}) \quad \text{(A9.4-25)}$$

where

x_k = point to analyze along the *x*-axis, ft
x_{k+1} = point ahead of the point being analyzed, ft
y_k = thickness at point being analyzed, ft
y_{k+1} = thickness at point ahead of the point being analyzed, ft

The integral represents the combined *R-value* of the air ~~*space*~~space and insulation over the region $0 < x < X_a$. Because the thermal conductivity of air is independent of the thickness, Equation 9.4.25 can be simplified using the air ~~*space*~~space mean thickness (Y_a) to produce Equation A9.4-26:

$$R = \frac{Y_a}{K_a} + \frac{1}{X_a}\int_0^{x_a}\left(\frac{Y_m - y}{K}\right)dx + \frac{Y_m}{K(Y_m)} \quad \text{(A9.4-26)}$$

However, if the air ~~*space*~~space is characterized by convection instead of conduction then the term Y_a/k_a can be replaced by the *R-value* for convection (R-0.92 h·ft^2·°F/Btu for *walls*). Adding the inside and outside layers is expressed in Equation A9.4-27:

$$R_{BP} = R1BP + R2BP \quad \text{(A9.4-27)}$$

Add the air film resistances at the exterior (R_{AT}) and interior (R_{AB}), which are defined as Equation A9.4-28:

$$R_{AB} = \frac{1}{h_{AB}} \quad \text{(A9.4-28)}$$

where h_{AB} is the air film heat transfer coefficient at the exterior in Btu/h·ft^2·°F.

$$R_{AT} = \frac{1}{h_{AT}} \quad \text{(A9.4-29)}$$

where h_{AT} is the air film heat transfer coefficient at the interior in Btu/h·ft^2·°F.

The sum of the *R-values* for the insulation and air films beyond the girt are expressed in Equation A9.4-30.

$$R_{BP+air} = R_{BP} + R_{AB} + R_{AT} \quad \text{(A9.4-30)}$$

Step 4: Calculate the *R-values* inside the girt and adjacent to the web.

The *R-values* inside the girt are the air ~~*space*~~space (RAUP) added in series with the insulation (R2UP); their combined value is then added in parallel to RPUP. Depending on the thickness of the air ~~*space*~~space, it can be modeled as conduction as shown in Equation A9.4-31:

$$\text{RAUP} = \frac{H3}{k_a} \quad \text{(A9.4-31)}$$

where

$H3$ = thickness of the air ~~*space*~~space, ft
k_a = thermal conductivity of air, Btu·ft/h·ft²·°F

When appropriate, the air ~~*space*~~space can be modeled as convection, which is a constant R-0.92 h·ft²·°F/Btu for *walls*.

The *R-value* for R2UP is expressed in Equation A9.4-32. The insulation thickness is also not limited by the girt height and can extend beyond it.

$$\text{R2UP} = \frac{H4}{A + B\frac{\rho_o \delta_o}{H4} + C\frac{H4}{\rho_o \delta_o}} \quad \text{(A9.4-32)}$$

where $H4$ is the thickness of the mineral fiber at $x = 0$ in feet.

The *R-value* of the web (RPUP) is calculated using 26.2 h·ft²·°F/Btu as the thermal conductivity of the girt in Equation A9.4-33:

$$\text{RPUP} = \frac{\text{Web Height}}{k_p} \quad \text{(A9.4-33)}$$

where

k_p =thermal conductivity of the girt, Btu·ft/h·ft²·°F
Web Height = height of the girt, ft

The addition of the air ~~*space*~~space and insulation in series are combined to be in parallel with the girt, which is expressed as Equation A9.4-34:

$$\frac{L_f}{\text{RUP}} = \frac{L_f - t_p}{\text{RAUP} + \text{R2UP}} + \frac{t_p}{\text{RPUP}} \quad \text{(A9.4-34)}$$

Equation A9.4-34 can be rearranged and solved for RUP as presented in Equation A9.4-35:

$$\text{RUP} = \frac{(\text{RAUP} + \text{R2UP})\text{RPUP}}{(L_f - t_p)\text{RPUP} + t_p(\text{RAUP} + \text{R2UP})} L_f \quad \text{(A9.4-35)}$$

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C3.5.5.2 Dynamic Glazing

~~Automatically~~*Automatically* controlled *dynamic glazing* is allowed to be modeled. Manually controlled *dynamic glazing* shall use the average of the minimum and maximum values for both *SHGC* and *VT*.

C3.5.5.3 Air Leakage

The air leakage rate of the *building envelope* (I_{75Pa}) at a pressure differential of 0.3 in. of water shall be 0.4 cfm/ft² of *building envelope* area. The air leakage of the *building envelope* shall be converted to the appropriate units to describe the air leakage as a function of the area of *walls* that separate *conditioned spaces* and *semiheated spaces* from the exterior as follows:

$$I_{AGW} = 0.112 \times I_{75Pa} \times S/A_{AGW}$$

where

I_{75Pa} = air leakage rate of the *building envelope* (cfm/ft^2) at a ~~*fixed*~~fixed *building* pressure differential of 0.3 in. of water, or 1.57 psf

S = total area of the *building envelope* (ft^2) including the lowest *floor*, any *below-grade walls* or *above-grade walls*, and *roof* (including *vertical fenestration* and *skylights*)

I_{AGW} = adjusted air leakage rate of the *building envelope* (cfm/ft^2) at a reference wind speed of 10 mph and relative to the area of the *above-grade walls*

A_{AGW} = the total area of *above-grade walls* that comprise the *building envelope*, ft^2

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C3.5.8 HVAC Systems

One *HVAC system* shall be provided for each thermal zone and shall have the following characteristics:

a. Constant-volume fan *control*.

b. Electrically-provided cooling with constant *COP*, excluding the indoor fan power equal to 4.4.

c. Gas furnace with constant thermal *efficiency* equal to the minimum *AFUE* allowed for gas-fired warm-air furnaces with maximum capacity <225,000 Btu/h, in accordance with Table 6.8.1-5.

d. The *ventilation* rate for each *building* area type shall be consistent with the *ventilation* rate in the *building envelope trade-off schedules and loads* for the applicable *building* area type.

e. *Air economizers*, except in Climate Zones 0 and 1. The high-limit shutoff shall be "~~*Fixed*~~Fixed Dry Bulb" type as described in Table 6.5.1.1.3.

f. *System* design supply air rates shall be based on a supply-air-to-room-air temperature difference of 20°F in cooling.

g. *System* capacities used in the annual simulation shall be 1.5 times the capacities determined by the sizing simulations.

h. Fans shall cycle ON whenever the *space* calls for heating or cooling. The fan power shall be 0.3 W/cfm, and the fan *energy* shall be modeled explicitly.

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C3.6 Calculation of Base Envelope Performance Factor

The simulation model for calculating the *base envelope performance factor* shall modify the simulation model for calculating the *proposed envelope performance factor* as follows:

a. All *opaque* assemblies shall be modeled with the maximum *U-factor* required in Section 5.5.3 for the appropriate *class of construction*, *space-conditioning category*, and climate zone. *Mass walls* and *mass floors* shall be modeled with *HC* equal to 7.2 Btu/ft^2·°F. All other *opaque* assemblies shall be modeled with the same *HC* as the *proposed design*. *Mass walls* shall be modeled with equal mass on each side of the insulation. All other *opaque* assemblies shall be modeled with insulation on the exterior.

b. The exterior *roof* surfaces shall be modeled with a solar *reflectance* and thermal *emittance* as required in Section 5.5.3.1.1(a). All other *roofs*, including *roofs* exempted from the requirements in Section 5.5.3.1.1, shall be modeled the same as in the *proposed design*.

c. *Fenestration* shall be assumed to be flush with the *wall* or *roof*. If the *fenestration area* for new *buildings* or *additions* exceeds the maximum allowed by Section 5.5.4.2, the area shall be reduced proportionally along each exposure until the limit set in Section 5.5.4.2 is met. If the *fenestration area* facing west or east of the *proposed design* exceeds the area limit set in Section 5.5.4.5, the *baseline building performance* shall be generated by simulating the *building* with its actual *orientation* and again after rotating the entire *building* 90, 180, and 270 degrees, then averaging the results of the four simulations. *Fenestration U-factor* and *SHGC* shall be the maximum allowed for the appropriate *class of construction*, *space-conditioning category*, and climate zone in accordance with Section 5.5.4. Where there is no *SHGC* requirement, the *SHGC* shall be equal to 0.40 for all *vertical fenestration* and 0.55 for *skylights*. The *VT* for *fenestration* in the base envelope design shall be equal to 1.10 times the *SHGC*.

d. Manually operated interior shades shall be modeled on all *vertical fenestration* as described in Section C3.5.5.1. Permanent shading devices, such as fins and overhangs, shall not be modeled.

e. *Daylight areas* and *photosensor* locations shall be modeled as described in Section C3.5.3 after reducing the *fenestration area* as described in Section C3.6(c).

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Informative Appendix E

Informative References

This appendix contains informative references for the convenience of users of Standard 90.1 and to acknowledge source documents when appropriate. Some documents are also included in Section 12, "Normative References," because there are other citations of those documents within the standard that are normative.

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NIBS
National Institute of Building Sciences
1090 Vermont Avenue NW, Suite 700
Washington, DC 20005-4950
(T) 202-289-7800

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Subsection No.	Reference	Title/Source
3.2 Computer Room Energy	Recommendations for Measuring and Reporting Overall Data Center Efficiency v2 17 May 2011	The Green Grid
3.2 IT	Recommendations for Measuring and Reporting	The Green Grid

Equipment Energy	Overall Data Center Efficiency v2 17 May 2011	
3.2 Power Usage Effectiveness	Recommendations for Measuring and Reporting Overall Data Center Efficiency v2 17 May 2011	The Green Grid
5.7.3.2	NIBS Guideline 3-2012	Building Enclosure Commissioning Process BECx, Annex O
5.7.3.2	ASTM E2947-14	Standard Guide for Building Enclosure Commissioning, Section 9.4
5.9.1	ASTM E2947-14	Standard Guide for Building Enclosure Commissioning
5.9.1	ASTM E2813-12	Standard Practice for Building Enclosure Commissioning
6.4.1	CTI STD-201 OM (13) Operations Manual for Thermal Performance Certification of Evaporative Heat Rejection Equipment	Cooling Technology Institute
6.4.2	2013 ASHRAE Handbook—Fundamentals	ASHRAE
6.4.3.11	ASHRAE Guideline 22-2012	Instrumentation for Monitoring Central Chilled-Water Plant Efficiency
6.4.4.1.1	MICA Insulation Standards—7th Edition	National Commercial and Industrial Insulation Standards
6.4.4.2.1	SMACNA Duct Construction Standards—2005	HVAC Duct Construction Standards, Metal and Flexible
6.4.4.2.2	SMACNA Duct Leakage Test Procedures—2012	HVAC Air Duct Leakage Test Manual Sections 3,5, and 6
6.7.2.2	ASHRAE Guideline 4-2008 (RA2013)	Preparation of Operating and Maintenance Documentation for Building Systems
6.7.2.3.1	AABC 2002	Associated Air Balance Council, National Standards for Total System Balance
6.7.2.3.1	ASHRAE Standard 111-2008	Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
6.7.2.46.9.2	ASHRAE Standard 202-2013	Commissioning Process for Buildings and Systems
6.7.2.46.9.2	ASHRAE Guideline 0-2013	The Commissioning Process
6.7.2.4	ASHRAE Guideline 1.1-2007	HVAC&R Technical Requirements for the Commissioning Process
~~6.7.2.3~~6.7.2.4	NEBB Procedural Standards—2013	Procedural Standards for Building Systems Commissioning
7.4.1 and 7.5	2011 ASHRAE Handbook—HVAC Applications	Chapter 49, Service Water Heating/ASHRAE
9.6.1	IES RP-6 (2015)	Recommended Practice for Sports and Recreational Area Lighting
11.4.1	DOE-2	Support provided by Lawrence Berkeley National Laboratory at the referenced Web site
11.4.1	BLAST	University of Illinois
11.4.2	CWEC	Canadian Weather for Energy Calculations
11.4.2	IWEC2	International Weather for Energy Calculations, Generation 2
11.4.2	TMY3	Typical Meteorological Year, Generation 3
A9.4.6 Metal Building U-Factor Equations	Choudhary, M.K., C. Kasprzak, R.H. Larson, and R. Venuturumilli. 2010. ASHRAE Standard 90.1 metal building U-factors—Part 1: Mathematical modeling and validation by calibrated hot box measurements	ASHRAE Transactions 116(1):10–017
A9.4.6 Metal Building U-Factor Equations	Choudhary, M.K., and C.P. Kasprzak. 2010. ASHRAE Standard 90.1 Metal building U-factors—Part 2: A system based approach for predicting the thermal performance of single	ASHRAE Transactions 116(1):10–018

	layer fiberglass batt insulation assemblies	
A9.4.6 Metal Building U-Factor Equations	McBride, M.F., and P.M. Gavin. 2010. ASHRAE Standard 90.1 metal building U-factors—Part 3: Equations for double layers of fiberglass batt insulation in roof and wall assemblies	ASHRAE Transactions 116(1):10–019
A9.4.6 Metal Building U-Factor Equations	Christianson, L. 2010. ASHRAE Standard 90.1 metal building U-factors—Part 4: Metal building U-factors for walls and roof based on experimental measurements.	ASHRAE Transactions 116(1):10–020
A9.4.6 Metal Building U-Factor Equations	Choudhary, M.K., C.P. Kasprzak, D.E. Musick, M.J. Henry, and N.D. Fast. 2012. ASHRAE Standard 90.1 metal building U-factors—Part 5: Mathematical modeling of wall assemblies and validation by calibrated hot box measurements	ASHRAE Transactions 118(1):12–006
A9.4.6 Metal Building U-Factor Equations	Choudhary, M.K 2016. A general approach for predicting the thermal performance of metal building fiberglass insulation assemblies	ASHRAE Transactions 122(1):16–014
G3.1 Building Performance Calculations	ISO 25745-2:2015	Energy performance of lifts, escalators and moving walks—Part 2: Energy calculation and classification for lifts (elevators)

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Table F-1 U.S. Minimum *Efficiency* Requirements for Single-Phase Air Conditioners and Heat Pumps that Have a Cooling Capacity < 65,000 Btu/h

Product Class	National Standards	Southeastern Region Standards[b]	Southwestern Region Standards[c]
Central Air Conditioners and Heat Pumps[d]			
Split-*system* air conditioners	*SEER* = 13	*SEER* = 14	*SEER* = 14 *EER* = 12.2 (for units with a rated cooling capacity less than 45,000 Btu/h) *EER* = 11.7 (for units with a rated cooling capacity equal to or greater than 45,000 Btu/h)
Split-*system* heat pumps	*SEER* = 14 *HSPF* = 8.2	*SEER* = 14 *HSPF* = 8.2	*SEER* = 14 *HSPF* = 8.2
Split-*system* air conditioners[a]	*SEER* = 14	*SEER* = 14	*SEER* = 14 *EER* = 11.0
Single-package heat pumps	*SEER* = 14 *HSPF* = 8.0	*SEER* = 14 *HSPF* = 8.0	*SEER* = 14 *HSPF* = 8.0
Small-duct high-velocity *systems*	*SEER* = 13 *HSPF* = 7.7	*SEER* = 13 *HSPF* = 7.7	*SEER* = 13 *HSPF* = 7.7
~~*Space*~~Space-constrained products—air conditioners[a]	*SEER* = 12	*SEER* = 12	*SEER* = 12
~~*Space*~~Space-constrained products—heat pumps[a]	*SEER* = 12 *HSPF* = 7.4	*SEER* = 12 *HSPF* = 7.4	*SEER* = 12 *HSPF* = 7.4

a. The Northern region for central air conditioners and heat pumps contains the following States: Alaska, Colorado, Connecticut, Idaho, Illinois, Indiana, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Washington, West Virginia, Wisconsin, and Wyoming.

b. The Southeastern region for central air conditioners and heat pumps contains the following States: Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia, and the District of Columbia.

c. The Southwestern region for central air conditioners and heat pumps contains the States of Arizona, California, Nevada, and New Mexico.

d. *SEER* is Seasonal *Energy Efficiency Ratio*; *EER* is *Energy Efficiency Ratio*; *HSPF* is *Heating Seasonal Performance Factor*; and Btu/h is British thermal units per hour.

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G1.2.1 Mandatory Provisions

~~This *performance rating method* requires conformance~~ The proposed *building* design shall comply with all of the following ~~provisions~~:

a. ~~All requirements of~~ Sections ~~5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 shall be met. These sections contain the mandatory provisions of the standard and are prerequisites for this rating method.~~ 5.2.1, 6.2.1, 7.2.1, 8.2.1, 9.2.1, and 10.2.1; and

b. ~~The i~~Interior lighting power shall not exceed the *interior lighting power allowance* determined using either

1. ~~Table~~s G3.7 ~~or G3.8~~ and the methodology described in Section~~s 9.5.1 and~~ 9.6.1, or

2. Table G3.8 and the methodology described in Section 9.5.1; and~~.~~

c. Energy efficiency levels of installed components and *systems* that meet or exceed the efficiency levels used to calculate the *proposed building performance*.

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Submittals~~Documentation Requirements~~

G1.3.1 General

Compliance documentation and supplemental information shall be submitted in accordance with Section 4.2.2 of this standard.

G1.3.2 Application Documentation

Simulated performance shall be documented, and documentation shall be submitted to the *rating authority*. The information shall be submitted in a report and shall include the following:

a. A brief description of the project, the key *energy efficiency* improvements compared with the requirements in Sections 5 through 10, the *simulation program* used, the version of the *simulation program*, and the results of the *energy* analysis. This summary shall contain the calculated values for the *baseline building performance*, the *proposed building performance*, and the percentage improvement.

b. An overview of the project that includes the number of stories (above and below *grade*), the typical *floor* size, the uses in the *building* (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is *conditioned space*.

c. A list of the *energy*-related features that are included in the design and on which the performance rating is based. This list shall document all *energy* features that differ between the models used in the *baseline building performance* and *proposed building performance* calculations.

d. A list showing compliance for the *proposed design* with all the requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 (mandatory provisions).

e. A list identifying those aspects of the *proposed design* that are less stringent than the requirements of 5.5, 6.5, 7.5,9.5, and 9.6 (prescriptive provisions).

f. A table with a summary by end use of the *energy* cost savings in the *proposed building performance*.

g. A site plan showing all adjacent *buildings* and topography that may shade the proposed *building* (with estimated height or number of stories).

h. *Building* elevations and *floor* plans (schematic is acceptable).

i. A diagram showing the *thermal blocks* used in the computer simulation.

j. An explanation of any significant modeling assumptions.

k. Backup calculations and material to support data inputs (e.g., *U-factors* for *building envelope* assemblies, NFRC ratings for *fenestration*, end-uses identified in Table G3.1, "1. Design Model," paragraph [a]).

l. Input and output reports from the *simulation program* or compliance software, including a breakdown of *energy* use by at least the following components: lights, internal *equipment* loads, *service water-heating equipment*, *space*-heating *equipment*, *space*-cooling and heat rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of *unmet load hours* for both the *proposed design* and *baseline building design*.

m. *Purchased energy rates* used in the simulations.

n. An explanation of any error messages noted in the *simulation program* output.

o. For any exceptional calculation methods employed, document the predicted *energy* savings by *energy* type, the *energy* cost savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.

p. The reduction in *proposed building performance* associated with *on-site renewable energy*.

G1.3.3 General

Completion requirements shall be in compliance with Section 5.7.3, 6.7.3, 7.7.3, 8.7.3, 9.7.3, and 10.7.3.

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Table G3.1 Modeling Requirements for Calculating Proposed and *Baseline Building Performance*

No.	Proposed *Building* Performance	*Baseline Building* Performance
1. Design Model		
a.	The simulation model of the *proposed design* shall be consistent with the design documents, including proper	The *baseline building design* shall be modeled with the same number of *floors* and identical *conditioned floor area* as the *proposed design*.

accounting of *fenestration* and *opaque building envelope* types and areas; interior lighting power and *controls*; *HVAC system* types, sizes, and *controls*; and *service water-heating systems* and *controls*. All end-use load components within and associated with the *building* shall be modeled, including but not limited to exhaust fans, parking garage *ventilation* fans, snow-melt and freeze-protection *equipment*, facade lighting, swimming *pool* heaters and pumps, elevators and escalators, refrigeration, and cooking. Where the *simulation program* does not specifically model the functionality of the installed *system*, spreadsheets or other documentation of the assumptions shall be used to generate the power *demand* and operating schedule of the *systems*. b. All *conditioned spaces* in the *proposed design* shall be simulated as being both heated and cooled even if no heating or cooling *system* is to be installed. **Exception:** *Spaces* designed with heating only *systems* serving storage rooms, stairwells, vestibules, electrical/mechanical rooms, and restrooms not exhausting or transferring air from mechanically cooled thermal zones in the *proposed design* shall not be modeled with *mechanical cooling*. **6.4.3.4.4** When the *performance rating method* is applied to *buildings* in which *energy*-related features have not yet been designed (e.g., a *lighting system*), those yet-to-be-designed features shall be described in the *proposed design* exactly as they are defined in the *baseline building design*. Where the *space* classification for a *space* is not known, the *space* shall be categorized as an office *space*.	The *baseline building design* shall be developed by modifying the *proposed design* as described in Section G3. Except as specifically instructed, all *building systems* and *equipment* shall be modeled identically in the *proposed design* and *baseline building design*.
2. Additions and *Alterations*	
It is acceptable to predict performance using *building* models that exclude parts of the *existing building*, provided that all of the following conditions are met: a. Work to be performed in excluded parts of the *building* shall meet the requirements of Sections 5 through 10. b. Excluded parts of the *building* are served by *HVAC systems* that are entirely separate from those serving parts of the *building* that are included in the *building* model. c. Design *space* temperature and *HVAC system* operating *set points* and schedules on either side of the boundary between included and excluded parts of the *building* are essentially the same. d. If a declining block or similar utility rate is being used in the analysis, and the excluded and included parts of the *building* are on the same utility meter, the rate shall reflect the utility block or rate for the *building* plus the ~~addition~~*addition*.	If the proposed *design* excludes parts of the *existing building*, the *baseline building design* shall exclude them as well. When modeled, unmodified *existing building* components shall follow the same rules as new and modified *building* components.
3. *Space* Use Classification	
Use shall be specified using the *building* type or *space* type lighting classifications in accordance with Section 9.5.1 or 9.6.1. The user shall specify the *space* use classifications using either the *building* type or *space* type categories but shall not combine the two types of categories. More than one *building* type	Same as proposed design.

category may be used in a *building* if it is a mixed-use facility. If *space* type categories are used, the user may simplify the placement of the various *space* types within the *building* model, provided that *building* total areas for each *space* type are accurate.	
4. Schedule	
Schedules capable of modeling hourly variations in occupancy, lighting power, miscellaneous *equipment* power, *thermostat set points*, and *HVAC system* operation shall be used. The schedules shall be typical of the proposed *building* type as determined by the designer and approved by the *rating authority*. **Temperature and Humidity Schedules.** Temperature and humidity *control set points* and schedules as well as *temperature control throttling range* shall be the same for *proposed design* and *baseline building design*. **HVAC Fan Schedules.** Schedules for HVAC fans that provide *outdoor air* for *ventilation* shall run continuously whenever *spaces* are occupied and shall be cycled ON and OFF to meet heating and cooling loads during unoccupied hours. **Exceptions:** 1. Where no heating and/or cooling *system* is to be installed, and a heating or cooling *system* is being simulated only to meet the requirements described in this table, heating and/or cooling *system* fans shall not be simulated as running continuously during occupied hours but shall be cycled ON and OFF to meet heating and cooling loads during all hours. 2. HVAC fans shall remain on during occupied and unoccupied hours in *spaces* that have health- and safety-mandated minimum *ventilation* requirements during unoccupied hours. 3. HVAC fans shall remain on during occupied and unoccupied hours in *systems* primarily serving *computer rooms*.	Same as *proposed design.* **Exceptions:** 1. *Set points* and schedules for *HVAC systems* that ~~automatically~~*automatically* provide occupant thermal comfort via means other than directly controlling the air dry-bulb and wet-bulb temperature may be allowed to differ, provided that equivalent levels of occupant thermal comfort are demonstrated via the methodology in ASHRAE Standard 55, Section 5.3.3, "Elevated Air Speed," or Standard 55, Appendix B, "Computer Program for Calculation of PMV-PPD." 2. **Schedules may be allowed to differ between *proposed design* and *baseline building design* when necessary to model nonstandard *efficiency* measures, provided that the revised schedules have been approved by the *rating authority*. Measures that may warrant use of different schedules include but are not limited to *automatic* lighting *controls*, *automatic* natural *ventilation controls*, *automatic demand control ventilation controls*, and *automatic controls* that reduce *service water-heating* loads. In no case shall schedules differ where the *controls* are *manual* (e.g., *manual* operation of light switches or *manual* operation of windows).**
5. *Building Envelope*	
a. All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as built for *existing building envelopes*. **Exceptions:** The following *building* elements are permitted to differ from architectural drawings: 1. All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate *floor* slabs, concrete *floor* beams over parking garages, *roof* parapet) shall be separately modeled using either of the following techniques: a. Separate model of each of these assemblies within the *energy* simulation model. b. Separate calculation of the *U-factor* for each of these assemblies. The *U-factors* of these assemblies are then averaged with larger adjacent surfaces using an area-weighted average method. This average *U-factor* is modeled within the *energy* simulation model. Any other *building envelope* assembly that covers less than 5% of the total area of that assembly type (e.g., *exterior walls*) need not be separately described, provided that it is similar to an assembly being modeled. If not separately described, the area of a *building envelope* assembly shall be added to the area of an assembly of that same type with the same *orientation* and thermal properties.	Equivalent dimensions shall be assumed for each *building envelope* component type as in the *proposed design*; i.e., the total gross area of *walls* shall be the same in the *proposed design* and *baseline building design*. The same shall be true for the areas of roofs, *floors*, and *doors*, and the exposed perimeters of concrete slabs on *grade* shall also be the same in the *proposed design* and *baseline building design*. The following additional requirements shall apply to the modeling of the *baseline building design*: a. ***Orientation*.** The *baseline building performance* shall be generated by simulating the *building* with its actual *orientation* and again after rotating the entire *building* 90, 180, and 270 degrees, then averaging the results. The *building* shall be modeled so that it does not shade itself. **Exceptions:** 1. If it can be demonstrated to the satisfaction of the *rating authority* that the *building orientation* is dictated by site considerations. 2. *Buildings* where the *vertical fenestration area* on each *orientation* varies by less than 5%. b. ***Opaque* Assemblies.** *Opaque* assemblies used for new *buildings*, *existing buildings*, or additions shall conform with assemblies detailed in Appendix A and shall match the appropriate assembly maximum *U-factors* in Tables G3.4-1 through G3.4-8:

2. Exterior surfaces whose azimuth *orientation* and tilt differ by less than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.	• Roofs—Insulation entirely above deck (A2.2). • *Above-grade walls—Steel-framed* (A3.3). • *Below-grade walls*—Concrete block (A4). • *Floors—Steel-joist* (A5.3). • *Slab-on-grade floors* shall match the *F-factor* for unheated slabs from the same tables (A6).

5. *Building Envelope* (contd.)

3. The exterior *roof* surface shall be modeled using the aged solar *reflectance* and thermal *emittance* determined in accordance with Section 5.5.3.1.1(a). Where aged test data are unavailable, the *roof* surface may be modeled with a *reflectance* of 0.30 and a thermal *emittance* of 0.90.
4. *Manual fenestration* shading devices, such as blinds or shades, shall be modeled or not modeled the same as in the *baseline building design*. ~~Automatically~~*Automatically* controlled *fenestration* shades or blinds shall be modeled. Permanent shading devices, such as fins, overhangs, and light shelves shall be modeled.
5. ~~Automatically~~*Automatically* controlled *dynamic glazing* may be modeled. Manually controlled *dynamic glazing* shall use the average of the minimum and maximum *SHGC* and *VT*.

b. *Infiltration* shall be modeled using the same methodology, air leakage rate, and adjustments for weather and *building* operation in both the *proposed design* and the *baseline building design*. These adjustments shall be made for each simulation time step and must account for but not be limited to weather conditions and *HVAC system* operation, including strategies that are intended to positively pressurize the *building*. The air leakage rate of the *building envelope* (I_{75Pa}) at a ~~*fixed*~~fixed *building* pressure differential of 0.3 in. of water shall be 0.4 cfm/ft^2. The air leakage rate of the *building envelope* shall be converted to appropriate units for the *simulation program* using one of the methods in Section G3.1.1.4.

Exceptions: When whole-*building* air leakage testing, in accordance with ASTM E779, is specified during design and completed after *construction*, the *proposed design* air leakage rate of the *building envelope* shall be as measured.

- *Opaque door* types shall be of the same type of *construction* as the *proposed design* and conform to the *U-factor* requirements from the same tables (A7).

c. ***Vertical Fenestration Areas.*** For *building* area types included in Table G3.1.1-1, *vertical fenestration areas* for new *buildings* and additions shall equal that in Table G3.1.1-1 based on the area of gross *above-grade walls* that separate *conditioned spaces* and *semiheated spaces* from the exterior. Where a *building* has multiple *building* area types, each type shall use the values in the table. The *vertical fenestration* shall be distributed on each face of the *building* in the same proportion as in the *proposed design*. For *building* areas not shown in Table G3.1.1-1, *vertical fenestration areas* for new *buildings* and additions shall equal that in the *proposed design* or 40% of gross *above-grade wall* area, whichever is smaller, and shall be distributed on each face of the *building* in the same proportions in the *proposed design*. The *fenestration area* for an *existing building* shall equal the existing *fenestration area* prior to the proposed work and shall be distributed on each face of the *building* in the same proportions as the *existing building*. ~~For portions of those tables where there are no *SHGC* requirements, the *SHGC* shall be equal to that determined in accordance with Section C3.6(c). The *VT* shall be equal to that determined in accordance with Section C3.6(c).~~

d. ***Vertical Fenestration* Assemblies.** *Fenestration* for new *buildings*, *existing buildings*, and additions shall comply with the following:
- *Fenestration U-factors* shall match the appropriate requirements in Tables G3.4-1 through G3.4-8 for the applicable glazing percentage for U_{all}.
- *Fenestration SHGCs* shall match the appropriate requirements in Tables G3.4-1 through G3.4-8 using the value for $SHGC_{all}$ for the applicable vertical glazing percentage.
- All *vertical fenestration* shall be assumed to be flush with the *exterior wall*, and no shading projections shall be modeled.
- *Manual* window shading devices such as blinds or shades are not required to be modeled.

e. ***Skylights* and Glazed Smoke Vents.** *Skylight* area shall be equal to that in the *proposed design* or 3%, whichever is smaller. If the *skylight* area of the *proposed design* is greater than 3%, baseline *skylight* area shall be decreased by an identical percentage in all *roof* components in which *skylights* are located to reach 3%. *Skylight orientation* and tilt shall be the same as in the *proposed design*. *Skylight U-factor* and *SHGC* properties shall match the appropriate requirements in

	Tables G3.4-1 through G3.4-8 using the value and the applicable *skylight* percentage. f. ***Roof* Solar *Reflectance* and Thermal *Emittance*.** The exterior *roof* surfaces shall be modeled using a solar *reflectance* of 0.30 and a thermal *emittance* of 0.90. **6.4.3.11.1 *Roof* Albedo.** All *roof* surfaces shall be modeled with a reflectivity of 0.30.fixed
6. Lighting	
Lighting power in the *proposed design* shall be determined as follows: a. Where a complete *lighting system* exists, the actual lighting power for each *thermal block* shall be used in the model. b. Where a *lighting system* has been designed and submitted with design documents, lighting power shall be determined in accordance with Sections 9.1.3 and 9.1.4. c. Where lighting neither exists nor is submitted with design documents, lighting shall comply with but not exceed the requirements of Section 9. Lighting power shall be determined in accordance with the *Building* Area Method. d. *Lighting system* power shall include all *lighting system* components shown or provided for on the plans (including *lamps* and *ballasts* and task and furniture-mounted *fixtures*). **Exceptions:** For multifamily *dwelling units*, hotel/motel guest rooms, and other *spaces* in which *lighting systems* are connected via receptacles and are not shown or provided for on *building* plans, assume identical lighting power for the *proposed design* and *baseline building design* in the simulations. e. Lighting power for parking garages and *building* facades shall be modeled. f. For lighting *controls*, at a minimum, the proposed design shall contain the mandatory *automatic* lighting *controls* specified in Section 9.4.1 (e.g., *automatic* daylight responsive *controls*, ~~occupancy sensors~~*occupancy sensors*, programmable *controls*, etc.). These *controls* shall be modeled in accordance with (g) and (h). g. *Automatic* daylighting responsive *controls* shall be modeled directly in the *proposed design* or through schedule adjustments determined by a separate daylighting analysis approved by the *rating authority*. Modeling and schedule adjustments shall separately account for *primary sidelighted areas*, *secondary sidelighted areas*, and toplighted areas. h. Other *automatic* lighting *controls* included in the *proposed design* shall be modeled directly in the *building* simulation by reducing the lighting schedule each hour by the ~~occupancy sensor~~*occupancy sensor* reduction factors in Table G3.7 for the applicable *space* type. This reduction shall be taken only for lighting controlled by the ~~occupancy sensors~~*occupancy sensors*. Credit for other programmable lighting *control* in *buildings* less than 5000 ft^2 can be taken by reducing the lighting schedule each hour by 10%.	Interior lighting power in the *baseline building design* shall be determined using the values in Table G3.7. Lighting shall be modeled having the *automatic* shutoff *controls* in *buildings* >5000 ft^2 and ~~occupancy sensors~~*occupancy sensors* in employee lunch and break rooms, conference/meeting rooms, and classrooms (not including shop classrooms, laboratory classrooms, and preschool through 12th-grade classrooms). These *controls* shall be reflected in the *baseline building design* lighting schedules. No additional *automatic* lighting *controls,* e.g., *automatic controls* for daylight utilization and ~~occupancy sensors~~*occupancy sensors* in *space* types not listed above, shall be modeled in the *baseline building design*. Exterior lighting in areas identified as “Tradable Surfaces” in Table G3.6 shall be modeled with the baseline lighting power shown in Table G3.6. Other exterior lighting shall be modeled the same in the *baseline building design* as in the *proposed design*.
7. *Thermal Blocks—HVAC Zones* Designed	
Where *HVAC zones* are defined on HVAC design drawings, each *HVAC zone* shall be modeled as a separate *thermal block*.	Same as *proposed design*.

Exceptions: Different *HVAC zones* may be combined to create a single *thermal block* or identical *thermal blocks* to which multipliers are applied, provided that all of the following conditions are met: 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* and glazed *semiexterior walls* face the same *orientation* or their orientations vary by less than 45 degrees. 3. **All of the zones are served by the same *HVAC system* or by the same kind of *HVAC system*.**	
8. *Thermal Blocks—HVAC Zones* Not Designed	
Where the *HVAC zones* and *systems* have not yet been designed, *thermal blocks* shall be defined based on similar internal load densities, occupancy, lighting, thermal and *space* temperature schedules, and in combination with the following guidelines: a. Separate *thermal blocks* shall be assumed for interior and perimeter *spaces*. Interior *spaces* shall be those located greater than 15 ft from an *exterior wall* or *semiexterior wall*. Perimeter *spaces* shall be those located within 15 ft of an *exterior wall* or *semiexterior wall*. A separate thermal zone does not need to be modeled for areas adjacent to *semiexterior walls* that separate *semiheated space* from *conditioned space*. b. Separate *thermal blocks* shall be assumed for *spaces* adjacent to glazed *exterior walls* or glazed *semiexterior walls*; a separate zone shall be provided for each *orientation*, except that orientations that differ by less than 45 degrees may be considered to be the same *orientation*. Each zone shall include all *floor* area that is 15 ft or less from a glazed perimeter *wall*, except that *floor* area within 15 ft of glazed perimeter *walls* having more than one *orientation* shall be divided proportionately between zones. c. 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. d. Separate *thermal blocks* shall be assumed for *spaces* having exterior ceiling or *roof* assemblies from zones that do not share these features.	Same as *proposed design*.
9. *Thermal Blocks*—Multifamily *Residential Buildings*	
Residential spaces shall be modeled using at least one *thermal block* per *dwelling unit*, except that those units facing the same orientations may be combined into one *thermal block*. Corner units and units with *roof* or *floor* loads shall only be combined with units sharing these features.	Same as *proposed design*.
10. *HVAC Systems*	
The *HVAC system* type and all related performance parameters in the *proposed design*, such as *equipment* capacities and efficiencies, shall be determined as follows: a. Where a complete *HVAC system* exists, the model shall reflect the actual *system* type using actual component capacities and efficiencies. b. Where an *HVAC system* has been designed and submitted with design documents, the HVAC model shall be consistent with design documents. Mechanical *equipment* efficiencies shall be adjusted from actual	The *HVAC systems* in the *baseline building design* shall be of the type and description specified in Section G3.1.1, shall meet the general *HVAC system* requirements specified in Section G3.1.2, and shall meet any *system*-specific requirements in Section G3.1.3 that are applicable to the baseline *HVAC system* types. If the *proposed design* includes humidification then the *baseline building design* shall use adiabatic humidification. **Exception:** If the proposed *building* humidification *system* complies with Section 6.5.2.4 then the *baseline building*

design conditions to the standard rating conditions specified in Section 6.4.1 if required by the simulation model. Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy* from the *efficiency* rating in the *baseline building design*. The equations in Section G3.1.2.1 shall not be used in the *proposed design*. The *proposed design HVAC system* shall be modeled using *manufacturers*' full- and part-load data for the *HVAC system* without fan power.

c. Where no heating *system* exists or no heating *system* has been submitted with design documents, the *system* type shall be the same *system* as modeled in the *baseline building design* and shall comply with but not exceed the requirements of Section 6.

design shall use nonadiabatic humidification.

For *systems* serving *computer rooms*, the *baseline building design* shall not have *reheat* for the purpose of dehumidification.

Fossil fuel systems shall be modeled using natural gas as their *fuel* source.

Exception: For *fossil fuel systems* where natural gas is not available for the proposed *building* site as determined by the *rating authority*, the baseline *HVAC systems* shall be modeled using propane as their *fuel*.

10. *HVAC Systems* (contd.)

d. Where no cooling *system* exists or no cooling *system* has been submitted with design documents, the cooling *system* type shall be the same as modeled in the *baseline building design* and shall comply with the requirements of Section 6.

Exception: *Spaces* using baseline *HVAC system* types 9 and 10.

11. *Service Water-Heating Systems*

The *service water-heating system* type and all related performance parameters, such as *equipment* capacities and efficiencies, in the *proposed design* shall be determined as follows:

a. Where a complete *service water-heating system* exists, the *proposed design* shall reflect the actual *system* type using actual component capacities and efficiencies.

b. Where a *service water-heating system* has been designed and submitted with design documents, the *service water-heating model* shall be consistent with design documents.

c. Where no *service water-heating system* exists or has been designed and submitted with design documents but the *building* will have *service water-heating* loads, a *service water-heating system* shall be modeled that matches the *system* type in the *baseline building design*, serves the same *water-heating* loads, and shall comply with but not exceed the requirements of Section 7.

d. For *buildings* that will have no *service water-heating* loads, no *service water-heating system* shall be modeled.

6.4.3.10.3 Where a combined *system* has been specified to meet both *space* heating and *service water-heating* loads, the *proposed design* shall reflect the actual *system* type using actual component capacities and efficiencies.

The *service water-heating system* in the *baseline building design* shall be as specified in Table G3.1.1-2 and conform with the following conditions:

a. Where a complete *service water-heating system* exists or a new *service water-heating system* has been specified, one *service water-heating system* shall be modeled for each *building* area type in the proposed *building*. Each *system* shall be sized according to the provisions of Section 7.4.1, and the *equipment* shall match the minimum *efficiency* requirements in Section 7.4.2.

b. Where no *service water-heating system* exists or has been specified but the *building* will have *service water-heating* loads, one *service water-heating system* shall be modeled for each anticipated *building* area type in the *proposed design*. Each *system* shall meet the minimum *efficiency* requirements of Section 7.4.2 and be modeled identically to the *proposed design*.

c. For *buildings* that will have no *service water-heating* loads, no *service water-heating* shall be modeled.

d. Where a combined *system* has been specified to meet both *space* heating and *service water-heating* loads, the baseline *building system* shall use separate *systems* meeting the minimum *efficiency* requirements applicable to each *system* individually.

6.4.3.10.3 For large, 24-hour-per-day facilities that meet the prescriptive criteria for use of condenser heat recovery *systems* described in Section 6.5.6.2, a *system* meeting the requirements of that section shall be included in the *baseline building design* regardless of the exceptions to Section 6.5.6.2.

Exceptions: If a condenser heat recovery *system* meeting the requirements described in Section 6.5.6.2 cannot be modeled, the requirement for including such a *system* in the actual *building* shall be met as a prescriptive requirement in accordance with Section 6.5.6.2, and no heat recovery *system* shall be included in the *proposed design* or *baseline building design*.

6.4.3.11 *Service water-heating energy* consumption shall be calculated explicitly based upon the volume of *service water heating* required and the entering makeup water and the leaving *service water-heating* temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements.

6.4.3.11.1 Where recirculation pumps are used to ensure prompt availability of *service water-heating* at the end use, the *energy* consumption of such pumps shall be calculated explicitly.

6.4.3.11.2 Service water loads and use shall be the same for both the *proposed design* and *baseline building design* and shall be documented by the calculation procedures described in Section 7.4.1.

Exceptions:

1. *Service water-heating* use can be demonstrated to be reduced by documented water conservation measures that reduce the physical volume of ~~*service*~~service water required. Examples include low-flow shower heads. Such reduction shall be demonstrated by calculations.

11. *Service Water-Heating Systems* (contd.)

Exceptions:

2. *Service water-heating energy* consumption can be demonstrated to be reduced by reducing the required temperature of ~~*service*~~service mixed water, by increasing the temperature, or by increasing the temperature of the entering makeup water. Examples include alternative sanitizing technologies for dishwashing and heat recovery to entering makeup water. Such reduction shall be demonstrated by calculations.
3. *Service water heating* use can be demonstrated to be reduced by reducing the hot fraction of mixed water to achieve required operational temperature. Examples include shower or laundry heat recovery to incoming cold-water supply, reducing the hot-water fraction required to meet required mixed-water temperature. Such reduction shall be demonstrated by calculations.

6.4.4 Gas storage *water heaters* shall be modeled using natural gas as their *fuel*.

6.4.3.5 Where natural gas is not available for the proposed *building* site, as determined by the *rating authority*, gas storage *water heaters* shall be modeled using propane as their *fuel*.

12. Receptacle and Other Loads

Receptacle and *process loads*, such as those for office and other *equipment*, shall be estimated based on the *building* area type or *space* type category and shall be assumed to be identical in the *proposed design* and *baseline building design*, except as specifically approved by the *rating authority* only when quantifying performance that exceeds the requirements of Standard 90.1 but not when the *Performance Rating Method* is used as an alternative path for minimum standard compliance in accordance with Section 4.2.1.1. These loads shall always be included in simulations of the *building*. These loads shall be included when calculating the *proposed building performance* and the *baseline building performance* as required by Section G1.2.1.

Motors shall have the *efficiency* ratings found in Table G3.9.1. Other *systems* covered by Section 10 and miscellaneous loads shall be modeled as identical to those in the *proposed design*, including schedules of operation and *control* of the *equipment*. *Energy* used for cooking *equipment*, receptacle loads, computers, medical or laboratory *equipment*, and manufacturing and industrial process *equipment* not specifically identified in the standard power and *energy* rating or capacity of the *equipment* shall be identical between the *proposed building performance* and the *baseline building performance*. Receptacle schedules shall be the same as the *proposed design* before the receptacle power credit is applied.

Exception: When receptacle controls installed in *spaces* where not required by Section 8.4.2 are included in the *proposed building design*, the hourly receptacle shall be reduced as follows: RPC = RC × 10% ~~W~~where~~:~~ RPC = ~~R~~receptacle power credit EPS_{pro} = EPS_{bas} × (1 – RPC) RC = p~~P~~ercentage of all controlled receptacles EPS_{bas} = ~~B~~baseline *equipment* power hourly schedule (fraction) EPS_{pro} = ~~P~~proposed *equipment* power hourly schedule (fraction) a. Where power and other *systems* covered by Sections 8 and 10 have been designed and submitted with design documents, those *systems* shall be determined in accordance with Sections 8 and 10. b. Where power and other *systems* covered by Sections 8 and 10 have not been submitted with design documents, those *systems* shall comply with but not exceed the requirements of those sections.	**Exceptions:** When quantifying performance that exceeds the requirements of Standard 90.1 (but not when using the *Performance Rating Method* as an alternative path for minimum standard compliance per Section 4.2.1.1) variations of the power requirements, schedules, or *control* sequences of the *equipment* modeled in the *baseline building design* from those in the *proposed design* shall be approved by the *rating authority* based on documentation that the *equipment* installed in the *proposed design* represents a significant verifiable departure from documented current conventional practice. The burden of this documentation is to demonstrate that accepted conventional practice would result in baseline *building equipment* different from that installed in the *proposed design*. Occupancy and occupancy schedules shall not be changed.
13. Modeling Limitations to the *Simulation Program*	
If the *simulation program* cannot model a component or *system* included in the *proposed design* explicitly, substitute a thermodynamically similar component model that can approximate the expected performance of the component that cannot be modeled explicitly.	Same as *proposed design*.
14. Exterior Conditions	
a. **Shading by Adjacent Structures and Terrain.** The effect that structures and significant vegetation or topographical features have on the amount of solar radiation being received by a structure shall be adequately reflected in the computer analysis. All elements whose effective height is greater than their distance from a proposed *building* and whose width facing the proposed *building* is greater than one-third that of the proposed *building* shall be accounted for in the analysis.	Same as *proposed design*.
14. Exterior Conditions (contd.)	
b. **Ground Temperatures for *Below-Grade Wall* and Basement *Floor* Heat-Loss Calculations.** It is acceptable to use either an annual average ground temperature or monthly average ground temperatures for calculation of heat loss through *below-grade walls* and basement *floors*. c. **Water Main Temperatures for *Service Water-Heating* Calculations.** It is acceptable to use either an annual water main supply temperature or monthly average water main supply temperatures for calculating *service water heating*. If annual or monthly water main supply temperatures are not available from the local water utility, annual average ground temperatures may be used.	Same as *proposed design.*
15. Distribution *Transformers*	
Low-voltage dry-type distribution *transformers* shall be modeled if the *transformers* in the *proposed design* exceed the *efficiency* required in Table 8.4.4.	Low-voltage dry-type distribution *transformers* shall be modeled only if the *proposed design transformers* exceed the *efficiency* requirements of Table 8.4.4. If modeled, the *efficiency*

	requirements from Table 8.4.4 shall be used. The ratio of the capacity to peak electrical load of the *transformer* shall be the same as the ratio in the *proposed design*.
16. Elevators	
Where the *proposed design* includes elevators, the elevator motor, *ventilation* fan, and light load shall be included in the model. The cab *ventilation* fan and lights shall be modeled with the same schedule as the elevator motor.	Where the *proposed design* includes elevators, the *baseline building design* shall be modeled to include the elevator cab motor, *ventilation* fans, and lighting power. The elevator peak motor power shall be calculated as follows: bhp = (Weight of Car + Rated Load – Counterweight) × Speed of Car/(33,000 × $h_{mechanical}$) P_m = bhp × 746/h_{motor} where Weight of Car = the *proposed design* elevator car weight, lb Rated Load = the *proposed design* elevator load at which to operate, lb Counterweight of Car = the elevator car counterweight, from Table G3.9.2, lb Speed of Car = the speed of the proposed elevator, ft/min $h_{mechanical}$ = the mechanical *efficiency* of the elevator from Table G3.9.2 h_{motor} = the motor *efficiency* from Table G3.9.2 P_m = peak elevator motor power,W The elevator motor use shall be modeled with the same schedule as the *proposed design*. When included in the *proposed design*, the baseline elevator cab *ventilation* fan shall be 0.33 W/cfm and the *lighting power density* shall be 3.14 W/ft^2; both operate continuously.
17. Refrigeration	
The *proposed design* shall be modeled using the actual *equipment* capacities and efficiencies.	Where refrigeration *equipment* is specified in the *proposed design* and listed in Tables G3.10.1 and G3.10.2, the *baseline building design* shall be modeled as specified in Tables G3.10.1 and G3.10.2 using the actual *equipment* capacities. If the refrigeration *equipment* is not listed in Tables G3.10.1 and G3.10.2, the *baseline building design* shall be modeled the same as the *proposed design*.

...

Table G3.1.1-1 Baseline *Building Vertical Fenestration* Percentage of Gross *Above-Grade-Wall* Area

***Building* Area Types**[a]	**Baseline *Building* Gross *Above-Grade-Wall* Area**
Grocery store	7%
Healthcare (outpatient)	21%
Hospital	27%
Hotel/motel (≤75 rooms)	24%
Hotel/motel (>75 rooms)	34%
Office (≤5000 ft^2)	19%
Office (5000 to 50,000 ft^2)	31%
Office (>50,000 ft^2)	40%
Restaurant (quick ~~*service*~~service)	34%
Restaurant (full ~~*service*~~service)	24%

Retail (stand alone)	11%
Retail (strip mall)	20%
School (primary)	22%
School (secondary and university)	22%
Warehouse (nonrefrigerated)	6%

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

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Table G3.1.1-3 Baseline *HVAC System* Types

***Building* Type, Number of *Floors*, and Gross Conditioned Floor Area**	**Climate Zones 3B, 3C, and 4 to 8**	**Climate Zones 0 to 3A**
Residential	*System* 1—*PTAC*	*System* 2—*PTHP*
Public assembly <120,000 ft^2	*System* 3—PSZ-AC	*System* 4—PSZ-HP
Public assembly ≥120,000 ft^2	*System* 12—SZ-CV-HW	*System* 13—SZ-CV-ER
Heated-only storage	*System* 9—Heating and *ventilation*	*System* 10—Heating and *ventilation*
Retail and 2 *floors* or fewer	*System* 3—PSZ-AC	*System* 4—PSZ-HP
Other nonresidential and 3 *floors* or fewer and <25,000 ft^2	*System* 3—PSZ-AC	*System* 4—PSZ-HP
Other nonresidential and 4 or 5 *floors* and <25,000 ft^2 or 5 *floors* or fewer and 25,000 ft^2 to 150,000 ft^2	*System* 5—Packaged *VAV* with *reheat*	*System* 6—Packaged *VAV* with PFP boxes
Other nonresidential and more than 5 *floors* or >150,000 ft^2	*System* 7—*VAV* with *reheat*	*System* 8—*VAV* with PFP boxes

Notes:
1. *Residential building* types include dormitory, hotel, motel, and multifamily. *Residential space* types include guest rooms, living quarters, private living *space*, and sleeping quarters. Other *building* and *space* types are considered *nonresidential*.
2. Where attributes make a *building* eligible for more than one baseline *system* type, use the predominant condition to determine the *system* type for the entire *building* except as noted in Section G3.1.1.
3. For laboratory *spaces* in a *building* having a total laboratory exhaust rate greater than 15,000 cfm, use a single *system* of type 5 or 7 serving only those *spaces*.
4. For hospitals, depending on *building* type, use *System* 5 or 7 in all climate zones.
5. Public assembly *building* types include houses of worship, auditoriums, movie theaters, performance theaters, concert halls, arenas, enclosed stadiums, ice rinks, gymnasiums, convention centers, exhibition centers, and natatoriums.

...

G3.1.1.4 Modeling Building Envelope Infiltration

The air leakage rate of the *building envelope* (I_{75Pa}) at a pressure differential of 0.3 in. of water shall be converted to appropriate units for the *simulation program* using one of the following formulas:

For methods describing air leakage as a function of *floor* area,

$$I_{FLR} = 0.112 \times I_{75Pa} \times S/A_{FLR}$$

For methods describing air leakage as a function of the area of *above-grade walls* that separate *conditioned spaces* and *semiheated spaces* from the exterior,

$$I_{AGW} = 0.112 \times I_{75Pa} \times S/A_{AGW}$$

When using the measured air leakage rate of the *building envelope* at a pressure differential of 0.3 in. of water for the *proposed design*, the air leakage rate shall be calculated as follows:

$$I_{75Pa} = Q/S$$

where

I_{75Pa} = air leakage rate of the *building envelope* (cfm/ft^2) at a ~~*fixed*~~fixed *building* pressure differential of 0.3 in. of water, or 1.57 psf

Q = volume of air in cfm flowing through the *building envelope* when subjected to a pressure differential of 0.3 in. of water, or 1.57 psf, in accordance with ASTM E 779

S = total area of the *building envelope* (ft^2), including the lowest *floor*, any *below-grade walls* or *above-grade walls*, and *roof* (including *vertical fenestration* and *skylights*)

I_{FLR} = adjusted air leakage rate of the *building envelope* (cfm/ft^2) at a reference wind speed of 10 mph and relative to the *gross floor area*

A_{FLR} = *gross floor area*, ft^2

I_{AGW} = adjusted air leakage rate of the *building envelope* (cfm/ft^2) at a reference wind speed of 10 mph and relative to the area of the *above-grade walls* of the *building envelope*

A_{AGW} = total area of *above-grade walls* of the *building envelope*, ft^2

...

G3.1.2.7 Economizer High-Limit Shutoff

The high-limit shutoff shall be a dry-bulb ~~*fixed*~~fixed switch with *set-point* temperatures in accordance with the values in Table G3.1.2.7.

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G3.1.3.11 Heat Rejection (Systems 7, 8, 9, 12, and 13)

The heat-rejection device shall be an axial-fan open-circuit cooling tower with variable-speed fan *control* and shall have an *efficiency* of 38.2 gpm/hp at the conditions specified in Table 6.8.1-7. Condenser-water design supply temperature shall be calculated using the cooling tower approach to the 0.4% *evaporation design wet-bulb temperature* as generated by the formula below, with a design temperature rise of 5.6°C:

Approach 10°F *Range* = 25.72 – (0.24 × WB)

where WB is the 0.4% *evaporation design wet-bulb temperature* (°F); valid for wet bulbs from 55°F to 90°F.

The tower shall be controlled to maintain a leaving water temperature, where weather permits, per Table G3.1.3.11, floating up to the design leaving water temperature for the cooling tower. The *baseline building design* condenser-water pump power shall be 19 W/gpm and modeled as constant volume. For *computer room systems* using *System* 11 with an integrated ~~water-side economizer~~*fluid economizer*, the *baseline building design* condenser-water-pump power shall be increased by 3 W/gpm for flow associated with the ~~water-side economizer~~*fluid economizer*. Each chiller shall be modeled with separate condenser-water and chilled-water pumps interlocked to operate with the associated chiller.

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G3.1.3.17 System 11 Supply Air Temperature and Fan Control

Minimum volume *set point* shall be 50% of the maximum design airflow rate, the minimum *ventilation* outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is larger.

Fan volume shall be *reset* from 100% airflow at 100% cooling load to minimum airflow at 50% cooling load. Supply air temperature *set point* shall be *reset* from minimum supply air temperature at 50% cooling load and above to *space* temperature at 0% cooling load. In heating mode supply air temperature shall be modulated to maintain *space* temperature, and fan volume shall be ~~*fixed*~~fixed at the minimum airflow.

G3.1.3.18 Dehumidification (Systems 3 through 8 and 11, 12, and 13)

If the *proposed design HVAC systems* have *humidistatic controls*, then the *baseline building design* shall use *mechanical cooling* for dehumidification and shall have *reheat* available to avoid overcooling. When the *baseline building design HVAC system* does not comply with any of the exceptions in Section 6.5.2.3, then only 25% of the *system reheat energy* shall be included in the *baseline building performance*. The *reheat* type shall be the same as the *system* heating type.

G3.1.3.19 Preheat Coils (Systems 5 through 8)

The baseline *system* shall be modeled with a preheat coil controlled to a ~~*fixed*~~fixed *set point* 20°F less than the design room heating temperature *set point*.

Table G3.4-1 *Performance Rating Method Building Envelope* Requirements for Climate Zones 0 and 1 (A,B)*

***Opaque* Elements**	**Nonresidential Assembly Maximum**	**Residential Assembly Maximum**	**Semiheated Assembly Maximum**
Roofs			
Insulation entirely above deck	U-0.063	U-0.063	U-1.282
Walls, Above-Grade			
Steel-framed	U-0.124	U-0.124	U-0.352
Wall, Below-Grade			
Below-grade wall	C-1.140	C-1.140	C-1.140

Floors									
Steel-joist	U-0.350			U-0.350			U-0.350		
Slab-on-Grade Floors									
Unheated	F-0.730			F-0.730			F-0.730		
Opaque Doors									
Swinging	U-0.700			U-0.700			U-0.700		
Nonswinging	U-1.450			U-1.450			U-1.450		
Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
10.1% to 20.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
20.1% to 30.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
30.1% to 40.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	VT_{all}-0.40	U_{all}-1.36	$SHGC_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61
2.1%+	U_{all}-1.36	$SHGC_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	$SHGC_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.
a. Exception to Section A3.1.3.1 applies.

Table G3.4-2 *Performance Rating Method Building Envelope* Requirements for Climate Zone 2 (A,B)*

	Nonresidential	**Residential**	**Semiheated**
***Opaque* Elements**	**Assembly Maximum**	**Assembly Maximum**	**Assembly Maximum**
Roofs			
Insulation entirely above deck	U-0.063	U-0.063	U-0.218
Walls, Above-Grade			
Steel-framed	U-0.124	U-0.124	U-0.352
Wall, Below-Grade			
Below-grade wall	C-1.140	C-1.140	C-1.140
Floors			
Steel-joist	U-0.052	U-0.052	U-0.350
Slab-on-Grade Floors			
Unheated	F-0.730	F-0.730	F-0.730
Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700
Nonswinging	U-1.450	U-1.450	U-1.450

Fenestration	Assembly Max. U	Assembly Max. *SHGC*	Visible Transmittance	Assembly Max. U	Assembly Max. *SHGC*	Visible Transmittance	Assembly Max. U	Assembly Max. *SHGC*	Visible Transmittance
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
10.1% to 20.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
20.1% to 30.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
30.1% to 40.0%	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	VT_{all}-0.40	U_{all}-1.36	$SHGC_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61
2.1%+	U_{all}-1.36	$SHGC_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	$SHGC_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.
a. Exception to Section A3.1.3.1 applies.

Table G3.4-3 *Performance Rating Method Building Envelope* Requirements for Climate Zone 3 (A,B,C)*

	Nonresidential			Residential			Semiheated		
***Opaque* Elements**	**Assembly Maximum**			**Assembly Maximum**			**Assembly Maximum**		
Roofs									
Insulation entirely above deck	U-0.063			U-0.063			U-0.218		
Walls, Above-Grade									
Steel-framed	U-0.124			U-0.084			U-0.352		
Wall, Below-Grade									
Below-grade wall	C-1.140			C-1.140			C-1.140		
Floors									
Steel-joist	U-0.052			U-0.052			U-0.069		
Slab-on-Grade Floors									
Unheated	F-0.730			F-0.730			F-0.730		
Opaque Doors									
Swinging	U-0.700			U-0.700			U-0.700		
Nonswinging	U-1.450			U-0.500			U-1.450		
Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
10.1% to 20.0%	U_{all}-0.57	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
20.1% to 30.0%	U_{all}-0.57	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-0.57	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
30.1% to 40.0%	U_{all}-0.57	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-0.57	$SHGC_{all}$-0.25	VT_{all}-0.28	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44

Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-0.69	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-0.69	*SHGC*$_{all}$-0.36	VT_{all}-0.40	U_{all}-1.36	*SHGC*$_{all}$-NR0.55	VT_{all}-0.61
2.1%+	U_{all}-0.69	*SHGC*$_{all}$-0.19	VT_{all}-0.21	U_{all}-0.69	*SHGC*$_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	*SHGC*$_{all}$-NR0.55	VT_{all}-0.61

***Fenestration* (for Zone 3C)**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-1.22	*SHGC*$_{all}$-0.61	VT_{all}-0.67	U_{all}-1.22	*SHGC*$_{all}$-0.61	VT_{all}-0.67	U_{all}-1.22	*SHGC*$_{all}$-0.40NR	VT_{all}-0.44
10.1% to 20.0%	U_{all}-1.22	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	*SHGC*$_{all}$-0.61	VT_{all}-0.67	U_{all}-1.22	*SHGC*$_{all}$-NR0.40	VT_{all}-0.44
20.1% to 30.0%	U_{all}-1.22	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	*SHGC*$_{all}$-NR0.40	VT_{all}-0.44
30.1% to 40.0%	U_{all}-1.22	*SHGC*$_{all}$-0.34	VT_{all}-0.37	U_{all}-1.22	*SHGC*$_{all}$-0.34	VT_{all}-0.37	U_{all}-1.22	*SHGC*$_{all}$-NR0.40	VT_{all}-0.44
Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-1.36	*SHGC*$_{all}$-0.61	VT_{all}-0.67	U_{all}-1.36	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-1.36	*SHGC*$_{all}$-NR0.55	VT_{all}-0.61
2.1%+	U_{all}-1.36	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-1.36	*SHGC*$_{all}$-0.19	VT_{all}-0.19	U_{all}-1.36	*SHGC*$_{all}$-NR0.55	VT_{all}-0.61

[*] The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.

[a.] Exception to Section A3.1.3.1 applies.

[b.] Insulation is not required for *nonresidential mass walls* in Climate Zone 3A located below the "Warm-Humid" line, and in Zone 3B.

Table G3.4-4 *Performance Rating Method Building Envelope* Requirements for Climate Zone 4 (A,B,C)*

	Nonresidential	**Residential**	**Semiheated**
***Opaque* Elements**	**Assembly Maximum**	**Assembly Maximum**	**Assembly Maximum**
Roofs			
Insulation entirely above deck	U-0.063	U-0.063	U-0.218
Walls, Above-Grade			
Steel-framed	U-0.124	U-0.064	U-0.124
Wall, Below-Grade			
Below-grade wall	C-1.140	C-1.140	C-1.140
Floors			
Steel-joist	U-0.052	U-0.038	U-0.069
Slab-on-Grade Floors			
Unheated	F-0.730	F-0.730	F-0.730
Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700
Nonswinging	U-1.450	U-0.500	U-1.450

Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-0.57	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	*SHGC*$_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	*SHGC*$_{all}$-NR0.40	VT_{all}-0.44

10.1% to 20.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
20.1% to 30.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
30.1% to 40.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.44
Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.58	$SHGC_{all}$-0.36	VT_{all}-0.40	U_{all}-1.36	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61
2.1%+	U_{all}-0.69	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.58	$SHGC_{all}$-0.19	VT_{all}-0.21	U_{all}-1.36	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.
[a.] Exception to Section A3.1.3.1 applies.

Table G3.4-5 *Performance Rating Method Building Envelope* Requirements for Climate Zone 5 (A,B,C)*

	Nonresidential			**Residential**			**Semiheated**		
***Opaque* Elements**	**Assembly Maximum**			**Assembly Maximum**			**Assembly Maximum**		
Roofs									
Insulation entirely above deck	U-0.063			U-0.063			U-0.173		
Walls, Above-Grade									
Steel-framed	U-0.084			U-0.064			U-0.124		
Wall, Below-Grade									
Below-grade wall	C-1.140			C-1.140			C-1.140		
Floors									
Steel-joist	U-0.052			U-0.038			U-0.069		
Slab-on-Grade Floors									
Unheated	F-0.730			F-0.730			F-0.730		
Opaque Doors									
Swinging	U-0.700			U-0.700			U-0.700		
Nonswinging	U-1.450			U-0.500			U-1.450		
Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
10.1% to 20.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.44
20.1% to 30.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.44
30.1% to 40.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.44
Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.69	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.36	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.61
2.1%+	U_{all}-0.69	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.69	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.36	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.61

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.

Table G3.4-6 *Performance Rating Method Building Envelope* Requirements for Climate Zone 6 (A,B)*

	Nonresidential			**Residential**			**Semiheated**		
***Opaque* Elements**	**Assembly Maximum**			**Assembly Maximum**			**Assembly Maximum**		
Roofs									
Insulation entirely above deck	U-0.063			U-0.063			U-0.173		
Walls, Above-Grade									
Steel-framed	U-0.084			U-0.064			U-0.124		
Wall, Below-Grade									
Below-grade wall	C-1.140			C-0.119			C-1.140		
Floors									
Steel-joist	U-0.038			U-0.038			U-0.069		
Slab-on-Grade Floors									
Unheated	F-0.730			F-0.730			F-0.730		
Opaque Doors									
Swinging	U-0.700			U-0.500			U-0.700		
Nonswinging	U-0.500			U-0.500			U-1.450		
Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
10.1% to 20.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.44
20.1% to 30.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.44
30.1% to 40.0%	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-0.57	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.22	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.44
Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.58	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.36	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.61
2.1%+	U_{all}-0.69	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.58	$SHGC_{all}$-0.39	VT_{all}-0.43	U_{all}-1.36	$SHGC_{all}$-0.40~~NR~~	VT_{all}-0.61

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.

Table G3.4-7 *Performance Rating Method Building Envelope* Requirements for Climate Zone 7*

	Nonresidential	**Residential**	**Semiheated**
***Opaque* Elements**	**Assembly Maximum**	**Assembly Maximum**	**Assembly Maximum**
Roofs			
Insulation entirely above deck	U-0.063	U-0.063	U-0.173
Walls, Above-Grade			
Steel-framed	U-0.064	U-0.064	U-0.124
Wall, Below-Grade			
Below-grade wall	C-0.119	C-0.119	C-1.140
Floors			

Steel-joist	U-0.038			U-0.038			U-0.052		
Slab-on-Grade Floors									
Unheated	F-0.730			F-0.540			F-0.730		
Opaque Doors									
Swinging	U-0.700			U-0.500			U-0.700		
Nonswinging	U-0.500			U-0.500			U-1.450		
Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									
0% to 10.0%	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.22	$SHGC_{all}$-NR	VT_{all}-0.44
10.1% to 20.0%	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.22	$SHGC_{all}$-NR	VT_{all}-0.44
20.1% to 30.0%	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.22	$SHGC_{all}$-NR	VT_{all}-0.44
30.1% to 40.0%	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-0.57	$SHGC_{all}$-0.49	VT_{all}-0.54	U_{all}-1.22	$SHGC_{all}$-NR	VT_{all}-0.44
Skylight All, % of *Roof*									
0% to 2.0%	U_{all}-0.69	$SHGC_{all}$-0.68	VT_{all}-0.75	U_{all}-0.69	$SHGC_{all}$-0.64	VT_{all}-0.70	U_{all}-1.36	$SHGC_{all}$-NR	VT_{all}-0.61
2.1%+	U_{all}-0.69	$SHGC_{all}$-0.64	VT_{all}-0.70	U_{all}-0.69	$SHGC_{all}$-0.64	VT_{all}-0.70	U_{all}-1.36	$SHGC_{all}$-NR	VT_{all}-0.61

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.

Table G3.4-8 *Performance Rating Method Building Envelope* Requirements for Climate Zone 8*

	Nonresidential	**Residential**	**Semiheated**
***Opaque* Elements**	**Assembly Maximum**	**Assembly Maximum**	**Assembly Maximum**
Roofs			
Insulation entirely above deck	U-0.048	U-0.048	U-0.093
Walls, Above-Grade			
Steel-framed	U-0.064	U-0.055	U-0.124
Wall, Below-Grade			
Below-grade wall	C-0.119	C-0.119	C-1.140
Floors			
Steel-joist	U-0.038	U-0.032	U-0.052
Slab-on-Grade Floors			
Unheated	F-0.540	F-0.520	F-0.730
Opaque Doors			
Swinging	U-0.500	U-0.500	U-0.700
Nonswinging	U-0.500	U-0.500	U-1.450

Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**	**Assembly Max. U**	**Assembly Max. *SHGC***	**Visible Transmittance**
Vertical Glazing, % of *Wall*									

0% to 10.0%	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
10.1% to 20.0%	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
20.1% to 30.0%	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
30.1% to 40.0%	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-0.46	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44	U_{all}-1.22	$SHGC_{all}$-~~NR~~0.40	VT_{all}-0.44
Skylight All, % of Roof									
0% to 2.0%	U_{all}-0.58	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61	U_{all}-0.58	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61	U_{all}-0.81	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61
2.1%+	U_{all}-0.58	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61	U_{all}-0.58	$SHGC_{all}$-0.55~~NR~~	VT_{all}-0.61	U_{all}-0.81	$SHGC_{all}$-~~NR~~0.55	VT_{all}-0.61

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), NR = no (insulation) requirement.
[a.] Exception to Section A3.1.3.1 applies.

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Table G3.7 *Performance Rating Method Lighting Power Density* Allowances and ~~Occupancy Sensor~~*Occupancy ~~s~~Sensor* Reductions Using the Space-by-Space Method

Common *Space* Types[a]	*Lighting Power Density*, W/ft^2	~~Occupancy Sensor~~*Occupancy ~~s~~Sensor* Reduction[b]
Audience Seating Area		
Auditorium	0.90	10%
Convention center	0.70	10%
Exercise center	0.30	10%
Gymnasium	0.40	10%
Motion picture theater	1.20	10%
Penitentiary	0.70	10%
Performing arts theater	2.60	10%
Religious facility	1.70	10%
In a sports arena	0.40	10%
Transportation facility	0.50	10%
All other audience seating area	0.90	10%
Atrium		
≤40 ft in height	0.0375 per foot in total height	10%
>40 ft in height	0.50 + 0.025 per foot in total height	10%
Banking Activity Area	1.50	10%
Breakroom (See Lounge/Breakroom)		
Classroom/Lecture Hall/Training Room		
Penitentiary	1.30	None
Preschool through 12th grade, laboratory, and shop classrooms	1.40	30%
All other classroom/lecture hall/training room	1.40	None

Conference/Meeting/Multipurpose Room	1.30	None
Confinement Cells	0.90	10%
Copy/Print Room	0.90	10%
Corridor		
Facility for the visually impaired (and used primarily by residents)	1.15	25%
Hospital	1.00	25%
Manufacturing facility	0.50	25%
All other corridor	0.50	25%
Courtroom	1.90	10%
Computer Room	2.14	35%
Dining Area		
Penitentiary	1.30	35%
Facility for the visually impaired (and used primarily by residents)	3.32	35%
Bar/lounge or leisure dining	1.40	35%
Cafeteria or fast food dining	0.90	35%
Family dining	2.10	35%
All other dining area	0.90	35%
Electrical/Mechanical Room	1.50	30%
Emergency Vehicle Garage	0.80	10%
Food Preparation Area	1.20	30%
Guest Room	1.14	45%
Judges Chambers	1.30	30%
Common *Space* Types[a]	*Lighting Power Density*, W/ft^2	~~Occupancy Sensor~~*Occupancy ~~s~~Sensor* Reduction[b]
Laboratory		
In or as a classroom	1.40	None
All other laboratory	1.40	10%
Laundry/Washing Area	0.60	10%
Loading Dock, Interior	0.59	10%
Lobby		
Facility for the visually impaired (and used primarily by residents)	2.26	25%
Elevator	0.80	25%
Hotel	1.10	25%
Motion picture theater	1.10	25%
Performing arts theater	3.30	25%
All other lobby	1.30	25%
Locker Room	*0.60*	*25%*
Lounge/Breakroom		
Healthcare facility	0.80	None
All other lounge/breakroom	1.20	None
Office		
Enclosed	1.10	30%
Open plan	1.10	15%[c]
Parking Area, Interior	0.20	15%

Pharmacy Area	1.20	10%
Restroom		
Facility for the visually impaired (and used primarily by residents)	1.52	45%
All other restroom	0.90	45%
Sales Area	1.70	15%
Seating Area, General	0.68	10%
Stairwell	0.60	75%
Storage Room		
Hospital	0.90	45%
≥50 ft^2	0.80	45%
<50 ft^2	0.80	45%
Vehicular Maintenance Area	0.70	10%
Workshop	1.90	10%
Building Type Specific *Space* Types [a]	*Lighting Power Density*, W/ft^2	~~Occupancy Sensor~~*Occupancy s*~~s~~*Sensor* Reduction [b]
Assisted Living Facility		
Chapel (used primarily by residents)	2.77	10%
Recreation room (used primarily by residents)	3.02	10%
Automotive (See “Vehicular Maintenance Area”)		10%
Convention Center—Exhibit *Space*	1.30	35%
Dormitory—Living Quarters	1.11	10%
Fire Station—Sleeping Quarters	0.30	10%
***Building* Type Specific *Space* Types** [a]	***Lighting Power Density*, W/ft^2**	~~**Occupancy Sensor**~~***Occupancy s*~~**s**~~***Sensor* Reduction** [b]
Gymnasium/Fitness Center		
Exercise area	0.90	35%
Playing area	1.40	35%
Healthcare Facility		
Emergency room	2.70	10%
Exam/treatment room	1.50	10%
Medical supply room	1.40	45%
Nursery	0.60	10%
Nurse's station	1.00	10%
Operating room	2.20	10%
Patient room	0.70	10%
Physical therapy room	0.90	10%
Recovery room	0.80	10%
Library		
Reading area	1.20	15%
Stacks	1.70	15%
Manufacturing Facility		
Detailed manufacturing area	2.10	10%
Equipment room	1.20	10%
Extra-high bay area (>50 ft *floor*-to-ceiling height)	1.32	10%

High bay area (25 to 50 ft *floor*-to-ceiling height)	1.70	10%
Low bay area (<25 ft *floor*-to-ceiling height)	1.20	10%
Museum		
General exhibition area	1.00	10%
Restoration room	1.70	10%
Post Office—Sorting Area	1.20	10%
Religious Facility		
Fellowship hall	0.90	10%
Worship/pulpit/choir area	2.40	10%
Retail Facilities		
Dressing/fitting room	0.89	10%
Mall concourse	1.70	10%
Sports Arena—Playing Area		
Class I facility	4.61	10%
Class II facility	3.01	10%
Class III facility	2.26	10%
Class IV facility	1.50	10%
Transportation Facility		
Baggage/carousel area	1.00	10%
Airport concourse	0.60	10%
~~*Terminal* t~~Ticket counter	1.50	10%
Warehouse—Storage Area		
Medium to bulky, palletized items	0.90	45%
Smaller, hand-carried items	1.40	45%

a. In cases where both a common *space* type and a *building* area specific *space* type are listed, the *building* area specific *space* type shall apply
b. For *manual*-ON or partial-auto-ON ~~occupancy sensors~~*occupancy sensors*, the ~~occupancy sensor~~*occupancy sensor* reduction factor shall be multiplied by 1.25.
c. For ~~occupancy sensors~~*occupancy sensors* controlling individual workstation lighting, ~~occupancy sensor~~*occupancy sensor* reduction factor shall be 30%.

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Table G3.10.2 *Performance Rating Method* Commercial Refrigeration

***Equipment* Type**					
***Equipment* Class[a]**	**Family Code**	**Operating Mode**	**Rating Temperature**	***Energy* Use Limits,[b,c] kWh/day**	**Test Procedure**
VOP.RC.M	Vertical open	Remote condensing	Medium temperature	1.01 × TDA + 4.07	AHRI 1200
SVO.RC.M	Semivertical open	Remote condensing	Medium temperature	1.01 × TDA + 3.18	
HZO.RC.M	Horizontal open	Remote condensing	Medium temperature	0.51 × TDA + 2.88	
VOP.RC.L	Vertical open	Remote condensing	Low temperature	2.84 × TDA + 6.85	
HZO.RC.L	Horizontal open	Remote condensing	Low temperature	0.68 × TDA + 6.88	
VCT.RC.M	Vertical transparent *door*	Remote condensing	Medium temperature	0.48 × TDA + 1.95	
VCT.RC.L	Vertical transparent *door*	Remote condensing	Low temperature	1.03 × TDA + 2.61	

SOC.RC.M	~~*Service*~~Service over counter	Remote condensing	Medium temperature	0.62 × TDA + 0.11	
VOP.*SC*.M	Vertical open	Self-contained	Medium temperature	2.34 × TDA + 4.71	
SVO.*SC*.M	Semivertical open	Self-contained	Medium temperature	2.23 × TDA + 4.59	
HZO.*SC*.M	Horizontal open	Self-contained	Medium temperature	1.14 × TDA + 5.55	
HZO.*SC*.L	Horizontal open	Self-contained	Low temperature	2.63 × TDA + 7.08	
VCT.*SC*.I	Vertical transparent *door*	Self-contained	Ice cream	1.63 × TDA + 3.29	
VCS.*SC*.I	Vertical solid *door*	Self-contained	Ice cream	0.55 × *V* + 0.88	
HCT.*SC*.I	Horizontal transparent *door*	Self-contained	Ice cream	1.33 × TDA + 0.43	
SVO.RC.L	Semivertical open	Remote condensing	Low temperature	2.84 × TDA + 6.85	
VOP.RC.I	Vertical open	Remote condensing	Ice cream	3.6 × TDA + 8.7	
SVO.RC.I	Semivertical open	Remote condensing	Ice cream	3.6 × TDA + 8.7	
HZO.RC.I	Horizontal open	Remote condensing	Ice cream	0.87 × TDA + 8.74	
VCT.RC.I	Vertical transparent *door*	Remote condensing	Ice cream	1.2 × TDA + 3.05	
HCT.RC.M	Horizontal transparent *door*	Remote condensing	Medium temperature	0.39 × TDA + 0.13	AHRI 1200
HCT.RC.L	Horizontal transparent *door*	Remote condensing	Low temperature	0.81 × TDA + 0.26	
HCT.RC.I	Horizontal transparent *door*	Remote condensing	Ice cream	0.95 × TDA + 0.31	
VCS.RC.M	Vertical solid *door*	Remote condensing	Medium temperature	0.16 × *V* + 0.26	
VCS.RC.L	Vertical solid *door*	Remote condensing	Low temperature	0.33 × *V* + 0.54	
VCS.RC.I	Vertical solid *door*	Remote condensing	Ice cream	0.39 × *V* + 0.63	
HCS.RC.M	Horizontal solid *door*	Remote condensing	Medium temperature	0.16 × *V* + 0.26	
HCS.RC.L	Horizontal solid *door*	Remote condensing	Low temperature	0.33 × *V* + 0.54	
HCS.RC.I	Horizontal solid *door*	Remote condensing	Ice cream	0.39 × *V* + 0.63	
SOC.RC.L	~~*Service*~~Service over counter	Remote condensing	Low temperature	1.3 × TDA + 0.22	
SOC.RC.I	~~*Service*~~Service over counter	Remote condensing	Ice cream	1.52 × TDA + 0.26	
VOP.*SC*.L	Vertical open	Self contained	Low temperature	5.87 × TDA + 11.82	
VOP.*SC*.I	Vertical open	Self-contained	Ice cream	7.45 × TDA + 15.02	
SVO.*SC*.L	Semivertical open	Self-contained	Low temperature	5.59 × TDA + 11.51	
SVO.*SC*.I	Semivertical open	Self-contained	Ice cream	7.11 × TDA + 14.63	
HZO.*SC*.I	Horizontal open	Self-contained	Ice cream	3.35 × TDA + 9.0	
SOC.*SC*.I	~~*Service*~~Service over counter	Self-contained	Ice cream	2.13 × TDA + 0.36	
HCS.*SC*.I	Horizontal solid *door*	Self-contained	Ice cream	0.55 × *V* + 0.88	

a. *Equipment* class designations consist of a combination (in sequential order separated by periods [AAA].[BB].[C]) of the following: (AAA) An *equipment* family code (VOP = vertical open, SVO = semivertical open, HZO = horizontal open, VCT = vertical transparent *doors*, VCS = vertical solid *doors*, HCT = horizontal transparent *doors*, HCS = horizontal solid *doors*, and SOC = ~~*service*~~service over counter); (BB) An operating mode code (RC = remote condensing and *SC* = self-contained); and (C) A rating temperature code (M = medium temperature [38°F], L = low temperature [0°F], or I = ice cream temperature [15°F]). For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" *equipment* class.

b. *V* is the volume of the case (ft^3) as measured in AHRI Standard 1200, Appendix C.

c. TDA is the total display area of the case (ft^2) as measured in AHRI Standard 1200, Appendix D.

This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal. at ASHRAE or ANSI.

Informative Appendix H

ANSI/ASHRAE/IES Standard 90.1-2019 incorporates all addenda to ANSI/ASHRAE/IES Standard 90.1-2016. Table H-1 lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE, IES, and ANSI approval dates for each addendum.

Table H-1 Addenda to ANSI/ASHRAE/IES Standard 90.1-2016

Addendum	Sections	Description of Changes[a]	ASHRAE Standard Committee Approval	ASHRAE BOD/Tech Council Approval	IES BOD Approval	ANSI Approval
bg (formerly addendum bg to 90.1-2013)	9.2, 9.3, Table 9.3	Adds a simplified building method for interior lighting in offices, schools, and retail buildings, and exterior lighting. This includes the addition of table 9.3.	1/12/2019	10/3/2019	12/14/2018	2/13/2019
dn (formerly addendum dn to 90.1-2013)	A9.4	Allows the use of the R-value of an airspace in enclosed cavities with or without insulation (Appendix A). Expands the R-value table in Appendix A (based on 2009 *ASHRAE Handbook—Fundamentals*, Chapter 26).	1/12/2019	1/16/2019	12/14/2018	1/17/2019
a	6.4.3.3.3, 6.3.3.4.2, 6.5.1.1.4	Changes term "ventilation air" to "outdoor air" in multiple locations. Revises tables and footnotes. Clarifies requirements for economizer return dampers.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
b	5.5.3.1.1, 12	Updates reference to ANSI/CRRC S100 "Standard Test Methods for Determining Radiative Properties of Materials".	6/24/2017	6/24/2017	6/13/2017	6/29/2017
c	3.2	Adds rooftop monitors to definition of fixed and operable vertical fenestration.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
d	Tables G3.1.1 \	Modifies text to make it consistent with other portions of Appendix G for projects undergoing phased permitting.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
e	Table G3.1.11	Adds direction that SWH piping losses shall not be modeled.	6/24/2017	6/24/2017	6/13/2017	6/29/2017

f	G3.1.2.1	Modifies text to require that the capacity used for selecting the system efficiency represents that for the size of the actual zone instead of the size of the zones as combined into a single thermal block.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
g	3.2, 6.3.2, 6.5.3.8	Provides definition of "occupied-standby mode" and adds new ventilation air requirements for zones served rooms in occupied-standby mode.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
h	6.5.6.1	Clarifies that exhaust air energy recovery systems should be sized to meet both heating and cooling design conditions unless one mode is not exempted by existing exceptions.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
j	6.4.3.8	Changes an exception related to demand control ventilation.	6/24/2017	6/24/2017	6/13/2017	6/29/2017
k	3.2, 6.4.3.3.5	Revises definition of "networked guest room control system" and aligns HVAC and lighting time-out periods for guest rooms.	6/23/2018	6/27/2018	5/30/2018	7/25/2018
l	Table G3.1.2.9	Adds requirements for fan break horsepower for two systems.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
m	Table G3.1.5	Lowers baseline building performance air leakage and sets an air leakage value to be used in conjunction with the air-barrier verification path.	1/12/2019	1/16/19	12/14/2018	2/13/2019
n	3.2	Removes ten unused definitions and changes definition of "unitary cooling equipment" to "unitary air conditioners".	1/20/2018	1/24/2018	1/8/2018	1/25/2018
o	3.2, 4.2.2.3, 5.5, 5.7 through 11.7, G 1.3	Revises the submittals section of the envelope and power chapters for consistency across the standard.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
p	Table 6.1.8 -14	Revises the rating conditions for indoor pool dehumidifiers.	1/20/2018	1/24/2018	1/8/2018	1/25/2018
q	5.4.3, 5.5, 5.8.3, 5.9.1	Clarifies and restructures air leakage requirements for the building envelope.	9/14/2018	10/10/2018	10/23/2018	12/7/2018
r	G3.1.2.6	Specifies air economizer control types for Appendix G.	1/20/2018	1/24/2018	1/8/2018	1/25/2018

s	4.2.1.1, 11.4.3.1, G2.4	Modifies the Performance Cost Index (PCI) equation to implement a 5% limitation on renewable energy usage and clarifies what types of renewable energy systems are eligible.	9/14/2018	10/10/2018	10/23/2018	12/7/2018
t	9.4.2, Table 9.4.2-2	Expands the exterior LPD application table to cover additional exterior spaces that are not currently in the exterior LPD table	6/22/2019	6/26/2019	6/10/2019	7/24/2019
v	6.5.6.3	Adds section 6.5.6.3 containing heat recovery requirements for space conditioning in acute inpatient hospitals.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
x	4.1.1.2, 4.2.1.1, 4.2.1.2, 4.2.1.3	Clarifies compliance paths for new construction, additions, and alterations.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
y	G3.1.2.2	Fixes duct sizing run parameters within the Appendix G.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
z	G3.1.2.1, Table G3.5.1, Table G3.5.2	Modifies the formulas in Section 11 and G3.1.2.1 for removing fan energy from baseline packaged heating and cooling efficiency ratings to cap the system capacity equations in Section 11 to levels allowed in Section 6 and provide a fixed baseline efficiency rating for Appendix G.	9/14/2018	9/28/2018	10/23/2018	10/1/2018
ab	3.2	Modifies definition of "door", "entrance door", "fenestration", and "sectional garage door".	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ac	3.1, 3.2	Clarifies use of defined terms to include the term with different tense or plurality.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ad	5.2 through 11.2	This addendum clarifies the requirements for showing compliance using the methods in Sections 5-10, or Section 11, or Appendix G.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ae	3.2, 6.4.3.6, G3.1.3.18	Clarify humidification and dehumidification control requirements.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ag	Table G3.1.12	Provides accounts for the inclusion of automatic receptacle controls in a proposed building design for spaces that are not required to have them.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ah	9.1.4	Updates the language and terminology of the lighting wattage section. Also adds a section specifically to address using DC power over Cat6 structured cable for connection of LED lighting to a remote power supply.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
ai	3.2., 4.2.5, 5.2.9, 6.7.2.4, 9.4.3, 5.9 through 10.9, 11.2	Restructures commissioning and functional testing requirements in all sections of Standard 90.1 to require verification for smaller and simpler buildings and commissioning for larger and more complex buildings.	1/12/2019	1/16/2019	12/14/2018	2/13/2019

aj	3.2, 6.5.1, 6.5.2.3, 6.5.4.4	Adds a new definition "process application" and uses it throughout Standard in place of "process load".	1/12/2019	1/16/2019	12/14/2018	2/13/2019
ak	Table G3.1.5, Tables G3.4-1 through G3.4-8	Defines SHGC baseline for buildings in zones where there is no prescriptive maximum SHGC.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
al	Table G3.1.3, Table G3.1.7	Clarifies the modeling rules within section G3.1.	6/22/2019	6/26/2019	6/10/19	7/1/2019
am	6.5.6.4	Adds an indoor pool dehumidifier energy recovery requirement in new section 6.5.6.4.	6/23/2018	6/27/2018	5/30/2018	6/28/2018
an	3.2; 10.4.7; Table 10.8-6; 12; Appendix E	Provides a new table (Table 10.8.6) of information about the new efficiency requirements for commercial and industrial clean water pumps to users of ASHRAE 90.1. It also provides new definitions that are needed to accompany the table. New section 10.4.7 was also added.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
ao	3.2; 6.5.3.1.3; 12	Introduces the revised fan product efficiency requirement FEI and complements the fan power limitation in section 6.5.3.1.1.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
ap	6.5.3.5	Revises supply air temperature reset controls.	9/14/2018	9/28/19	10/23/2018	10/1/2018
aq	9.1.1, 9.2.2.3, 9.4.1.1, 9.4.1.3, 9.4.4, 9.6.2	Clarifies lighting control requirements for applications not covered in Section 9.6.2.	9/14/2018	9/28/19	10/23/2018	10/1/2018
ar	Table G3.1.12, G3.1.2.9, Table G 3.5.5, Table G.3.5.6, Table G3.6, Table G3.9.1	Cleanup of motor requirements in Appendix G related to Addend di in Standard 90.1-2016.	9/14/2018	9/28/19	10/23/2018	10/1/2018
as	Appendix I	Adds an informative appendix specific to commissioning.	NA	NA	NA	NA
at	11.5.1; G1.2.2	Revises language for energy accounting at buildings that provide fuel or electricity to vehicles.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
au	6.5.2.1	Eliminates the requirement that zones with DDC have air flow rates that are no more than 20% of the zone design peak flow rate.	1/12/2019	1/16/2019	12/14/2018	1/17/2019
aw	3.2; Tables 5.5-0 through 5.5-8, 5.8.2.5, 12	Revises the fenestration prescriptive criteria in Tables 5.5-0 through 5.5-8.	6/22/2019	6/26/2019	6/10/2019	7/24/2019

ay	3.2, 6.5.6	Provides separate requirements for nontransient dwelling unit exhaust air energy recovery.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
az	Table G3.1.17	Revises the modeling methodology language to clarify the baseline and proposed designs for refrigeration equipment.	1/12/2019	1/16/2019	12/14/2018	1/17/2019
ba	Table G3.1.1 Table G3.1.11	Establishes a methodology for determining the baseline flow rates on projects where service water-heating is demonstrated to be reduced by water conservation measures that reduce the physical volume of service water required.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bb	Table 9.6.1	Revises the lighting power densities for the Space-by-Space method	6/22/2019	6/26/2019	6/10/2019	7/24/2019
bd	Table 6.8.1-16	Adds the minimum efficiency requirements of Heat Pump and Heat Reclaim Chiller Packages. ~~and~~	6/22/2019	6/26/2019	6/10/2019	7/1/2019
be	6.4.1.1; Table 6.8.1-10 & 6.8.1-17	Revises the efficiency requirements for Computer Room air conditioners.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bf	5.4.3.4; 10.4.5	Establishes an alternative to the requirement for vestibules by use of an air curtain that meets specific requirements prescribed in the proposed language. Adds new section 10.4.5.	6/22/2019	6/26/2019	6/10/2019	7/24/2019
bh	Table 5.8.3.2	Corrects an omission related to nonswinging doors in Table 5.8.3.2	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bi	11.4.2; 12; Appendix C; Appendix G	Updates the reference year for Standard 140 in Sections 11 and 12 as well as Appendix C and G.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bj	6.5.5.1	Adds tables to the list of products that are exempt from meeting the requirements of section 6.5.6 - Heat Rejection Equipment.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bk	3.2, 11.4.3.2, G2.4.2	Clarifies that such projects must model the same electricity generation system in the baseline and proposed design and is aligned with the interpretation IC 90.1- 2013-16 OF ANSI/ASHRAE/IES STANDARD 90.1-2013 form January 21, 2018.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bl	Table 6.8.1-1	Revises Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bm	Table 6.8.1-2, 6.8.1-15	Revises Table 6.8.1-2 Electrically Operated Air Cooled Unitary Heat Pumps—Minimum Efficiency Requirements. Adds Table 6.8.1-15.	7/22/2019	8/15/2019	7/19/2019	8/19/2019

bn	3.2, Table 6.8.1-4, Table F3	Revises Table 6.8.1-4 Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps—Minimum Efficiency Requirements. Adds Table F-3.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bo	3; Table 6.8.1-5; Table F-4	Revises Table 6.8.1-5 Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters—Minimum Efficiency Requirements and adds Table F-4 Residential Warm Air Furnaces – Minimum Efficiency Requirements for sale in the US (see 10 CFR Part 430).	6/26/2019	8/1/2019	7/19/2019	8/26/2019
bp	Table 6.8.1-6; Table F-5	Revises Table 6.8.1.6 – Gas and Oil-Fired Boilers – Minimum Efficiency Requirements and adds table F-5 - Residential Boiler Minimum Efficiency Requirements for applications in the US (Refer to 10 CFR 430).	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bq	Table 6.8.1-7; 12	Revises Table 6.8.1-7 Performance Requirements for Heat Rejection Equipment—Minimum Efficiency Requirements.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
br	Table 6.8.1-11	Revises the previous Tables 6.8.1-12 & 13 and combines them into one table - Table 6.8.1-131 Commercial Refrigerators, Commercial Freezers and Refrigeration—Minimum Efficiency Requirements.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bs	Table 7.8; F2; Table F-2	Revises Table 7.8 Performance Requirements for Water-Heating Equipment—Minimum Efficiency Requirements and Table F-2 Minimum Energy Efficiency Requirements for Water Heaters.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bt	Table 4.2.1.1	Revises Table 4.2.1.1 Building Performance Factor (BPF).	6/22/2019	6/26/2019	6/10/2019	7/1/2019
bu	Table G3.1.1-1, G3.1.1, G3.1.3, Table G3.4-1 through Table G3.4-8	Clarifies requirements in the Appendix G as they related to HVAC zones and baseline heating.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bv	6.2.1, 6.6.2, 8.2.1, 8.6.1	Clarifies that designers have the option to use ASHRAE Standard 90.4 requirements instead of ASHRAE 90.1 requirements in computer rooms that have an IT equipment load larger than 10 kW. Adds section 8.6.1.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
bx	3.2, A6.1, A6.3	Adds heated slab F-factors for multiple combinations of under-slab and perimeter insulation in Appendix A. Adds Table A6.3.1-1&2.	6/22/2019	6/26/2019	6/10/2019	6/27/2019
bz	3.2; Appendix C1.4, C2, C3.1.2, C3.3,	Clarifies requirements of Appendix C as they pertain to informative outputs, the schedule of shades, energy costs, and updated references to Section 6.	6/22/2019	6/26/2019	6/10/2019	7/1/2019

	C3.5.5.1, C3.5.8					
ca	Table A3.2.3	Adds U-factors to Table A3.2.3 for use of continuous insulation on metal building walls with double layer cavity insulation.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cc	A9.4.6	Clarifies the limitations of the calculation procedures in A9.4.6.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
ce	6.5.3.1.2	Makes revisions to provide energy savings potential by removing one of three criteria for fan motor selections, increasing the design options for load-matching variable-speed fan applications, accommodating new motor and drive technologies, and simplifying the motor selection criteria for fans.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cf	6.4.5	Adds vacuum insulating glazing to the list of options for reach-in doors in walk-in coolers and freezers.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cg	Table 9.5.1	Revises Table 9.5.1 Lighting Power Density Allowances Using the Building Area Method.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
ch	3.2; 9.4.1.1 (e)	Clarifies daylighted area requirements as they relate to skylights and clarifies primary sidelighting requirements.	6/22/2019	6/26/2019	6/10/2019	6/27/2019
ci	Table 4.2.1.1	Further revises Table 4.2.1.1 Building Performance Factor (BPF).	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cj	Table 11.5.1.6; Table G3.1.6; Table G3.7	Revises the energy cost budget method in reference to lighting.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cl	3.2; 11; Appendix G	Clarifies requirements throughout Section 11 to better align with Appendix G providing greater consistency between the two sections.	6/26/2019	8/1/2019	7/19/2019	8/26/2019
cm	6.5.2.1	Revises exceptions related to DDC enabled zones.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cn	6.4, 6.4.1.1, 6.4.5m; Tables 6.8.1-18,19, & 20.	Cleans up outdated language regarding walk-in cooler and walk-in freezer requirements, and make the requirements consistent with current federal regulations that either already came into effect June 5, 2017 or will come into effect July 10, 2020. Adds new section 6.4.5m and Tables 6.8.1-18, 19, & 20.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
co	12	Revises the normative references in Standard 90.1.	6/22/2019	6/26/2019	6/10/2019	7/1/2019
cq	3.2; 6.4.1.2, 6.5.3.1.3	Makes clarifications ensure that the maximum fan power input is properly reported for installations both inside and outside the United States. Adds sections 6.4.1.3 and 6.5.3.1.3.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cs	Appendix E	Revises the informative references of the Informative Appendix E.	NA	NA	NA	NA
ct	12	Updates the CTI normative reference in Standard 90.1.	7/22/2019	8/15/2019	7/19/2019	8/19/2019

cu	6.4.1.1, 6.4.1.5, Table 6.8.1-8	Revises requirements for liquid-to-liquid heat exchangers.	7/22/2019	8/15/2019	7/19/2019	8/19/2019
cv	9.4.1.2	Updates lighting control requirements for parking garages in section 9.4.1.2.	6/26/2019	8/1/2019	7/19/2019	8/26/2019
cw	9.4.1.1(e), 9.4.1.1(f)	Revises the daylight responsiveness requirements to continuous dimming.	6/26/2019	8/1/2019	7/19/2019	8/26/2019
cy	9.4.1(e)	Revises the sidelighting requirement exceptions.	7/22/2019	8/15/2019	7/19/2019	8/19/2019

NOTE

Approved errata or interpretations for this standard can be downloaded free of charge from the ASHRAE Web site at www.ashrae.org/technology.

a. *These descriptions may not be complete and are provided for information only.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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About ASHRAE

Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

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