ADDENDA

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Energy Standard for Buildings Except Low-Rise Residential Buildings

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

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3.2 Definitions

…

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*.

Best Efficiency Point (BEP): the pump hydraulic power operating point (consisting of both flow and head conditions) that results in the maximum efficiency.

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

…

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):

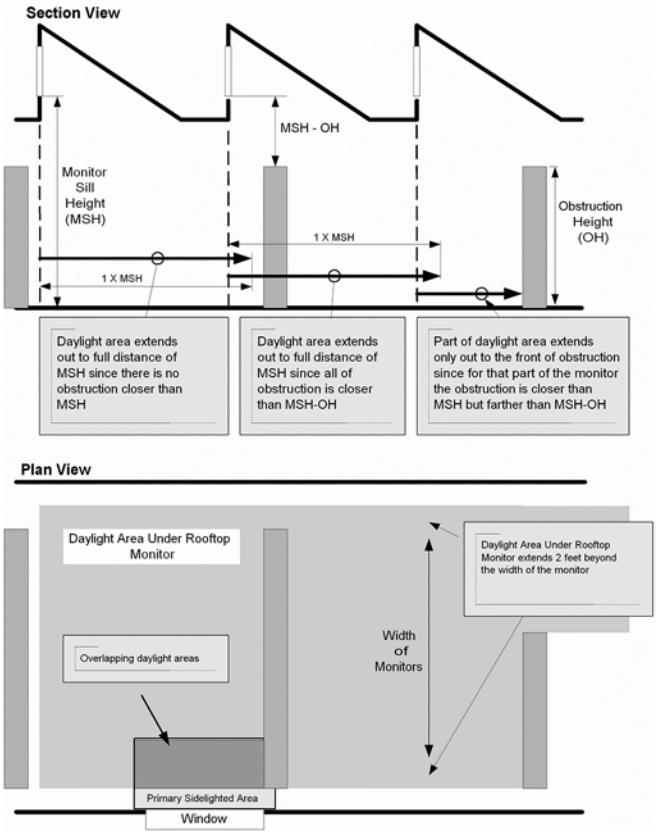

Figure 3.2-1 Computing the *daylight area under roof monitors*.

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

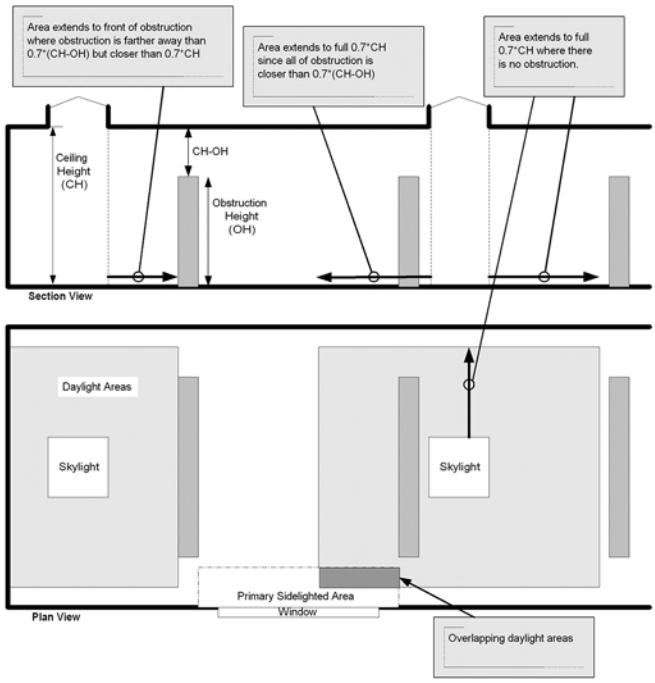

Figure 3.2-2 Computing the *daylight area under skylights*.

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).

daylight area under skylights in multistory spaces: the *daylight area under skylights in multistory spaces* shall include *floor* areas directly beneath the skylight and portions of the uppermost *floor* adjacent to the multistory space that meet the criteria for a *daylight area under skylights*, where CH is the ceiling height of the uppermost *floor* (see Figure 3.2-5).

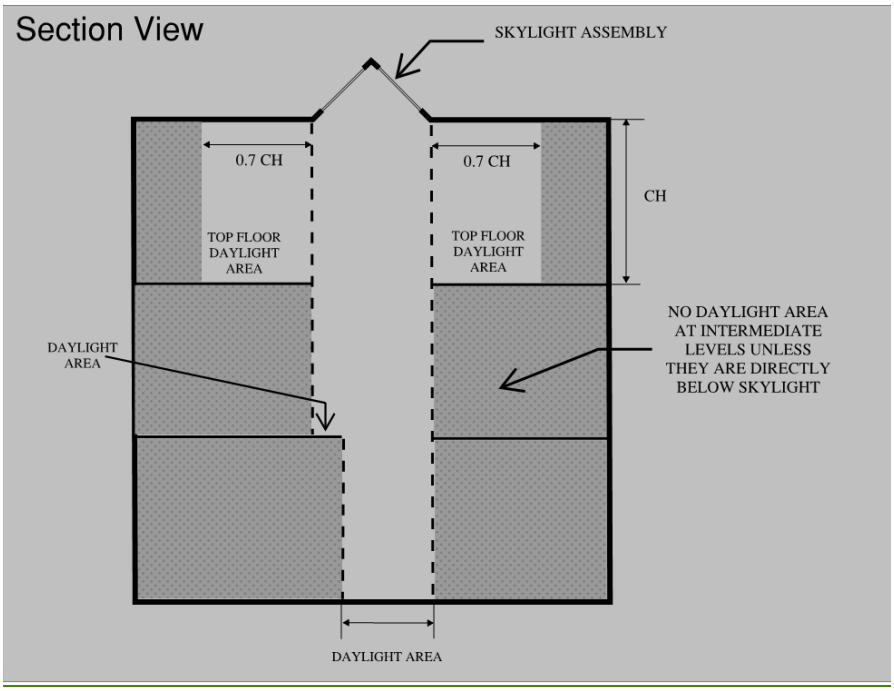

Figure 3.2-5 Computing *daylight area under skylights* in multistory spaces

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* in an exterior *wall* below the ceiling (see Figure 3.2-3).

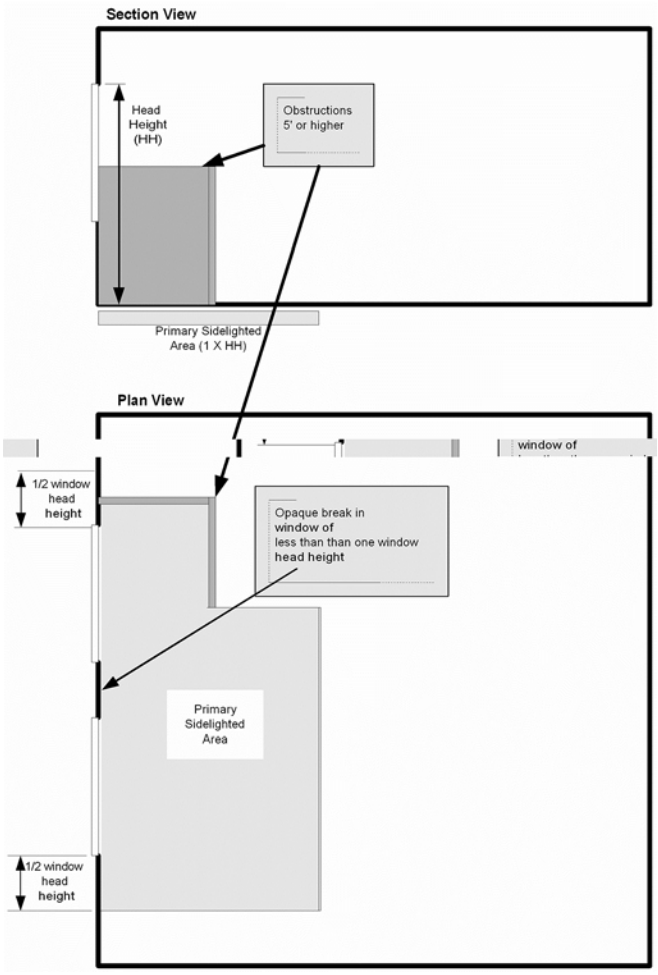

Figure 3.2-3 Computing the *primary sidelighted area*.

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):

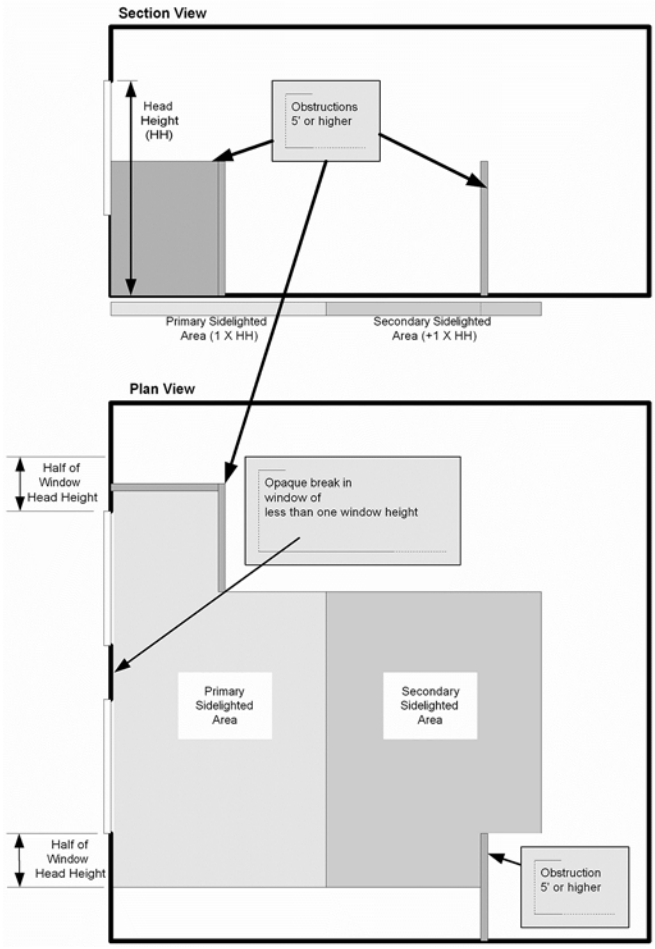

Figure 3.2-4 Computing the *secondary sidelighted area*.

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[Errata1] higher opaque vertical obstruction, there is no *secondary sidelighted area* beyond such obstruction.

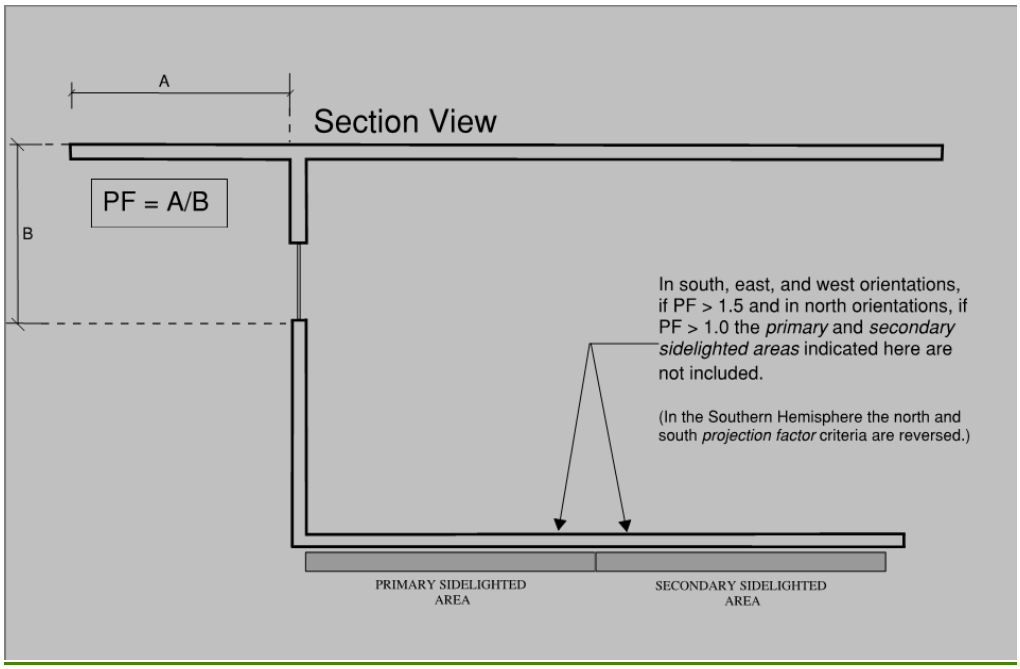

Figure 3.2-6 Computing *primary* and *secondary sidelighted areas* with external projections

daylighted area: the *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 *operable* opening areas (that are not *fenestration*) in the *building envelope*, including swinging and roll-up *doors*, fire *doors*, and *access hatches*. *Doors* that are more than one-half glass are considered *fenestration* (see *fenestration*). 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 other *doors* that are not *swinging doors*.

swinging door: all *operable* opaque panels with hinges 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* 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 *fenestration.*

envelope performance factor: the trade-off value for the *building envelope* performance compliance option expressed in annual energy cost 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, electric power, lighting, transportation, 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, embedded: A fan that is part of a manufactured assembly where the assembly includes functions other than air movement.

fan array: multiple fans in parallel between two *plenum* sections in an air *distribution system*.

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

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

fan energy index (FEI): the ratio of the electric input power of a reference fan to the electric input power of the actual fan as calculated per AMCA 208.

fan nameplate electrical input power: the nominal electrical input power rating stamped on a fan assembly nameplate.

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 electrical power: the sum of the fan electrical power 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/or return it to the source or exhaust it to the outdoors.

…

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*.

nontransient: occupancy of a dwelling unit or sleeping unit for more than 30 days.

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 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 electricity generation systems: systems located at the *building* site that generate electricity, including but not limited to generators, combined heat and power systems, fuel cells, and *on-site renewable energy* systems.

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 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* between two buildings.

PEI_{CL}: The pump energy index for a constant load (hp) (kW).

PEI_{VL}: The pump energy index for a variable load.

PER_{CL}: The pump energy rating for a constant load (hp) (kW), determined in accordance with either testing for bare pumps, pumps sold with single-phase induction motors, and pumps sold with drivers other than electric motors, or testing for pumps sold with motors and rated using the testing-based approach, or testing for pumps sold with motors and rated using the calculation-based approach.

PER_{STD}: The PER_{CL} for a pump that is minimally compliant with U.S. Department of Energy energy conservation standards with the same flow and specific speed characteristics as the tested pump (hp/KW).

PER_{VL}: The pump energy rating for a variable load (hp) (kW) determined in accordance with testing for pumps sold with motors and continuous or non-continuous controls rated using the testing-based approach, or testing for pumps sold with motors and continuous controls rated using the calculation-based approach.

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* 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*.

process energy: *energy* consumed in support of a manufacturing, industrial, or commercial *process* other than conditioning *spaces* and maintaining comfort and amenities for the occupants of a *building*.

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: Equipment designed to move liquids that may include entrained gases, free solids, and totally dissolved solids by physical or mechanical action and includes a bare pump and, if included by the manufacturer at the time of sale, mechanical equipment, driver, and controls.

Informative Note: The US *Code of Federal Regulations* contains official definitions related to pumps in Title 10 Section 431.462. In the United States, the official definitions take precedence over the definitions shown below.

clean water pump: A device that is designed for use in pumping water with a maximum non-absorbent free solid content of 0.016 pouds per cubic foot (0.26 kilograms per cubic meter), and with a maximum dissolved solid content of 3.1 pounds per cubic foot (50 kilograms per cubic meter), provided that the total gas content of the water does not exceed the saturation volume, and disregarding any additives necessary to prevent the water from freezing at a minimum of 14°F (-10°C).

end suction close-coupled (ESCC) pump: A close-coupled, dry rotor, end suction device that has a shaft input power greater than or equal to 1.0 horsepower (0.75 kW) and less than or equal to 200 horsepower (150 kW) at its *Best Efficiency Point (BEP)* and full impeller diameter and that is not a dedicated-purpose pool pump. It is also a single-stage, rotodynamic pump in which the liquid enters the bare pump in a direction parallel to the impeller shaft and on the side opposite the bare pump's driver-end, and is then discharged through a volute in a plane perpendicular to the shaft.

end suction frame mounted/own bearings (ESFM) pump: A mechanically-coupled, dry rotor, end suction device that has a shaft input power greater than or equal to 1.0 horsepower (0.75 kW) and less than or equal to 200 horsepower (150 kW) at its *Best Efficiency Point (BEP)* and full impeller diameter and that is not a dedicated-purpose pool pump. It is also a single-stage, rotodynamic pump in which the liquid enters the bare pump in a direction parallel to the impeller shaft and on the side opposite the bare pump's driver-end, and is then discharged through a volute in a plane perpendicular to the shaft.

In-line (IL) pump: A device that is either a twin-head pump or a single-stage, single-axis flow, dry rotor, rotodynamic pump that has a shaft input power greater than or equal to 1.0 horsepower (0.75 kW) and less than or equal to 200 horsepower (150 kW) at its *Best Efficiency Point (BEP)* and full impeller diameter, in which liquid is discharged through a volute in a plane perpendicular to the shaft. Such pumps do not

include pumps that are mechanically coupled or close-coupled, have a pump power output that is less than or equal to 5.0 horsepower (3.7 kW) at its *Best Efficiency Point (BEP)* at full impeller diameter, and are distributed in commerce with a horizontal motor.

radially split, multi-stage, vertical, in-line diffuser casing (RSV) pump: A device that is a vertically suspended, multi-stage, single axis flow, dry rotor, rotodynamic pump and:

1) Has a shaft input power greater than or equal to 1.0 horsepower (0.75 kW) and less than or equal to 200 horsepower (150 kW) at its *Best Efficiency Point (BEP)* and full impeller diameter and at the number of stages required for testing and,

2) In which liquid is discharged in a place perpendicular to the impeller shaft; and

3) For which each stage (or bowl) consists of an impeller and diffuser; and

4) For which no external part of such a pump is designed to be submerged in the pumped liquid.

submersible turbine (ST) pump: A device that is a single-stage or multi-stage, dry rotor, rotodynamic pump that is designed to be operated with the motor and stage(s) fully submerged in the pumped liquid; that has a shaft input power greater than or equal to 1.0 horsepower (0.75 kW) and less than or equal to 200 horsepower (150 kW) at its *Best Efficiency Point (BEP)* and full impeller diameter and at the number of stages required for testing; and in which each stage of this pump consists of an impeller and diffuser, and liquid enters and exits each stage of the bare pump in a direction parallel to the impeller shaft.

…

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*, 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*.

…

4.2 Compliance

4.2.1 Compliance Paths

4.2.1.1 New Buildings

New *buildings* shall comply with 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. Appendix G, "*Performance Rating Method*."

When using Appendix G, the Performance Cost Index (PCI) 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*.

Regulated *energy* cost shall be calculated by multiplying the total *energy* cost by the ratio of *regulated energy use* to total *energy* use for each *fuel* type. Unregulated *energy* cost shall be calculated by subtracting regulated *energy* cost from total *energy* cost.

~~Table 4.2.1.1 *Building* Performance Factor (BPF)~~

~~*Building* Area Type~~[a]	~~Climate Zone~~																
	~~0A and 1A~~	~~0B and 1B~~	~~2A~~	~~2B~~	~~3A~~	~~3B~~	~~3C~~	~~4A~~	~~4B~~	~~4C~~	~~5A~~	~~5B~~	~~5C~~	~~6A~~	~~6B~~	~~7~~	~~8~~
~~Multifamily~~	~~0.73~~	~~0.73~~	~~0.71~~	~~0.69~~	~~0.74~~	~~0.73~~	~~0.68~~	~~0.78~~	~~0.81~~	~~0.81~~	~~0.76~~	~~0.80~~	~~0.81~~	~~0.76~~	~~0.79~~	~~0.74~~	~~0.80~~
~~Healthcare/ hospital~~	~~0.64~~	~~0.56~~	~~0.60~~	~~0.56~~	~~0.60~~	~~0.56~~	~~0.54~~	~~0.57~~	~~0.53~~	~~0.55~~	~~0.59~~	~~0.52~~	~~0.55~~	~~0.57~~	~~0.52~~	~~0.56~~	~~0.56~~
~~Hotel/motel~~	~~0.64~~	~~0.65~~	~~0.62~~	~~0.60~~	~~0.63~~	~~0.65~~	~~0.64~~	~~0.62~~	~~0.64~~	~~0.62~~	~~0.60~~	~~0.61~~	~~0.60~~	~~0.59~~	~~0.61~~	~~0.57~~	~~0.58~~
~~Office~~	~~0.58~~	~~0.62~~	~~0.57~~	~~0.62~~	~~0.60~~	~~0.64~~	~~0.54~~	~~0.58~~	~~0.60~~	~~0.58~~	~~0.60~~	~~0.61~~	~~0.58~~	~~0.61~~	~~0.61~~	~~0.57~~	~~0.61~~
~~Restaurant~~	~~0.62~~	~~0.62~~	~~0.58~~	~~0.61~~	~~0.60~~	~~0.60~~	~~0.61~~	~~0.58~~	~~0.55~~	~~0.60~~	~~0.62~~	~~0.58~~	~~0.60~~	~~0.63~~	~~0.60~~	~~0.65~~	~~0.68~~
~~Retail~~	~~0.52~~	~~0.58~~	~~0.53~~	~~0.58~~	~~0.54~~	~~0.62~~	~~0.60~~	~~0.55~~	~~0.60~~	~~0.60~~	~~0.55~~	~~0.59~~	~~0.61~~	~~0.55~~	~~0.58~~	~~0.53~~	~~0.53~~
~~School~~	~~0.46~~	~~0.53~~	~~0.47~~	~~0.53~~	~~0.49~~	~~0.52~~	~~0.50~~	~~0.49~~	~~0.50~~	~~0.49~~	~~0.50~~	~~0.50~~	~~0.50~~	~~0.49~~	~~0.50~~	~~0.47~~	~~0.51~~
~~Warehouse~~	~~0.51~~	~~0.52~~	~~0.56~~	~~0.58~~	~~0.57~~	~~0.59~~	~~0.63~~	~~0.58~~	~~0.60~~	~~0.63~~	~~0.60~~	~~0.61~~	~~0.65~~	~~0.66~~	~~0.66~~	~~0.67~~	~~0.67~~

~~All others~~	~~0.62~~	~~0.61~~	~~0.55~~	~~0.57~~	~~0.56~~	~~0.61~~	~~0.59~~	~~0.58~~	~~0.57~~	~~0.61~~	~~0.57~~	~~0.57~~	~~0.61~~	~~0.56~~	~~0.56~~	~~0.53~~	~~0.52~~

~~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~~

Table 4.2.1.1 *Building* Performance Factor (BPF)

***Building* Area Type**[a]	**Climate Zone**																
	0A and 1A	**0B and 1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
Multifamily	0.68	0.70	0.66	0.66	0.69	0.68	0.59	0.74	0.76	0.74	0.70	0.73	0.75	0.68	0.71	0.68	0.72
Healthcare/ hospital	0.60	0.60	0.58	0.54	0.56	0.55	0.55	0.55	0.54	0.54	0.57	0.52	0.54	0.57	0.52	0.57	0.57
Hotel/motel	0.55	0.53	0.53	0.52	0.53	0.54	0.54	0.53	0.53	0.53	0.50	0.51	0.51	0.50	0.51	0.50	0.50
Office	0.52	0.57	0.50	0.56	0.53	0.56	0.48	0.51	0.52	0.52	0.51	0.51	0.49	0.52	0.51	0.49	0.51
Restaurant	0.63	0.64	0.60	0.60	0.60	0.61	0.58	0.62	0.57	0.61	0.63	0.60	0.64	0.65	0.62	0.67	0.70
Retail	0.51	0.54	0.49	0.55	0.51	0.55	0.53	0.51	0.55	0.54	0.50	0.54	0.55	0.50	0.51	0.48	0.50
School	0.39	0.47	0.38	0.43	0.38	0.42	0.40	0.37	0.40	0.38	0.36	0.40	0.36	0.36	0.37	0.36	0.37
Warehouse	0.38	0.42	0.40	0.42	0.43	0.44	0.43	0.44	0.43	0.46	0.49	0.47	0.48	0.54	0.51	0.57	0.57
All others	0.56	0.57	0.50	0.52	0.50	0.54	0.53	0.53	0.52	0.54	0.51	0.51	0.50	0.50	0.50	0.50	0.46

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

4.2.1.2 Additions to Existing Buildings

a. *Additions* to *existing buildings* shall comply with either the provisions of Sections 5, 6, 7, 8, 9, and 10, or Section 11 or Normative Appendix G.

4.2.1.2.1

When an 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 shall employ the procedures of Section 11 or Normative Appendix G; the addition shall not increase the *energy* consumption of the *existing building* plus the addition beyond the *energy* that would be consumed by the *existing building* plus the addition if the addition alone did comply.

…

5.4.3.3 Loading Dock Weatherseals

In Climate Zones 0 and 4 through 8, cargo *doors* and loading dock *doors* shall be equipped with weatherseals to restrict *infiltration* when vehicles are parked in the doorway.

5.4.3.4 Vestibules **and revolving doors.** Vestibules and revolving doors shall be installed in accordance with this section.

5.4.3.3.1 Location.

Building entrances that separate *conditioned space* from the exterior shall ~~be~~ have one of the following:

a. ~~protected with~~ an enclosed vestibule, with all *doors* opening into and out of the vestibule equipped with self-closing devices.~~,~~

b. a revolving door(s) opening into a vestibule or directly into the conditioned space, or,

c. a combination of ‘a’ and ‘b’ above.

5.4.3.3.2 Vestibule size. 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 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*.

5.4.3.3.3 Vestibule envelope. 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.~~1. *Doors* not intended to be used as a *building entrance.*

~~3.~~2. *Doors* opening directly from a *dwelling unit.*

~~4.~~3. *Building entrances* in *buildings* located in Climate Zone 1 or 2.

~~5.~~4. *Building entrances* in *buildings* that are located in Climate Zone 3, where the *building* is less than four *stories* above *grade*, and less than 10,000 ft^2 in *gross conditioned floor area.*

~~6.~~5. *Building entrances* in *buildings* that are located in Climate Zones 0, 4, 5, 6, 7, or 8 and the *building* is ~~are~~ less than 1000 ft^2 in *gross conditioned floor area.*

~~7.~~6. *Doors* that open directly from a *space* that is less than 3000 ft^2 in area and is separate from the *building entrance.*

~~8.~~7. *Doors* opening into ~~S~~*semiheated spaces*.

8. Enclosed elevator lobbies for *building entrances* directly from parking garages.

9. Self closing doors in buildings in Climate Zone 0, 3, and 4 that have an air curtain complying with Section 10.4.5.

~~9.~~10. Self closing doors in buildings 15 stories or less in Climate Zones 5 through 8 that have an air curtain complying with Section 10.4.5.

5.4.3.4.1~~4~~

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

5.5.1

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

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.)

5.5.3 Opaque Areas

For all *opaque* surfaces except *doors*, compliance shall be demonstrated by one of the following two methods:

a. Minimum rated *R-value* of insulation for the *thermal resistance* of the added insulation in framing cavities and *continuous insulation* only. Specifications listed in Normative Appendix A for each *class of construction* shall be used to determine compliance.

b. Maximum *U-factor*, *C-factor*, or *F-factor* for the entire assembly. The values for typical *construction* assemblies listed in Normative Appendix A shall be used to determine compliance.

Exceptions to 5.5.3

1. For assemblies significantly different than those in Appendix A, calculations shall be performed in accordance with the procedures required in Appendix A.
2. For multiple assemblies within a single *class of construction* for a single *space-conditioning category*, compliance shall be shown for either (a) the most restrictive requirement or (b) an area-weighted average *U-factor*, *C-factor*, or *F-factor*.

5.5.3.1 Roof Insulation

All *roofs* shall comply with the insulation values specified in Tables 5.5-0 through 5.5-8. *Skylight* curbs shall be insulated to the level of *roofs* with insulation entirely above deck or R-5.0, whichever is less.

5.5.3.1.1 Roof Solar Reflectance and Thermal Emittance

Roofs in Climate Zones 0 through 3 shall have one of the following:

a. A minimum three-year-aged solar *reflectance* of 0.55 and a minimum three-year-aged thermal *emittance* of 0.75 when tested in accordance with CRRC-1 Standard.

Table 5.5-0 *Building Envelope* Requirements for Climate Zone 0 (A,B)*

	Nonresidential		*Residential*		*Semiheated*	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.039	R-25 c.i.	U-0.032	R-30 c.i.	U-0.218	R-3.8 c.i.
Metal building[a]	U-0.041	R-10 + R-19 FC	U-0.041	R-10 + R-19 FC	U-0.115	R-10
Attic and other	U-0.027	R-38	U-0.027	R-38	U-0.081	R-13
Walls, above-*Grade*						
Mass	U-0.580	NR	U-0.151[b]	R-5.7 c.i.[b]	U-0.580	NR
Metal building	U-0.094	R-0 + R-9.8 c.i.	U-0.094	R-0 + R-9.8 c.i.	U-0.352	NR
Steel-framed	U-0.124	R-13	U-0.124	R-13	U-0.352	NR
Wood-framed and other	U-0.089	R-13	U-0.089	R-13	U-0.292	NR
Wall, below-*Grade*						
Below-grade wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood-framed and other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-on-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.370		U-0.370		U-0.700	

Nonswinging	U-0.310			U-0.310			U-1.450		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	0.32	0.22	1.10	0.32	0.22	1.10	0.93	NR	NR
Metal framing, *fixed*	0.50			0.50			1.20		
Metal framing, *operable*	0.65			0.65			1.20		
Metal framing, *entrance door*	0.83			0.83			1.10		
Skylight, 0% to 3% of *Roof*									
All types	0.75	0.35	NR	0.75	.35	NR	1.80	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).
b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-0 *Building Envelope* Requirements for Climate Zone 0 (A,B)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.220	R-4.4 c.i.	U-0.184	R-5.3 c.i.	U-1.240	R-0.7 c.i.
Metal building[a]	U-0.233	R-1.8 + R-3.3 FC	U-0.233	R-1.8 + R-3.3 FC	U-0.653	R-1.8
Attic and other	U-0.153	R-6.7	U-0.153	R-6.7	U-0.459	R-2.3
Walls, above Grade						
Mass	U-3.293	NR	U-0.857[b]	R-1.0 c.i.[b]	U-3.293	NR
Metal building	U-0.533	R-0 + R-1.7 c.i.	U-0.533	R-0 + R-1.7 c.i.	U-1.998	NR
Steel-framed	U-0.705	R-2.3	U-0.705	R-2.3	U-1.998	NR
Wood-framed and other	U-0.504	R-2.3	U-0.504	R-2.3	U-1.660	NR
Wall, below Grade						
Below-grade wall	C-6.473	NR	C-6.473	NR	C-6.473	NR
Floors						
Mass	U-1.825	NR	U-1.825	NR	U-1.825	NR
Steel joist	U-1.986	NR	U-1.986	NR	U-1.986	NR
Wood-framed and other	U-1.599	NR	U-1.599	NR	U-1.599	NR
Slab-on-Grade Floors						
Unheated	F-1.264	NR	F-1.264	NR	F-1.264	NR
Heated	F-1.766	R-1.3 for 300 mm	F-1.766	R-1.3 for 300 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						

Swinging	U-2.101			U-2.101			U-3.975		
Nonswinging	U-1.760			U-1.760			U-8.233		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~			~~(for all frame types)~~			~~(for all frame types)~~	
~~*Nonmetal framing*, all~~	~~1.82~~	~~0.22~~	1.10 (for all types)	~~0.32~~	~~0.22~~	1.10 (for all types)	~~0.93~~	NR (for all types)	NR (for all types)
~~*Metal framing*,~~ fixed	0.50	0.22		0.50	0.22		1.20		
~~*Metal framing*,~~ operable	~~0.650~~0.62	~~0.220~~.20		~~0.650~~0.62	~~0.220~~.20		1.20		
~~*Metal framing*,~~ *entrance door*	0.83	~~0.220~~.20		0.83	~~0.220~~.20		1.10		
Skylight, 0% to 3% of *Roof*									
All types	~~0.750~~.70	~~0.350~~.30	NR	~~0.750~~.70	~~0.350~~.30	NR	1.80	NR	NR

* The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).
b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-1 *Building Envelope* Requirements for Climate Zone 1 (A,B)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.048	R-20 c.i.	U-0.039	R-25 c.i.	U-0.218	R-3.8 c.i.
Metal building[a]	U-0.041	R-10 + R-19 FC	U-0.041	R-10 + R-19 FC	U-0.115	R-10
Attic and other	U-0.027	R-38	U-0.027	R-38	U-0.081	R-13
Walls, above Grade						
Mass	U-0.580	NR	U-0.151[b]	R-5.7 c.i.[b]	U-0.580	NR
Metal building	U-0.094	R-0 + R-9.8 c.i.	U-0.094	R-0 + R-9.8 c.i.	U-0.352	NR
Steel-framed	U-0.124	R-13	U-0.124	R-13	U-0.352	NR
Wood-framed and other	U-0.089	R-13	U-0.089	R-13	U-0.292	NR
Wall, below Grade						
Below-grade wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood-framed and other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-on-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR

Heated	F-1.020	R-7.5 for 12 in.		F-1.020	R-7.5 for 12 in.		F-1.020	R-7.5 for 12 in.	
Opaque Doors									
Swinging	U-0.370			U-0.370			U-0.700		
Nonswinging	U-0.310			U-0.310			U-1.450		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~			~~(for all frame types)~~			~~(for all frame types)~~	
~~*Nonmetal framing*, all~~	~~0.50~~	~~0.25~~	1.10 (for all types)	~~0.50~~	~~0.25~~	1.10 (for all types)	~~0.93~~	NR (for all types)	NR (for all types)
~~*Metal framing*,~~ *fixed*	~~0.57~~0.50	~~0.25~~0.23		~~0.57~~0.50	~~0.25~~0.23		1.20		
~~*Metal framing*,~~ *operable*	~~0.65~~0.62	~~0.25~~0.21		~~0.65~~0.62	~~0.25~~0.21		1.20		
~~*Metal framing*,~~ *entrance door*	~~1.10~~0.83	~~0.25~~0.21		~~1.10~~0.83	~~0.25~~0.21		1.10		
Skylight, 0% to 3% of *Roof*									
All types	~~0.75~~0.70	~~0.35~~0.30	NR	~~0.75~~0.70	~~0.35~~0.30	NR	1.80	NR	NR

* The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).
b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-1 *Building Envelope* Requirements for Climate Zone 1 (A,B)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.273	R-3.5 c.i.	U-0.220	R-4.4 c.i.	U-1.240	R-0.7 c.i.
Metal building[a]	U-0.233	R-1.8 + R-3.3 FC	U-0.233	R-1.8 + R-3.3 FC	U-0.653	R-1.8
Attic and other	U-0.153	R-6.7	U-0.153	R-6.7	U-0.459	R-2.3
Walls, above Grade						
Mass	U-3.293	NR	U-0.857[b]	R-1.0 c.i.[b]	U-3.293	NR
Metal building	U-0.533	R-0 + R-1.7 c.i.	U-0.533	R-0 + R-1.7 c.i.	U-1.998	NR
Steel-framed	U-0.705	R-2.3	U-0.705	R-2.3	U-1.998	NR
Wood-framed and other	U-0.504	R-2.3	U-0.504	R-2.3	U-1.660	NR
Wall, below Grade						
Below-grade wall	C-6.473	NR	C-6.473	NR	C-6.473	NR
Floors						
Mass	U-1.825	NR	U-1.825	NR	U-1.825	NR
Steel joist	U-1.986	NR	U-1.986	NR	U-1.986	NR

Wood-framed and other	U-1.599	NR		U-1.599	NR		U-1.599	NR	
Slab-on-Grade Floors									
Unheated	F-1.264	NR		F-1.264	NR		F-1.264	NR	
Heated	F-1.766	R-1.3 for 300 mm		F-1.766	R-1.3 for 300 mm		F-1.766	R-1.3 for 300 mm	
Opaque Doors									
Swinging	U-2.101			U-2.101			U-3.975		
Nonswinging	U-1.760			U-1.760			U-8.233		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	2.84	0.25	1.10	2.84	0.25	1.10	5.28	NR	NR
Metal framing, fixed	3.24			3.24			6.81		
Metal framing, operable	3.69			3.69			6.81		
Metal framing, entrance door	6.25			6.25			6.25		
Skylight, 0% to 3% of *Roof*									
All types	4.26	0.35	NR	4.26	0.35	NR	10.22	NR	NR

The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).
Exception to 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-2 *Building Envelope* Requirements for Climate Zone 2 (A,B)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.039	R-25 c.i.	U-0.039	R-25 c.i.	U-0.173	R-5 c.i.
Metal building[a]	U-0.041	R-10 + R-19 FC	U-0.041	R-10 + R-19 FC	U-0.096	R-16
Attic and other	U-0.027	R-38	U-0.027	R-38	U-0.053	R-19
Walls, above Grade						
Mass	U-0.151[b]	R-5.7 c.i.[b]	U-0.123	R-7.6 c.i.	U-0.580	NR
Metal building	U-0.094	R-0 + R-9.8 c.i.	U-0.094	R-0 + R-9.8. c.i.	U-0.162	R-13
Steel-framed	U-0.084	R-13 + R-3.8 c.i.	U-0.064	R-13 + R-7.5 c.i.	U-0.124	R-13
Wood-framed and other	U-0.089	R-13	U-0.089	R-13	U-0.089	R-13
Wall, below Grade						
Below-grade wall	C-1.140	NR	C-1.140	NR	C-1.140	NR

Floors									
Mass	U-0.107	R-6.3 c.i.		U-0.087	R-8.3 c.i.		U-0.322	NR	
Steel joist	U-0.038	R-30		U-0.038	R-30		U-0.069	R-13	
Wood-framed and other	U-0.033	R-30		U-0.033	R-30		U-0.066	R-13	
Slab-on-Grade Floors									
Unheated	F-0.730	NR		F-0.730	NR		F-0.730	NR	
Heated	F-0.900	R-10 for 24 in.		F-0.860	R-15 for 24 in.		F-1.020	R-7.5 for 12 in.	
Opaque Doors									
Swinging	U-0.370			U-0.370			U-0.700		
Nonswinging	U-0.310			U-0.310			U-1.450		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~		-	~~(for all frame types)~~		-	~~(for all frame types)~~	
~~*Nonmetal framing*, all~~	~~0.37~~	~~0.25~~	1.10 (for all types)	~~0.37~~	~~0.25~~	1.10 (for all types)	~~0.93~~	NR (for all types)	NR (for all types)
~~*Metal framing,* fixed~~	~~0.540.45~~	0.25		~~0.540.45~~	0.25		~~1.200.50~~		
~~*Metal framing,* operable~~	~~0.650.60~~	~~0.250.23~~		~~0.650.60~~	~~0.250.23~~		~~1.200.65~~		
~~*Metal framing,* entrance door~~	~~0.830.77~~	~~0.250.23~~		0.77	~~0.250.23~~		~~0.830.77~~		
Skylight, 0% to 3% of *Roof*									
All types	0.65	~~0.350.30~~	NR	0.65	~~0.350.30~~	NR	~~U-1.800.90~~	NR	NR

* The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).
b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-2 *Building Envelope* Requirements for Climate Zone 2 (A,B)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.220	R-4.4 c.i.	U-0.220	R-4.4 c.i.	U-0.982	R-0.9 c.i.
Metal building[a]	U-0.233	R-1.8 + R-3.3 FC	U-0.233	R-1.8 + R-3.3 FC	U-0.545	R-2.8
Attic and other	U-0.153	R-6.7	U-0.153	R-6.7	U-0.300	R-3.3
Walls, above Grade						
Mass	U-0.857[b]	R-1.0 c.i.[b]	U-0.701	R-1.3 c.i.	U-3.293	NR
Metal building	U-0.533	R-0 + R-1.7 c.i.	U-0.533	R-0 + R-1.7 c.i.	U-0.920	R-2.3
Steel-framed	U-0.479	R-2.3 + R-0.7 c.i.	U-0.365	R-2.3 + R-1.3 c.i.	U-0.705	R-2.3

Wood-framed and other	U-0.504	R-2.3		U-0.504	R-2.3		U-0.504	R-2.3	
Wall, below Grade									
Below-grade wall	C-6.473	NR		C-6.473	NR		C-6.473	NR	
Floors									
Mass	U-0.606	R-1.9		U-0.496	R-1.5		U-1.825	NR	
Steel joist	U-0.214	R-5.3		U-0.214	R-5.3		U-0.390	R-2.3	
Wood-framed and other	U-0.188	R-5.3		U-0.188	R-5.3		U-0.376	R-2.3	
Slab-on-Grade Floors									
Unheated	F-1.264	NR		F-1.264	NR		F-1.264	NR	
Heated	F-1.558	R-1.8 for 600 mm		F-1.489	R-2.6 for 600 mm		F-1.766	R-1.3 for 300 mm	
Opaque Doors									
Swinging	U-2.101			U-2.101			U-3.975		
Nonswinging	U-1.760			U-1.760			U-8.233		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	2.10	0.25	1.10	2.10	0.25	1.10	5.28	NR	NR
Metal framing, fixed	3.07			3.07			6.81		
Metal framing, operable	3.69			3.69			6.81		
Metal framing, entrance door	4.71			4.37			4.71		
Skylight, 0% to 3% of *Roof*									
All types	3.69	0.35	NR	3.69	0.35	NR	10.22	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).
b. Exception to 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-3 *Building Envelope* Requirements for Climate Zone 3 (A,B,C)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.039	R-25 c.i.	U-0.039	R-25 c.i.	U-0.119	R-7.6 c.i.
Metal building[a]	U-0.041	R-10 + R-19 FC	U-0.041	R-10 + R-19 FC	U-0.096	R-16
Attic and other	U-0.027	R-38	U-0.027	R-38	U-0.053	R-19
Walls, above Grade						

Mass	U-0.123	R-7.6 c.i.	U-0.104	R-9.5 c.i.	U-0.580	NR
Metal building	U-0.094	R-0 + R-9.8 c.i.	U-0.072	R-0 + R-13 c.i.	U-0.162	R-13
Steel-framed	U-0.077	R-13 + R-5 c.i.	U-0.064	R-13 + R-7.5 c.i.	U-0.124	R-13
Wood-framed and other	U-0.089	R-13	U-0.064	R-13 + R-3.8 c.i. or R-20	U-0.089	R-13
Wall, below Grade						
Below-grade wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.074	R-10 c.i.	U-0.074	R-10 c.i.	U-0.137	R-4.2 c.i.
Steel joist	U-0.038	R-30	U-0.038	R-30	U-0.052	R-19
Wood-framed and other	U-0.033	R-30	U-0.033	R-30	U-0.051	R-19
Slab-on-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.370		U-0.370		U-0.370	
Nonswinging	U-0.310		U-0.310		U-0.360	

Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
~~*Nonmetal framing*, all~~	~~0.33~~	~~0.25~~	1.10 (for all types)	~~0.35~~	~~0.25~~	1.10 (for all types)	~~0.87~~	NR (for all types)	NR (for all types)
~~*Metal framing,* fixed~~	0.45	0.25		~~0.490~~.42	0.25		~~1.200~~.50		
~~*Metal framing,* operable~~	0.60	~~0.250~~.23		~~0.600~~.54	~~0.250~~.23		~~1.200~~.65		
~~*Metal framing,* entrance door~~	0.77	~~0.250~~.23		0.68	~~0.250~~.23		0.77		
Skylight, 0% to 3% of *Roof*									
All types	0.55	~~0.350~~.30	NR	0.55	~~0.350~~.30	NR	~~1.700~~.90	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

Table 5.5-3 *Building Envelope* Requirements for Climate Zone 3 (A,B,C)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.220	R-4.4 c.i.	U-0.220	R-4.4 c.i.	U-0.677	R-1.3 c.i.
Metal building[a]	U-0.233	R-1.8 + R-3.3 FC	U-0.233	R-1.8 + R-3.3 FC	U-0.545	R-2.8
Attic and other	U-0.153	R-6.7	U-0.153	R-6.7	U-0.300	R-3.3
Walls, above Grade						
Mass	U-0.701	R-1.3 c.i.	U-0.592	R-1.7 c.i.	U-3.293	NR

ANSI/ASHRAE/IES addenda t, v, y, al, an, ao, at, aw, ay, az, ba, bb, bd, bf, bh, bi, bj, bk, bl bq, bt, bx, bz, ca, cc, ce, cg, ch, ci, cj, cn, and co to ANSI/ASHRAE/IES Standard 90.1-2016

Metal building	U-0.533	R-0 + R-1.7 c.i.		U-0.410	R-0 + R-2.3 c.i.		U-0.920	R-2.3	
Steel-framed	U-0.435	R-2.3 + R-0.9 c.i.		U-0.365	R-2.3 + R-1.3 c.i.		U-0.705	R-2.3	
Wood-framed and other	U-0.504	R-2.3		U-0.365	R-2.3 + R-0.7 c.i. or R-3.5		U-0.504	R-2.3	
Wall, below Grade									
Below-grade wall	C-6.473	NR		C-6.473	NR		C-6.473	NR	
Floors									
Mass	U-0.420	R-1.8 c.i.		U-0.420	R-1.8 c.i.		U-0.780	R-0.7 c.i.	
Steel joist	U-0.214	R-5.3		U-0.214	R-5.3		U-0.296	R-3.3	
Wood-framed and other	U-0.188	R-5.3		U-0.188	R-5.3		U-0.288	R-3.3	
Slab-on-Grade Floors									
Unheated	F-1.264	NR		F-0.935	R-1.8 for 600 mm		F-1.264	NR	
Heated	F-1.489	R-2.6 for 600 mm		F-1.489	R-2.6 for 600 mm		F-1.766	R-1.3 for 300 mm	
Opaque Doors									
Swinging	U-2.101			U-2.101			U-2.101		
Nonswinging	U-1.760			U-1.760			U-2.044		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	1.87	0.25	1.10	1.99	0.25	1.10	4.94	NR	NR
Metal framing, fixed	2.56			2.78			6.81		
Metal framing, operable	3.41			3.41			6.81		
Metal framing, entrance door	4.37			3.86			4.37		
Skylight, 0% to 3% of *Roof*									
All types	3.12	0.35	NR	3.12	0.35	NR	9.65	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

Table 5.5-4 *Building Envelope* Requirements for Climate Zone 4 (A,B,C)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.093	R-10 c.i.
Metal building[a]	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*	U-0.082	R-19
Attic and other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30
Walls, above Grade						
Mass	U-0.104	R-9.5 c.i.	U-0.090	R-11.4 c.i.	U-0.580	NR
Metal building	U-0.060	R-0 + R-15.8 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.162	R-13

ANSI/ASHRAE/IES addenda t, v, y, al, an, ao, at, aw, ay, az, ba, bb, bd, bf, bh, bi, bj, bk, bl bq, bt, bx, bz, ca, cc, ce, cg, ch, ci, cj, cn, and co to ANSI/ASHRAE/IES Standard 90.1-2016

Steel-framed	U-0.064	R-13 + R-7.5 c.i.		U-0.064	R-13 + R-7.5 c.i		U-0.124	R-13	
Wood-framed and other	U-0.064	R-13 + R-3.8 c.i. or R-20		U-0.064	R-13 + R-3.8 c.i. or R-20		U-0.089	R-13	
Wall, below Grade									
Below-grade wall	C-0.119	R-7.5 c.i.		C-0.092	R-10 c.i.		C-1.140	NR	
Floors									
Mass	U-0.057	R-14.6 c.i.		U-0.051	R-16.7 c.i.		U-0.107	R-6.3 c.i.	
Steel joist	U-0.038	R-30		U-0.038	R-30		U-0.052	R-19	
Wood-framed and other	U-0.033	R-30		U-0.033	R-30		U-0.051	R-19	
Slab-on-Grade Floors									
Unheated	F-0.520	R-15 for 24 in.		F-0.520	R-15 for 24 in.		F-0.730	NR	
Heated	F-0.843	R-20 for 24 in.		F-0.688	R-20 for 48 in.		F-0.900	R-10 for 24 in.	
Opaque Doors									
Swinging	U-0.370			U-0.370			U-0.370		
Nonswinging	U-0.310			U-0.310			U-0.360		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~		-	~~(for all frame types)~~		-	~~(for all frame types)~~	
~~*Nonmetal framing,*~~ all	~~0.31~~	~~0.36~~	1.10 (for all types)	~~0.31~~	~~0.36~~	1.10 (for all types)	~~0.51~~	NR (for all types)	NR (for all types)
~~*Metal framing,*~~ *fixed*	~~0.38~~0.36	0.36		~~0.38~~0.36	0.36		~~0.73~~0.50		
~~*Metal framing,*~~ *operable*	~~0.46~~0.45	~~0.36~~0.33		~~0.46~~0.45	~~0.36~~0.33		~~0.81~~0.65		
~~*Metal framing,*~~ *entrance door*	~~0.68~~0.63	~~0.36~~0.33		~~0.68~~ 0.63	~~0.36~~0.33		0.77		
Skylight, 0% to 3% of *Roof*									
All types	0.50	0.40	NR	0.50	0.40	NR	~~1.15~~0.75	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), *Ls* = *liner system* (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

Table 5.5-4 *Building Envelope* Requirements for Climate Zone 4 (A,B,C)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.184	R-5.3 c.i.	U-0.184	R-5.3 c.i.	U-0.527	R-1.8 c.i.
Metal building[a]	U-0.210	R-3.3 + R-1.9 Ls or R-4.4 + R-1.4 Ls	U-0.210	R-3.3 + R-1.9 Ls or R-4.4 + R-1.4 Ls	U-0.466	R-3.3
Attic and other	U-0.119	R-8.6	U-0.119	R-8.6	U-0.192	R-5.3
Walls, above Grade						
Mass	U-0.592	R-1.7 c.i.	U-0.513	R-2.0 c.i.	U-3.293	NR
Metal building	U-0.341	R-0 + R-2.8 c.i.	U-0.286	R-0 + R-3.3 c.i.	U-0.920	R-2.3

ANSI/ASHRAE/IES addenda t, v, y, al, an, ao, at, aw, ay, az, ba, bb, bd, bf, bh, bi, bj, bk, bl bq, bt, bx, bz, ca, cc, ce, cg, ch, ci, cj, cn, and co to ANSI/ASHRAE/IES Standard 90.1-2016

Steel-framed	U-0.365	R-2.3 + R-1.3 c.i.		U-0.365	R-2.3 + R-1.3 c.i.		U-0.705	R-2.3	
Wood-framed and other	U-0.365	R-2.3 + R-0.7 c.i. or R-3.5		U-0.365	R-2.3 + R-0.7 c.i. or R-3.5		U-0.504	R-2.3	
Wall, below Grade									
Below-grade wall	C-0.678	R-1.3 c.i.		C-0.522	R-1.8 c.i.		C-6.473	NR	
Floors									
Mass	U-0.321	R-2.6 c.i.		U-0.287	R-2.9 c.i.		U-0.606	R-1.1 c.i.	
Steel joist	U-0.214	R-5.3		U-0.214	R-5.3		U-0.296	R-3.3	
Wood-framed and other	U-0.188	R-5.3		U-0.188	R-5.3		U-0.288	R-3.3	
Slab-on-Grade Floors									
Unheated	F-0.900	R-2.6 for 600 mm		F-0.900	R-2.6 for 600 mm		F-1.264	NR	
Heated	F-1.459	R-3.5 for 600 mm		F-1.191	R-3.5 for 1200 mm		F-1.558	R-1.8 for 600 mm	
Opaque Doors									
Swinging	U-2.101			U-2.101			U-2.101		
Nonswinging	U-1.760			U-1.760			U-2.044		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	1.76	0.36	1.10	1.76	0.36	1.10	2.90	NR	NR
Metal framing, fixed	2.16			2.16			4.14		
Metal framing, operable	2.61			2.61			4.60		
Metal framing, entrance door	3.86			3.86			4.37		
Skylight, 0% to 3% of *Roof*									
All types	2.84	0.40	NR	2.84	0.40	NR	6.53	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), Ls = liner system (see Section A2.3.2.4), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

Table 5.5-5 *Building Envelope* Requirements for Climate Zone 5 (A,B,C)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.063	R-15 c.i.
Metal building[a]	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*	U-0.082	R-19
Attic and other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30
Walls, above grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[b]	R-5.7 c.i.[b]
Metal building	U-0.050	R-0 + R-19 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.094	R-0 + R-9.8 c.i.
Steel-framed	U-0.055	R-13 + R-10 c.i.	U-0.055	R-13 + R-10 c.i.	U-0.084	R-13+R-3.8 c.i.

Wood-framed and other	U-0.051	R-13 + R-7.5 c.i. or R-19 + R-5 c.i.	U-0.051	R-13 + R-7.5 c.i. or R-19 + R-5 c.i.	U-0.089	R-13
Wall, below Grade						
Below-grade wall	C-0.119	R-7.5 c.i.	C-0.092	R-10 c.i.	C-1.140	NR
Floors						
Mass	U-0.057	R-14.6 c.i.	U-0.051	R-16.7 c.i.	U-0.107	R-6.3 c.i.
Steel joist	U-0.038	R-30	U-0.038	R-30	U-0.052	R-19
Wood-framed and other	U-0.033	R-30	U-0.033	R-30	U-0.051	R-19
Slab-on-Grade Floors						
Unheated	F-0.520	R-15 for 24 in	F-0.510	R-20 for 24 in.	F-0.730	NR
Heated	F-0.688	R-20 for 48 in.	F-0.688	R-20 for 48 in.	F-0.900	R-10 for 24 in.
Opaque Doors						
Swinging	U-0.370		U-0.370		U-0.370	
Nonswinging	U-0.310		U-0.310		U-0.360	

Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~		-	~~(for all frame types)~~		-	~~(for all frame types)~~	
~~*Nonmetal framing,* all~~	~~0.31~~	~~0.38~~	1.10 (for all types)	~~0.31~~	~~0.38~~	1.10 (for all types)	~~0.45~~	NR (for all types)	NR (for all types)
~~*Metal framing,* fixed~~	~~0.38~~0.36	~~0.38~~0.36		~~0.38~~0.36	~~0.38~~0.36		~~0.62~~0.50		
~~*Metal framing,* operable~~	~~0.46~~ 0.45	~~0.38~~0.33		~~0.46~~ 0.45	~~0.38~~0.33		~~0.70~~0.65		
~~*Metal framing,* entrance door~~	~~0.68~~0.63	~~0.38~~0.33		~~0.68~~0.63	~~0.38~~0.33		0.77		
Skylight, 0% to 3% of *Roof*									
All types	0.50	0.40	NR	0.50	0.40	NR	~~0.98~~0.75	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), *Ls* = *liner system* (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-5 *Building Envelope* Requirements for Climate Zone 5 (A,B,C)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.184	R-5.3 c.i.	U-0.184	R-5.3 c.i.	U-0.360	R-2.6 c.i.
Metal building[a]	U-0.210	R-3.3 + R-1.9 Ls or R-4.4 + R1.4 Ls	U-0.210	R-3.3 + R-1.9 Ls or R-4.4 + R1.4 Ls	U-0.466	R-3.3
Attic and other	U-0.119	R-8.6	U-0.119	R-8.6	U-0.192	R-5.3
Walls, above Grade						
Mass	U-0.513	R-2.0 c.i.	U-0.453	R-2.3 c.i.	U-0.857[b]	R-1.0 c.i.[b]
Metal building	U-0.286	R-0 + R-3.3 c.i.	U-0.286	R-0 + R-3.3 c.i.	U-0.533	R-0 + R-1.7 c.i.
Steel-framed	U-0.315	R-2.3 + R-1.8 c.i.	U-0.315	R-2.3 + R-1.8 c.i.	U-0.479	R-2.3+ R-0.7 c.i.

Wood-framed and other	U-0.291	R-2.3 + R-0.9 c.i. or R-3.3 + R-0.9 c.i.		U-0.291	R-2.3 + R-0.9 c.i. or R-3.3 + R-0.9 c.i.		U-0.504	R-2.3	
Wall, below Grade									
Below-grade wall	C-0.678	R-1.3 c.i.		C-0.522	R-1.8 c.i.		C-6.473	NR	
Floors									
Mass	U-0.321	R-2.6 c.i.		U-0.287	R-2.9 c.i.		U-0.606	R-1.1 c.i.	
Steel joist	U-0.214	R-5.3		U-0.214	R-5.3		U-0.296	R-3.3	
Wood-framed and other	U-0.188	R-6.7		U-0.188	R-6.7		U-0.288	R-3.3	
Slab-on-Grade Floors									
Unheated	F-0.900	R-2.6 for 600 mm		F-0.882	R-3.5 for 600 mm		F-1.264	NR	
Heated	F-1.191	R-3.5 for 1200 mm		F-1.191	R-3.5 for 1200 mm		F-1.558	R-1.8 for 600 mm	
Opaque Doors									
Swinging	U-2.101			U-2.101			U-2.101		
Nonswinging	U-1.760			U-1.760			U-2.044		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	1.76	0.38	1.10	1.76	0.38	1.10	2.56	NR	NR
Metal framing, fixed	2.16			2.16			3.52		
Metal framing, operable	2.61			2.61			3.97		
Metal framing, entrance door	3.86			3.86			4.37		
Skylight, 0% to 3% of *Roof*									
All types	2.84	0.40	NR	2.84	0.40	NR	5.56	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), Ls = liner system (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-6 *Building Envelope* Requirements for Climate Zone 6 (A,B)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.063	R-15 c.i.
Metal building[a]	U-0.031	R-25 + R-11 *Ls*	U-0.029	R-30 + R-11 *Ls*	U-0.060	R-19 + R-19
Attic and other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30
Walls, above Grade						
Mass	U-0.080	R-13.3 c.i.	U-0.071	R-15.2 c.i.	U-0.151[b]	R-5.7 c.i.[b]
Metal building	U-0.050	R-0 + R-19 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.094	R-0 + R-9.8 c.i.
Steel-framed	U-0.049	R-13 + R-12.5 c.i.	U-0.049	R-13 + R-12.5 c.i.	U-0.084	R-13 + R-3.8 c.i.
Wood-framed and	U-0.051	R-13 + R-7.5 c.i. or	U-0.051	R-13 + R-7.5 c.i. or	U-0.089	R-13

other		R-19 + R-5 c.i.			R-19 + R-5 c.i.				
Wall, below Grade									
Below-grade wall	C-0.092	R-10 c.i.		C-0.063	R-15 c.i.		C-0.119	R-7.5 c.i.	
Floors									
Mass	U-0.051	R-16.7 c.i.		U-0.051	R-16.7 c.i.		U-0.087	R-8.3 c.i.	
Steel joist	U-0.032	R-38		U-0.032	R-38		U-0.052	R-19	
Wood-framed and other	U-0.027	R-38		U-0.027	R-38		U-0.051	R-19	
Slab-on-Grade Floors									
Unheated	F-0.510	R-20 for 24 in.		F-0.434	R-20 for 48 in		F-0.730	NR	
Heated	F-0.688	R-20 for 48 in.		F-0.671	R-25 for 48 in.		F-0.860	R-15 for 24 in.	
Opaque Doors									
Swinging	U-0.370			U-0.370			U-0.370		
Nonswinging	U-0.310			U-0.310			U-0.360		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~		-	~~(for all frame types)~~		-	~~(for all frame types)~~	
~~*Nonmetal framing,* all~~	~~0.30~~	~~0.40~~	1.10 (for all types)	~~0.30~~	~~0.40~~	1.10 (for all types)	~~0.45~~	NR (for all types)	NR (for all types)
~~*Metal framing,* fixed~~	~~0.36~~0.34	~~0.40~~0.38		~~0.36~~0.34	~~0.40~~0.38		~~0.51~~0.39		
~~*Metal framing*~~, *operable*	~~0.45~~ 0.42	~~0.40~~0.34		~~0.45~~0.42	~~0.40~~0.34		~~0.59~~0.48		
~~*Metal framing,* entrance door~~	~~0.68~~0.63	~~0.40~~0.34		~~0.68~~0.63	~~0.40~~0.34		~~0.77~~0.68		
Skylight, 0% to 3% of *Roof*									
All types	~~0.50~~0.47	0.40	NR	~~0.50~~0.47	0.40	NR	~~0.85~~0.75	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), *Ls* = *liner system* (see Section A2.3.2.4), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).
b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-6 *Building Envelope* Requirements for Climate Zone 6 (A,B)*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.184	R-5.3 c.i.	U-0.184	R-5.3 c.i.	U-0.360	R-2.6 c.i.
Metal building[a]	U-0.175	R-4.4 + R-1.9 Ls	U-0.163	R-5.3 + R-1.9 Ls	U-0.341	R-3.3 + R-3.3
Attic and other	U-0.119	R-8.6	U-0.119	R-8.6	U-0.192	R-5.3
Walls, above Grade						
Mass	U-0.453	R-2.3 c.i.	U-0.404	R-2.7 c.i.	U-0.857[b]	R-1.0 c.i.[b]
Metal building	U-0.286	R-0 + R-3.3 c.i.	U-0.286	R-0 + R-3.3 c.i.	U-0.533	R-0 + R-1.7 c.i.
Steel-framed	U-0.277	R-2.3 + R-2.2 c.i.	U-0.277	R-2.3 + R-2.2 c.i.	U-0.479	R-2.3 + R-0.7 c.i.
Wood-framed and	U-0.291	R-2.3 + R-1.3 c.i. or R-	U-0.291	R-2.3 + R-1.3 c.i. or	U-0.504	R-2.3

other		3.3 + R-0.9 c.i.			R-3.3 + R-0.9 c.i.				
Wall, below Grade									
Below-grade wall	C-0.522	R-1.8 c.i.		C-0.358	R-2.6 c.i.		C-0.678	R-1.3 c.i.	
Floors									
Mass	U-0.287	R-2.9 c.i.		U-0.287	R-2.9 c.i.		U-0.496	R-1.5 c.i.	
Steel-joist	U-0.183	R-6.7		U-0.183	R-6.7		U-0.296	R-3.3	
Wood-framed and other	U-0.153	R-6.7		U-0.153	R-6.7		U-0.288	R-3.3	
Slab-on-Grade Floors									
Unheated	F-0.882	R-3.5 for 600 mm		F-0.750	R-3.5 for 1200 mm		F-1.264	NR	
Heated	F-1.191	R-3.5 for 1200 mm		F-1.162	R-4.4 for 1200 mm		F-1.489	R-2.6 for 600 mm	
Opaque Doors									
Swinging	U-2.101			U-2.101			U-2.101		
Nonswinging	U-1.760			U-1.760			U-2.044		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	1.70	0.40	1.10	1.70	0.40	1.10	2.56	NR	NR
Metal framing, fixed	2.04			2.04			2.90		
Metal framing, operable	2.56			2.56			3.35		
Metal framing, entrance door	3.86			3.86			4.37		
Skylight, 0% to 3% of *Roof*									
All types	2.84	0.40	NR	2.84	0.40	NR	4.83	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), Ls = liner system (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

b. Exception to Section 5.5.3.2 applies for *mass walls* above *grade*.

Table 5.5-7 *Building Envelope* Requirements for Climate Zone 7*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.028	R-35 c.i.	U-0.028	R-35 c.i.	U-0.039	R-25 c.i.
Metal building[a]	U-0.029	R-30 + R-11 *Ls*	U-0.029	R-30 + R-11 *Ls*	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*
Attic and other	U-0.017	R-60	U-0.017	R-60	U-0.027	R-38
Walls, above Grade						
Mass	U-0.071	R-15.2 c.i.	U-0.071	R-15.2 c.i.	U-0.123	R-7.6 c.i.
Metal building	U-0.044	R-0 + R.22.1 c.i.	U-.044	R-0 + R.22.1 c.i.	U-0.072	R-0 + R-13 c.i.
Steel-framed	U-0.049	R-13 + R-12.5 c.i.	U-0.042	R-13 + R-15.6 c.i.	U-0.064	R-13 + R-7.5 c.i.
Wood-framed and	U-0.051	R-13 + R-7.5 c.i. or	U-0.051	R-13 + R-7.5 c.i. or	U-0.064	R-13 + R-3.8 c.i.

other		R-19 + R-5 c.i.			R-19 + R-5 c.i.				
Wall, below Grade									
Below-grade wall	C-0.063	R-15 c.i.		C-0.063	R-15 c.i.		C-0.119	R-7.5 c.i.	
Floors									
Mass	U-0.042	R-20.9 c.i.		U-0.042	R-20.9 c.i.		U-0.074	R-10.4 c.i.	
Steel joist	U-0.032	R-38		U-0.032	R-38		U-0.052	R-19	
Wood-framed and other	U-0.027	R-38		U-0.027	R-38		U-0.051	R-19	
Slab-on-Grade Floors									
Unheated	F-0.510	R-20 for 24 in.		F-0.434	R-20 for 48 in.		F-0.730	NR	
Heated	F-0.671	R-25 for 48 in.		F-0.671	R-25 for 48 in.		F-0.860	R-15 for 24 in.	
Opaque Doors									
Swinging	U-0.370			U-0.370			U-0.370		
Nonswinging	U-0.310			U-0.310			U-0.310		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~			~~(for all frame types)~~			~~(for all frame types)~~	
~~*Nonmetal framing,* all~~	~~0.28~~	~~0.45~~	1.10 (for all types)	~~0.28~~	~~0.45~~	1.10 (for all types)	~~0.32~~	NR (for all types)	NR (for all types)
~~*Metal framing,* fixed~~	~~0.33~~0.29	~~0.45~~0.40		~~0.33~~0.29	~~0.45~~0.40		~~0.38~~0.36		
~~*Metal framing,* operable~~	~~0.40~~0.36	~~0.45~~0.36		~~0.40~~0.36	~~0.45~~0.36		0.44		
~~*Metal framing,* entrance door~~	~~0.68~~0.63	~~0.45~~0.36		~~0.68~~0.63	~~0.45~~0.36		~~0.77~~0.63		
Skylight, 0% to 3% of *Roof*									
All types	~~0.50~~0.44	NR	NR	~~0.50~~0.44	NR	NR	~~0.85~~0.75	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), *Ls* = *liner system* (see Section A2.3.2.4), NR = no (insulation) requirement.
a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

Table 5.5-7 *Building Envelope* Requirements for Climate Zone 7*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.158	R-6.2 c.i.	U-0.158	R-6.2 c.i.	U-0.220	R-4.4 c.i.
Metal building[a]	U-0.163	R-5.3 + R-1.9 Ls	U-0.163	R-5.3 + R-1.9 Ls	U-0.210	R-3.3 + R-1.9 Ls or R-4.4. + R-1.4 Ls
Attic and other	U-0.098	R-10.6	U-0.098	R-10.6	U-0.153	R-6.7 c.i.
Walls, above Grade						
Mass	U-0.404	R-2.7 c.i.	U-0.404	R-2.7 c.i.	U-0.701	R-1.3 c.i.
Metal building	U-0.248	R-0 + R-3.9 c.i.	U-0.248	R-0 + R-3.9 c.i.	U-0.410	R-0 + R-2.3 c.i.
Steel-framed	U-0.277	R-2.3 + R-2.2 c.i.	U-0.240	R-2.3 + R-2.7 c.i.	U-0.365	R-2.3 + R-1.3 c.i.
Wood-framed and	U-0.291	R-2.3 + R-1.3 c.i. or R-	U-0.291	R-2.3 + R-1.3 c.i. or	U-0.365	R-2.3 + R-0.7 c.i.

other		3.3 + R-0.9 c.i.			R-3.3 + R-0.9 c.i.				
Wall, below Grade									
Below-grade wall	C-0.358	R-2.6 c.i.		C-0.358	R-2.6 c.i.		C-0.678	R-1.3 c.i.	
Floors									
Mass	U-0.236	R-3.7 c.i.		U-0.236	R-3.7 c.i.		U-0.420	R-1.8 c.i.	
Steel joist	U-0.183	R-6.7		U-0.183	R-6.7		U-0.296	R-3.3	
Wood-framed and other	U-0.153	R-6.7		U-0.153	R-6.7		U-0.288	R-3.3	
Slab-on-Grade Floors									
Unheated	F-0.882	R-3.5 for 600 mm		F-0.750	R-3.5 for 1200 mm		F-1.264	NR	
Heated	F-1.162	R-4.4 for 1200 mm		F-1.162	R-4.4 for 1200 mm		F-1.489	R-2.6 for 600 mm	
Opaque Doors									
Swinging	U-2.101			U-2.101			U-2.101		
Nonswinging	U-1.760			U-1.760			U-1.760		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of Wall		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	1.59	0.45	1.10	1.59	0.45	1.10	1.82	NR	NR
Metal framing, fixed	1.87			1.87			2.16		
Metal framing, operable	2.27			2.27			2.50		
Metal framing, entrance door	3.86			3.86			4.37		
Skylight, 0% to 3% of *Roof*									
All types	2.84	NR	NR	2.84	NR	NR	4.83	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), Ls = liner system (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

Table 5.5-8 *Building Envelope* Requirements for Climate Zone 8*

	Nonresidential		***Residential***		***Semiheated***	
Opaque Elements	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***	***Assembly Maximum***	***Insulation Min. R-Value***
Roofs						
Insulation entirely above deck	U-0.028	R-35 c.i.	U-0.028	R-35 c.i.	U-0.039	R-25 c.i.
Metal building[a]	U-0.026	R-25 + R-11+R-11 *Ls*	U-0.026	R-25 + R-11+R-11 *Ls*	U-0.037	R-19+R-11 *Ls* or R-25 + R-8 *Ls*
Attic and other	U-0.017	R-60	U-0.017	R-60	U-0.027	R-38
Walls, above Grade						
Mass	U-0.048	R-19 c.i.	U-0.048	R-19 c.i.	U-0.104	R-9.5 c.i.
Metal building	U-0.039	R-0 + R-25 c.i.	U-0.039	R-0 + R-25 c.i.	U-0.060	R-0 + R-15.8 c.i.
Steel-framed	U-0.037	R-13 + R-18.8 c.i.	U-0.037	R-13 + R-18.8 c.i.	U-0.064	R-13 + R-7.5 c.i.
Wood-framed and other	U-0.032	R-13 + R-18.8 c.i.	U-0.032	R-13 + R-18.8 c.i.	U-0.051	R-13 + R-7.5 c.i.

Wall, below Grade									
Below-grade wall	C-0.063	R-15 c.i.		C-0.063	R-15 c.i.		C-0.119	R-7.5 c.i.	
Floors									
Mass	U-0.038	R-23 c.i.		U-0.038	R-23 c.i.		U-0.064	R-12.5 c.i.	
Steel joist	U-0.032	R-38		U-0.032	R-38		U-0.052	R-19	
Wood-framed and other	U-0.027	R-38		U-0.027	R-38		U-0.033	R-30	
Slab-on-Grade Floors									
Unheated	F-0.434	R-20 for 48 in.		F-0.424	R-25 for 48 in.		F-0.540	R-10 for 24 in.	
Heated	F-0.671	R-25 for 48 in.		F-0.373	R-20 full slab		F-0.860	R-15 for 24 in.	
Opaque Doors									
Swinging	U-0.370			U-0.370			U-0.370		
Nonswinging	U-0.310			U-0.310			U-0.310		
Fenestration	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***	***Assembly Max. U***	***Assembly Max. SHGC***	***Assembly Min. VT/SHGC***
Vertical Fenestration, 0% to 40% of *Wall*		~~(for all frame types)~~			~~(for all frame types)~~			~~(for all frame types)~~	
~~*Nonmetal framing*, all~~	~~0.25~~	~~0.45~~	1.10 (for all types)	~~0.25~~	~~0.45~~	1.10 (for all types)	~~0.32~~	NR (for all types)	NR (for all types)
Metal framing, fixed	~~0.29~~0.26	~~0.45~~0.40		~~0.29~~0.26	~~0.45~~0.40		~~0.38~~0.36		
Metal framing, operable	~~0.35~~0.32	~~0.45~~0.36		~~0.35~~0.32	~~0.45~~0.36		0.44		
Metal framing, entrance door	~~0.68~~0.63	~~0.45~~0.36		~~0.68~~0.63	~~0.45~~0.36		~~0.77~~0.63		
Skylight, 0% to 3% of *Roof*									
All types	0.41	NR	NR	0.41	NR	NR	~~0.85~~0.75	NR	NR

*The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), *Ls* = *liner system* (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

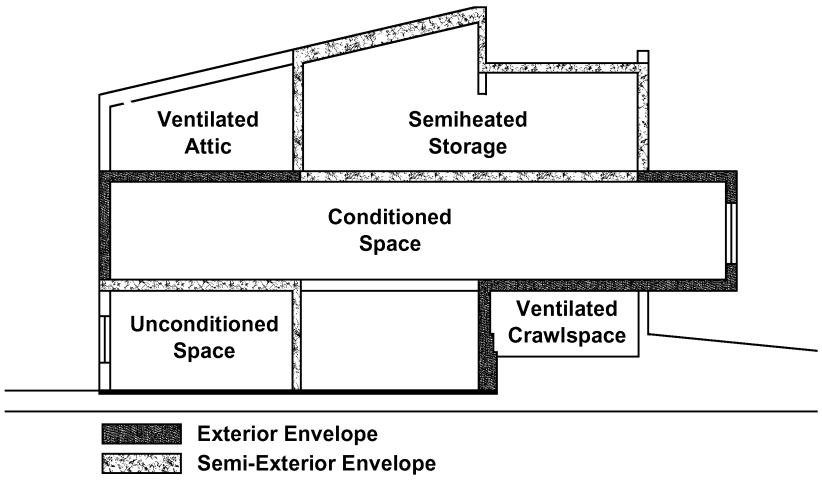

Figure 5.5.2 Exterior and *semiexterior building envelope*.

Table 5.5.3.1.1 Increased *Roof* Insulation Levels

Roofs	***Nonresidential***	***Residential***

ANSI/ASHRAE/IES addenda t, v, y, al, an, ao, at, aw, ay, az, ba, bb, bd, bf, bh, bi, bj, bk, bl bq, bt, bx, bz, ca, cc, ce, cg, ch, ci, cj, cn, and co to ANSI/ASHRAE/IES Standard 90.1-2016

***Opaque* Elements**	**Assembly Maximum**	**Insulation Min. *R-Value***	**Assembly Maximum**	**Insulation Min. *R-Value***
Climate Zone 0				
Insulation entirely above deck	U-0.027	R-36 c.i.	U-0.027	R-36 c.i.
Metal buildings	U-0.028	R-35		
Climate Zones 1 to 3				
Insulation entirely above deck	U-0.030	R-33 c.i.	U-0.029	R-34 c.i.
Metal buildings	U-0.028	R-35		

b. A minimum Solar Reflectance Index of 64 when determined in accordance with the Solar Reflectance Index method in ASTM E1980 using a convection coefficient of 2.1 Btu/h·ft^2·°F, based on three-year-aged solar *reflectance* and three-year-aged thermal *emittance* tested in accordance with CRRC-1 Standard.

c. Increased *roof* insulation levels found in Table 5.5.3.1.1.

The values for three-year-aged solar *reflectance* and three-year-aged thermal *emittance* shall be determined by a laboratory accredited by a nationally recognized accreditation organization and shall be *labeled* and certified by the *manufacturer*.

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.

…

5.8.2.5 Visible Transmittance

VT shall be determined in accordance with NFRC 200. *VT* shall be verified and certified by the *manufacturer*.

Exceptions to 5.8.2.5

1. VT_{annual} determined in accordance with NFRC 203 shall be an acceptable alternative for determining compliance with the *VT* requirements for tubular daylighting devices.

2. For *skylights* whose transmittances are not within the scope of NFRC 200, their transmittance shall be the solar photometric transmittance of the *skylight* glazing materials determined in accordance with ASTM E972.5.4.3.13Testing, Acceptable Materials, and AssembliesThe *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).

b. Air leakage for materialsthathave an air permanence not exceeding0.004 cfm/ft^2 under a pressure differential of 0.3 in. of water (1.57 psf) when tested in accordance with ASTM E2178.

The following materials meet theserequirements :

1. Plywood–minimum 3/8 in. (10 mm)
2. Oriented strand board–minimum 3/8 in. (10 mm)
3. Extruded polystyrene insulation board–minimum ½ in. (12 mm)
4. Foil-faced urethaneinsulation board–minimum ½ in. (12 mm)
5. Exterior gypsum sheathing or interior gypsum board–minium ½ in. (12 mm)
6. Cement board–minimum ½ in. (12 mm)
7. Built-up roofing membrane
8. Modified bituminous *roof* membrane
9. Single-ply *roof* membrane
10. A Portland cement/sand parge, stucco, or gypsum plaster–minimum ½ in. (12 mm) thick
11. Cast-in-place and precast concrete
12. Sheet metal
13. Closed-cell 2 lb/ft^3 (32 kg/m^3) nominal density spray polyurethane foam–minimum 1 in. (25 mm)

1. c. Assemblies of materials and components (sealants, tapes, etc.)that used as a component of the continuous air barrier shall have an average air leakage not to exceed 0.04 cfm/ft^2 under a pressure differential of 0.3 in. of water (1.57 psf) when tested in accordance with ASTM E2357, ASTM E1677, ASTM E1680, or ASTM E283. The following assemblies meet these requirements:The following assemblies meet these requirements Concrete masonry *walls* that are

   a) fully grouted, or

   b) painted to fill the pores.

5.4.3.2 Air leakage for *fenestration* and *doors* shall be determined in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, NFRC 400, or ASTM E283 as specified below. Air leakage shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be *labeled* and certified by the *manufacturer*. Air leakage shall not exceedExceptions to 5.8.3.2

1. *Field-fabricated fenestration* and *doors*.
2. Air leakage shall not exceed 1.0 cfm/ft^2 when tested at a pressure of at least 1.57 psf in accordance with ANSI/DASMA 105, NFRC 400, or ASTM E283 for *metal coiling doors* in *semiheated spaces* in Climate Zones 0 through 6.

Products in *buildings* that comply with a whole *building* air leakage rate of 0.4 cfm/ft^2 under a pressure differential of0.3 in. of water, 1.57 psf when tested in accordance with ASTM E779.

nonswinging doors intended for vehicular access and material transportation, with a minimum opening rate of 32 in/s (0.8 m/s)	1.3 (6.6)	1.57 (75)	ANSI/DASMA 105, NFRC 400, or ASTM E283

…

6.4 Mandatory Provisions

6.4.1 Equipment Efficiencies, Verification, and Labeling Requirements

6.4.1.1 Minimum Equipment Efficiencies—Listed Equipment—Standard Rating and Operating Conditions

Equipment shown in Tables 6.8.1-1 through 6.8.1-~~16~~18 shall have a minimum performance at the specified rating conditions when tested in accordance with the specified test procedure. Where multiple rating conditions or performance requirements are provided, the

equipment shall satisfy all stated requirements unless otherwise exempted by footnotes in the table. *Equipment* covered under the Federal *Energy* Policy Act of 1992 (EPACT) shall have no minimum *efficiency* requirements for operation at minimum capacity or other than standard rating conditions. *Equipment* used to provide *service water-heating* functions as part of a combination *system* shall satisfy all stated requirements for the appropriate *space* heating or cooling category.

Tables are as follows:

a. Table 6.8.1-1, "Electrically Operated Unitary Air Conditioners and *Condensing Units*—Minimum *Efficiency* Requirements"
b. Table 6.8.1-2, "Electrically Operated Unitary and Applied Heat Pumps—Minimum *Efficiency* Requirements"
c. Table 6.8.1-3, "Water-Chilling Packages—*Efficiency* Requirements" (See Section 6.4.1.2 for water-cooled centrifugal water-chilling packages that are designed to operate at nonstandard conditions.)
d. 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"
e. 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"
f. Table 6.8.1-6, "Gas- and Oil-Fired *Boilers*—Minimum *Efficiency* Requirements"
g. Table 6.8.1-7, "Performance Requirements for Heat-Rejection *Equipment*"
h. Table 6.8.1-8, "Heat Transfer *Equipment*"
i. Table 6.8.1-9, "Electrically Operated Variable-Refrigerant-Flow Air Conditioners—Minimum *Efficiency* Requirements"
j. Table 6.8.1-10, "Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps—Minimum *Efficiency* Requirements
k. Table 6.8.1-11, "Air Conditioners and *Condensing Units* Serving *Computer Rooms*"
l. Table 6.8.1-12, "Commercial Refrigerators and Freezers—Minimum *Efficiency* Requirements"
~~m.~~ Table 6.8.1-13, "Commercial Refrigeration—Minimum *Efficiency* Requirements"
n. Table 6.8.1-14, "Vapor-Compression-Based *Indoor Pool Dehumidifiers*—Minimum *Efficiency* Requirements"
o. Table 6.8.1-15, "Electrically Operated *DX-DOAS Units*, Single-Package and Remote Condenser, without *Energy* Recovery—Minimum *Efficiency* Requirements"

Table 6.8.1-16, "Electrically Operated *DX-DOAS Units*, Single-Package and Remote Condenser, with *Energy* Recovery—Minimum *Efficiency* Requirements"r. Table 6.8.1-18, Heat Pump and Heat Recovery Chiller Packages – Minimum Efficiency Requirement

t. Table 6.8.1-20, Walk-In Cooler and Freezer Display Door Efficiency Requirements

u. Table 6.8.1-21, Walk-In Cooler and Freezer Non-display Door Efficiency Requirements

v. Table 6.8.1-22, Walk-In Cooler and Freezer Refrigeration System Efficiency Requirements

All furnaces with input ratings of ≥225,000 Btu/h, including electric furnaces, that are not located within the *conditioned space* shall have jacket losses not exceeding 0.75% of the input rating. Air conditioners primarily serving *computer rooms* and covered by

ASHRAE Standard 127 shall meet the requirements in Table 6.8.1-11. All other air conditioners shall meet the requirements in Table 6.8.1-1.

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6.4.5 Walk-In Coolers and Walk-In Freezers

Site-assembled or site-constructed *walk-in coolers* and *walk-in freezers* shall conform to the following requirements:

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

Exception to 6.4.5(a)
Doors wider than 3 ft 9 in. or taller than 7 ft.

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

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

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 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.

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

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

i. Antisweat heaters without antisweat heater *controls* shall have a total *door* rail, glass, and frame heater power draw of ≤7.1 W/ft^2 of *door* opening for *walk-in freezers* and 3.0 W/ft^2 of *door* opening for *walk-in coolers*.

j. 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.

k. Condenser fan motors that are less than 1 hp shall use electronically commutated motors, permanent split-capacitor-type motors, or three-phase motors.

l. All *walk-in freezers* shall incorporate temperature-based defrost termination *control* with a time limit default. The defrost cycle shall terminate first on an upper temperature limit breach and second upon a time limit breach.

Exception to 6.4.5(l)
Walk-in coolers and *walk-in freezers* combined in a single enclosure greater than 3000 ft^2.

Doors in *walk-in coolers* and *walk-in freezers* shall meet the requirements of Tables 6.8.1-20 and 6.8.1-21. *Walk-in cooler* and *walk-in freezer* refrigeration systems, except for walk-in process cooling refrigeration systems as defined in 10 CFR 431.302, shall meet the requirements of Table 6.8.1-22.

…

6.5.3 Air System Design and Control

6.5.3.1 Fan System Power and Efficiency

6.5.3.1.1

Each *HVAC system* having a total *fan system motor nameplate horsepower* exceeding 5 hp at *fan system design conditions* shall not exceed the allowable *fan system motor nameplate horsepower* (Option 1) or fan *system* bhp (Option 2) as shown in Table 6.5.3.1-1. This includes supply fans, return/relief fans, exhaust fans, and fan-powered *terminal* units associated with *systems* providing heating or cooling capability that operate at *fan system design conditions*. Single-zone *VAV systems* shall comply with the constant-volume fan power limitation.

Exceptions to 6.5.3.1.1

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

6.5.3.1.2 Fan Motor ~~Nameplate Horsepower~~ Selection

1. For each fan less than 6 bhp, the selected fan motor shall be no larger than the first available motor with a *nameplate rating* ~~size~~ greater than 1.5 times the bhp.

2. For each fan 6 bhp and larger, the selected fan motor shall be no larger than the first available motor with a *nameplate rating* greater than 1.3 times the bhp.

The fan bhp must be indicated on the design documents to allow for compliance verification by the *building official*.

Exceptions to 6.5.3.1.2

1. *Motors* equipped with electronic speed *control devices* to vary the fan airflow as a function of load. ~~For fans less than 6 bhp, where the first available motor larger than the bhp has a *nameplate rating* within 50% of the bhp, the next larger nameplate motor size may be selected.~~
2. ~~For fans 6 bhp and larger, where the first available motor larger than the bhp has a *nameplate rating* within 30% of the bhp, the next larger nameplate motor size may be selected.~~
2. *Systems* complying with Section 6.5.3.1.1, Option 1.
3. Fans with motor *nameplate horsepower* of less than 1 hp.
4. Fans with a *fan nameplate electrical input power* of less than 0.89 kW.

6.5.3.1.3 Fan Efficiency

Each ~~F~~fan~~s~~ and *fan array* shall have a ~~*fan efficiency grade (FEG) of 67 fan energy index (FEI)*~~ of 1.00 or higher. ~~based on *manufacturers'* certified data, as defined by AMCA 205. The total *efficiency* of the fan at the design point of operation shall be within 15 percentage points of the maximum total *efficiency* of the fan.~~Each fan and *fan array* used for a *variable-air-volume system* that meets the requirements of Section 6.5.3.2.1 shall have an *FEI* of 0.95 or higher. The *FEI* for *fan arrays* shall be calculated in accordance with AMCA 208 Annex C.

Exceptions to 6.5.3.1.3

1. ~~Individual fans~~ Fans that are not *embedded fans* with a motor *nameplate horsepower* of less than ~~5~~1.0 hp (0.75 kW) or with a *fan nameplate electrical input power* of less than 0.89 kW ~~or less that are not part of a group operated as the functional equivalent of a single fan~~.
2. *Embedded fans* and *fan arrays* with ~~Multiple fans in series or parallel (e.g., fan arrays) that have~~ a combined motor *nameplate horsepower* of 5 hp or less or with a *fan system electrical input power* of 4.1 kW or less ~~and are operated as the functional equivalent of a single fan~~.
3. *Embedded fans* ~~Fans~~ that are part of *equipment* listed under Section 6.4.1.1.
4. *Embedded fans*~~Fans~~ included in *equipment* bearing a third-party-certified seal for air or *energy* performance of the *equipment* package.
5. ~~Powered *wall/roof* ventilators (*PRV*).~~Ceiling fans, i.e., nonportable devices suspended from a ceiling or overhead structure for circulating air via the rotation of fan blades.
6. Fans used for moving gases at temperatures above 482°F (250°C).
7. Fans used for operation in explosive atmospheres.
8. Reversible fans used for tunnel ventilation.
9. Fans outside the scope of AMCA ~~205~~208.
10. Fans that are intended to only operate during emergency conditions.

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6.5.5 Heat-Rejection Equipment

6.5.5.1 General

Section 6.5.5 applies to heat-rejection *equipment* used in comfort cooling *systems*, such as air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers, and evaporative condensers.

Exception to 6.5.5.1

Heat-rejection devices whose *energy* use is included in the *equipment efficiency* ratings listed in Tables 6.8.1-1 through 6.8.1-4 and Tables 6.8.1-9 through 6.8.1-16.

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* 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 modulate the fan speed to *control* the leaving fluid temperature or condensing temperature/pressure of the heat-rejection device.

Exceptions to 6.5.5.2.1

1. Condenser fans serving multiple refrigerant or fluid cooling circuits.
2. Condenser fans serving flooded condensers.

6.5.5.2.2

Multicell heat-rejection *equipment* with variable-speed fan drives shall

a. operate the maximum number of fans allowed that comply with the *manufacturer*'s requirements for all *system* components and

b. *control* all fans to the same fan speed required for the instantaneous cooling duty, as opposed to staged (on/off) operation. Minimum fan speed shall comply with the minimum allowable speed of the fan drive *system* per the *manufacturer*'s recommendations.

6.5.5.3 Limitation on Centrifugal Fan Open-Circuit Cooling Towers

Centrifugal fan open-circuit cooling towers with a combined rated capacity of 1100 gpm or greater at 95°F condenser water return, 85°F condenser water supply, and 75°F *outdoor air* wet-bulb temperature shall meet the *energy efficiency* requirement for axial fan open-circuit cooling towers listed in Table 6.8.1-7.

Exception to 6.5.5.3

Centrifugal open-circuit cooling towers that are ducted (inlet or discharge) or require external sound attenuation.

6.5.5.4 Tower Flow Turndown

Open-circuit cooling towers used on water-cooled chiller *systems* that are configured with multiple- or variable-speed condenser water pumps shall be designed so that all open-circuit cooling tower cells can be run in parallel with the larger of

a. the flow that is produced by the smallest pump at its minimum expected flow rate or
b. 50% of the design flow for the cell.

6.5.6 Energy Recovery

6.5.6.1 Exhaust Air Energy Recovery

6.5.6.1.1 Nontransient *dwelling units*

Nontransient dwelling units shall be provided with outdoor air energy recovery ventilation systems. For *nontransient dwelling units*, *energy* recovery *systems* shall result in an *enthalpy recovery ratio* of at least 50% at cooling design condition and at least 60% at heating design condition. The *energy* recovery *system* shall provide the required *enthalpy recovery ratio* at both heating and cooling *design conditions*, unless one mode is not required for the climate zone by the exceptions below.

Exceptions to 6.5.6.1.1:

1. *Nontransient dwelling units* in Climate Zone 3C.
2. *Nontransient dwelling units* with no more than 500 ft^2 of conditioned floor area in Climate Zone 0, 1, 2, 3, 4C, and 5C.
3. *Enthalpy recovery ratio* requirements at heating design condition in Climate Zones 0, 1, and 2.
4. *Enthalpy recovery ratio* requirements at cooling design condition in Climate Zones 4, 5, 6, 7, 8.

6.5.6.1.2 Spaces other than nontransient *dwelling units*

Each fan *system* serving spaces other than *nontransient dwelling units* shall have an *energy* recovery *system* where ~~when~~ the design supply fan airflow rate exceeds the value listed in Tables 6.5.6.1.2-1 and ~~–~~6.5.6.1.2-2, based on the climate zone and percentage of *outdoor air* at design airflow conditions. Table 6.5.6.1.2-1 shall be used for all *ventilation systems* that operate less than 8000 hours per year, and Table 6.5.6.1.2-2 shall be used for all *ventilation systems* that operate 8000 or more hours per year.

For spaces other than *nontransient dwelling units*, e*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 6.5.6.1.2

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. *Enthalpy recovery ratio* requirements at heating design condition ~~Heating *energy* recovery~~ in Climate Zones 0, 1, and 2.
5. *Enthalpy recovery ratio* requirements at cooling design condition ~~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.

9 *Systems* expected to operate less than 20 hours per week at the *outdoor air* percentage covered by Table 6.5.6.1.2-1.

Table 6.5.6.1.2-1 Exhaust Air *Energy* Recovery Requirements for *Ventilation Systems* Operating Less than 8000 Hours per Year

	% *Outdoor Air* at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
Climate Zone	**Design Supply Fan Airflow Rate, cfm**							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 5C	NR	NR	NR	NR	≥26000	≥12000	≥5000	≥4000
6B	≥28,000	≥26,500	≥11000	≥5500	≥4500	≥3500	≥2500	≥1500
0A, 1A, 2A, 3A, 4A, 5A, 6A	≥26,000	≥16,000	≥5500	≥4500	≥3500	≥2000	≥1000	≥120
7,8	≥4500	≥4000	≥2500	≥1000	≥140	≥120	≥100	≥80

NR—Not required

Table 6.5.6.1.2-2 Exhaust Air *Energy* Recovery Requirements for *Ventilation Systems* Operating Greater than or Equal to 8000 Hours per Year

	% *Outdoor Air* at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and < 80%	≥80%
Climate Zone	**Design Supply Fan Airflow Rate, cfm**							
3C	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 3B, 4C, 5C	NR	≥19,500	≥9000	≥5000	≥4000	≥3000	≥1500	≥120
0A, 1A, 2A, 3A, 4B, 5B	≥2500	≥2000	≥1000	≥500	≥140	≥120	≥100	≥80
4A, 5A, 6A, 6B, 7, 8	≥200	≥130	≥100	≥80	≥70	≥60	≥50	≥40

NR—Not required

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* 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* hot-water draw to 85°F.

Exceptions to 6.5.6.2.2

1. Facilities that employ condenser heat recovery for *space* heating with a heat recovery design exceeding 30% of the peak water-cooled condenser load at *design conditions*.
2. Facilities that provide 60% of their *service water heating* from *site-solar energy* or *site-recovered energy* or from other sources.

6.5.6.3. Heat Recovery for Space Conditioning

Where heating water is used for space heating, a condenser heat recovery *system* shall be installed provided all of the following are true:

a. The building is an acute inpatient hospital, where the building or portion of a building is used on a 24-hour basis for the inpatient medical, obstetric, or surgical care for patients.
b. The total design chilled water capacity for the acute inpatient hospital, either air cooled or water cooled, required at cooling *design conditions* exceeds 3,600,000 Btu/h (1,100 kW) of cooling.
c. Simultaneous heating and cooling occurs above 60°F (16°C) *outdoor air temperature*.

The required heat recovery *system* shall have a cooling capacity that is at least 7% of the total design chilled water capacity of the acute inpatient hospital at peak *design conditions*.

Exceptions to 6.5.6.3

1. Buildings that provide ≥ 60% of their reheat energy from *on-site renewable energy* or *site-recovered energy*.
2. Buildings in climate zones 5C, 6B, 7, & 8.

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6.8 Minimum Equipment Efficiency Tables

6.8.1 Minimum Efficiency Requirement Listed Equipment—Standard Rating and Operating Conditions

Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and *Condensing Units*—Minimum *Efficiency* Requirements *(Continued)*

***Equipment* Type**	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**Minimum *Efficiency***	**Test Procedure[a]**
Air conditioners, air cooled	<65,000 Btu/h[b]	All	Split *system*, three phase and applications outside US single phase[b]	13.0 *SEER* before 1/1/2023 13.4 *SEER2* after 1/1/2023	AHRI 210/240-2017 before 1/1/2023

			Single package, three phase and applications outside US single phase[b]	14 *SEER* before 1/1/2023 13.4 *SEER2* after 1/1/2023	AHRI 210/240-2023 after 1/1/2023
~~Through the wall, air cooled~~Space constrained air cooled	≤30,000 Btu/h[b]	All	Split *system*, three phase and applications outside US single phase[b]	12.0 *SEER* before 1/1/2023 11.7 *SEER2* after 1/1/2023	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023
			Single package, three phase and applications outside US single phase[b]	12.0 *SEER* before 1/1/2023 11.7 *SEER2* after 1/1/2023	
Small duct, high velocity, air cooled	<65,000 Btu/h[b]	All	Split *system*, three phase and applications outside US single phase[b]	~~11.0~~ 12.0 *SEER* before 1/1/2023 12.0 *SEER2* after 1/1/2023	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023
Air conditioners, air cooled	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)	Split *system* and single package	11.2 *EER* 12.9 *IEER* before 1/1/2023 14.8 *IEER* after 1/1/2023	AHRI 340/360
		All other		11.0 *EER* 12.7 *IEER* before 1/1/2023 14.6 *IEER* after 1/1/2023	
	≥135,000 Btu/h and <240,000 Btu/h	*Electric resistance* (or none)		11.0 *EER* 12.4 *IEER* before 1/1/2023 14.2 *IEER* after 1/1/2023	
		All other		10.8 *EER* 12.2 *IEER* before 1/1/2023 14.0 *IEER* after 1/1/2023	
	≥240,000 Btu/h and <760,000 Btu/h	*Electric resistance* (or none)		10.0 *EER* 11.6 *IEER* before 1/1/2023 13.2 *IEER* after 1/1/2023	
		All other		9.8 *EER* 11.4 *IEER* before 1/1/2023 13.0 *IEER* after 1/1/2023	
	≥760,000 Btu/h	*Electric resistance* (or none)		9.7 *EER* 11.2 *IEER* before 1/1/2023 12.5 *IEER* after 1/1/2023	
		All other		9.5 *EER* 11.0 *IEER* before 1/1/2023 12.3 *IEER* after 1/1/2023	
Air conditioners,	<65,000 Btu/h	All	Split *system* and	12.1 *EER*	AHRI

water cooled			single package	12.3 *IEER*	210/240
	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)		12.1 *EER* 13.9 *IEER*	AHRI 340/360
		All other		11.9 *EER* 13.7 *IEER*	
	≥135,000 Btu/h and <240,000 Btu/h	*Electric resistance* (or none)		12.5 *EER* 13.9 *IEER*	
		All other		12.3 *EER* 13.7 *IEER*	
	≥240,000 Btu/h and <760,000 Btu/h	*Electric resistance* (or none)		12.4 *EER* 13.6 *IEER*	
		All other		12.2 *EER* 13.4 *IEER*	
	≥760,000 Btu/h	*Electric resistance* (or none)		12.2 *EER* 13.5 *IEER*	
		All other		12.0 *EER* 13.3 *IEER*	
Air conditioners, evaporatively cooled	<65,000 Btu/h[b]	All	Split *system* and single package	12.1 *EER* 12.3 *IEER*	AHRI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)		12.1 *EER* 12.3 *IEER*	AHRI 340/360
		All other		11.9 *EER* 12.1 *IEER*	
	≥135,000 Btu/h and <240,000 Btu/h	*Electric resistance* (or none)		12.0 *EER* 12.2 IERR	
		All other		11.8 *EER* 12.0 *IEER*	
	≥240,000 Btu/h and <760,000 Btu/h	*Electric resistance* (or none)		11.9 *EER* 12.1 *IEER*	
		All other		11.7 *EER* 11.9 *IEER*	
	≥760,000 Btu/h	*Electric resistance* (or none)		11.7 *EER* 11.9 *IEER*	
		All other		11.5 *EER* 11.7 *IEER*	
Condensing units, air cooled	≥135,000 Btu/h			10.5 *EER* 11.8 *IEER*	AHRI 365
Condensing units, water cooled	≥135,000 Btu/h			13.5 *EER* 14.0 *IEER*	AHRI 365
Condensing units, evaporatively cooled	≥135,000 Btu/h			13.5 *EER* 14.0 *IEER*	AHRI 365

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Single-phase, air-cooled air conditioners <65,000 Btu/h are regulated by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430. *SEER* values for single-phase products are set by the U.S. Department of Energy.

Informative Note: See Informative Appendix F for the U.S. Department of Energy minimum *efficiency* requirements of single-phase air conditioners for US applications.

Table 6.8.1-2 Electrically Operated Unitary and Applied Heat Pumps—Minimum *Efficiency* Requirements *(Continued)*

***Equipment* Type**	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**Minimum *Efficiency***	**Test Procedure[a]**
Air cooled (cooling mode)	<65,000 Btu/h[b]	All	Split *system*, three phase	14 *SEER*	AHRI 210/240
			Single package, three phase	14 *SEER*	

Through the *wall*, air cooled (cooling mode)	≤30,000 Btu/h[b]	All	Split *system*, three phase	12.0 *SEER*	AHRI 210/240
			Single package, three phase	12.0 *SEER*	
Small duct, high velocity, air cooled	<65,000 Btu/h[b]	All	Split *System*, three phase	11.0 *SEER*	AHRI 210/240
Air cooled (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)	Split *system* and single package	11.0 *EER* 12.2 *IEER*	AHRI 340/360
		All other		10.8 *EER* 12.0 *IEER*	
	≥135,000 Btu/h and <240,000 Btu/h	*Electric resistance* (or none)		10.6 *EER* 11.6 *IEER*	
		All other		10.4 *EER* 11.4 *IEER*	
	≥240,000 Btu/h	*Electric resistance* (or none)		9.5 *EER* 10.6 *IEER*	
		All other		9.3 *EER* 10.4 *IEER*	
Water to air, water loop (cooling mode)	<17,000 Btu/h	All	86°F entering water	12.2 *EER*	ISO 13256-1
	≥17,000 Btu/h and <65,000 Btu/h			13.0 *EER*	
	≥65,000 Btu/h and <135,000 Btu/h			13.0 *EER*	
Water to air, groundwater (cooling mode)	<135,000 Btu/h	All	59°F entering water	18.0 *EER*	ISO 13256-1
Brine to air, ground loop (cooling mode)	<135,000 Btu/h	All	77°F entering water	14.1 *EER*	ISO 13256-1
Water to water, water loop (cooling mode)	<135,000 Btu/h	All	86°F entering water	10.6 *EER*	ISO 13256-2
Water to water, groundwater (cooling mode)	<135,000 Btu/h	All	59°F entering water	16.3 *EER*	ISO 13256-2
Brine to water, ground loop (cooling mode)	<135,000 Btu/h	All	77°F entering water	12.1 *EER*	ISO 13256-2
Air cooled (heating mode)	<65,000 Btu/h[b] (cooling capacity)		Split *system*, three phase	8.2 *HSPF*	AHRI 210/240
			Single package, three phase	8.0 *HSPF*	
Through the *wall*, air cooled (heating mode)	≤30,000 Btu/h[b] (cooling capacity)		Split *system*, three phase	7.4 *HSPF*	AHRI 210/240
			Single package, three phase	7.4 *HSPF*	
Small duct high velocity, air cooled (heating mode)	<65,000 Btu/h[b]		Split *system*, three phase	6.8 *HSPF*	AHRI 210/240
Air cooled (heating mode)	≥65,000 Btu/h[c] and		47°F db/43°F wb *outdoor air*	3.3 COP_H	AHRI 340/360

ANSI/ASHRAE/IES addenda t, v, y, al, an, ao, at, aw, ay, az, ba, bb, bd, bf, bh, bi, bj, bk, bl bq, bt, bx, bz, ca, cc, ce, cg, ch, ci, cj, cn, and co to ANSI/ASHRAE/IES Standard 90.1-2016

	<135,000 Btu/h (cooling capacity)		17°F db/15°F wb *outdoor air*	2.25 COP_H	
	≥135,000 Btu/h[c] (cooling capacity)		47°F db/43°F wb *outdoor air*	3.2 COP_H	
			17°F db/15°F wb *outdoor air*	2.05 COP_H	
Water to air, water loop (heating mode)	<135,000 Btu/h (cooling capacity)		68°F entering water	4.3 COP_H	ISO 13256-1
Water to air, groundwater (heating mode)	<135,000 Btu/h (cooling capacity)		50°F entering water	3.7 COP_H	ISO 13256-1
Brine to air, ground loop (heating mode)	<135,000 Btu/h (cooling capacity)		32°F entering fluid	3.2 COP_H	ISO 13256-1
Water to water, water loop (heating mode)	<135,000 Btu/h (cooling capacity)		68°F entering water	3.7 COP_H	ISO 13256-2
Water to water, groundwater (heating mode)	<135,000 Btu/h (cooling capacity)		50°F entering water	3.1 COP_H	ISO 13256-2
Brine to water, ground loop (heating mode)	<135,000 Btu/h (cooling capacity)		32°F entering fluid	2.5 COP_H	ISO 13256-2

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Single-phase, air-cooled heat pumps <65,000 Btu/h are regulated by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430. *SEER* and *HSPF* values for single-phase products are set by the U.S. Department of Energy.
Informative Note: See Informative Appendix F for the U.S. Department of Energy minimum.

Table 6.8.1-3 Water-Chilling Packages—Minimum *Efficiency* Requirements[a,b,e]

***Equipment* Type**	**Size Category**	**Units**	**Path A**	**Path B**	**Test Procedure[c]**
Air-cooled chillers	<150 tons	*EER* (Btu/Wh)	≥10.100 FL	≥9.700 FL	AHRI 550/590
			≥13.700 *IPLV*.IP	≥15.800 *IPLV*.IP	
	≥150 tons		≥10.100 FL	≥9.700 FL	
			≥14.000 *IPLV*.IP	≥16.100 *IPLV*.IP	
Air-cooled without condenser, electrically operated	All capacities	*EER* (Btu/Wh)	Air-cooled chillers without condenser must be rated with matching condensers and comply with air-cooled chiller *efficiency* requirements		AHRI 550/590
Water-cooled, electrically operated positive displacement	<75 tons	*kW*/ton	≤0.750 FL	≤0.780 FL	AHRI 550/590
			≤0.600 *IPLV*.IP	≤0.500 *IPLV*.IP	
	≥75 tons and <150 tons		≤0.720 FL	≤0.750 FL	
			≤0.560 *IPLV*.IP	≤0.490 *IPLV*.IP	
	≥150 tons and <300 tons		≤0.660 FL	≤0.680 FL	
			≤0.540 *IPLV*.IP	≤0.440 *IPLV*.IP	
	≥300 tons and		≤0.610 FL	≤0.625 FL	

	<600 tons		≤0.520 *IPLV*.IP	≤0.410 *IPLV*.IP	
	≥600 tons		≤0.560 FL	≤0.585 FL	
			≤0.500 *IPLV*.IP	≤0.380 *IPLV*.IP	
Water cooled, electrically operated centrifugal	<150 tons	*kW*/ton	≤0.610 FL	≤0.695 FL	AHRI 550/590
			≤0.550 *IPLV*.IP	≤0.440 *IPLV*.IP	
	≥150 tons and <300 tons		≤0.610 FL	≤0.635 FL	
			≤0.550 *IPLV*.IP	≤0.400 *IPLV*.IP	
	≥300 tons and <400 tons		≤0.560 FL	≤0.595 FL	
			≤0.520 *IPLV*.IP	≤0.390 *IPLV*.IP	
	≥400 tons and <600 tons		≤0.560 FL	≤0.585 FL	
			≤0.500 *IPLV*.IP	≤0.380 *IPLV*.IP	
	≥600 tons		≤0.560 FL	≤0.585 FL	
			≤0.500 *IPLV*.IP	≤0.380 *IPLV*.IP	
Air-cooled absorption, single effect	All capacities	*COP* (W/W)	≥0.600 FL	NA[d]	AHRI 560
Water-cooled absorption, single effect	All capacities	*COP* (W/W)	≥0.700 FL	NA[d]	AHRI 560
Absorption double effect, indirect fired	All capacities	*COP* (W/W)	≥1.000 FL	NA[d]	AHRI 560
			≥1.050 *IPLV*.IP		
Absorption double effect, direct fired	All capacities	*COP* (W/W)	≥1.000 FL	NA[d]	AHRI 560
			≥1.000 *IPLV*		

a. The requirements for centrifugal chillers shall be adjusted for nonstandard rating conditions per Section 6.4.1.2.1 and are only applicable for the range of conditions listed there. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.
b. Both the full-load and *IPLV*.IP requirements must be met or exceeded to comply with this standard. When there is a Path B, compliance can be with either Path A or Path B for any application.
c. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
d. NA means the requirements are not applicable for Path B, and only Path A can be used for compliance.
e. FL is the full-load performance requirements, and *IPLV*.IP is for the part-load performance requirements.

~~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[Errata2])[c] (before 1/1/2015) 14.0 – (0.300 × Cap/1000[Errata3])[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[Errata4])[c] *EER*	AHRI 310/380
PTHP (cooling mode) standard size	All capacities	95°F db *outdoor air*	14.0 – (0.300 × Cap/1000[Errata5])[c]	AHRI 310/380
PTHP (cooling mode) nonstandard size[b]	All capacities	95°F db *outdoor air*	10.8 – (0.213 × Cap/1000[Errata6])[c] *EER*	AHRI 310/380
PTHP (heating mode) standard size	All capacities		3.7 – (0.052 × Cap/1000[Errata7])[c] COP_H	AHRI 310/380
PTHP (heating mode) nonstandard size[b]	All capacities		2.9 – (0.026 × Cap/1000[Errata8])[c]	AHRI 310/380

			COP_H	
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* 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* 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* 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 6.8.1-5 Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters—Minimum *Efficiency* Requirements

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum *Efficiency*	Test Procedure[a]
Warm-air furnace, gas fired	<225,000 Btu/h	Maximum capacity[c]	78% *AFUE* or 80% E_t [b,d]	DOE 10 CFR Part 430 or Section 2.39, Thermal *Efficiency*, ANSI Z21.47
	□225,000 Btu/h		80% E_t[d]	Section 2.39, Thermal *Efficiency*, ANSI Z21.47
Warm-air furnace, oil fired	<225,000 Btu/h	Maximum capacity[c]	78% *AFUE* or 80% E_t[b,d]	DOE 10 CFR Part 430 or Section 42, Combustion, UL 727
	≥225,000 Btu/h		81% E_t[d]	Section 42, Combustion, UL 727
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[c]	80% E_c[e]	Section 2.10, *Efficiency*, ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[c]	80% E_c[e,f]	Section 2.10, *Efficiency*, ANSI Z83.8
Warm-air unit heaters, oil fired	All capacities	Maximum capacity[c]	80% E_c[e,f]	Section 40, Combustion, UL 731

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Combination units not covered by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430 (three-phase power or cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating.
c. Compliance of multiple firing rate units shall be at the maximum firing rate.
d. E_t = thermal *efficiency*. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a *flue damper*. A *vent damper* is an acceptable alternative to a *flue damper* for those furnaces where combustion air is drawn from the *conditioned space*.
e. E_c = combustion *efficiency* (100% less flue losses). See test procedure for detailed discussion.
f. As of August 8, 2008, according to the *Energy* Policy Act of 2005, units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an *automatic flue damper*.

Table 6.8.1-6 Gas- and Oil-Fired *Boilers*—Minimum *Efficiency* Requirements

Equipment Type[a]	Subcategory or Rating Condition	Size Category (Input)	Minimum *Efficiency*	*Efficiency* as of 3/2/2020	Test Procedure
Boilers, hot water	Gas fired	<300,000 Btu/h[f,g]	82% *AFUE*	82% *AFUE*	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	80% E_t	80% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	82% E_c	82% E_c	
	Oil fired[e]	<300,000 Btu/h[g]	84% *AFUE*	84% *AFUE*	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	82% E_t	82% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	84% E_c	84% E_c	
Boilers, steam	Gas fired	<300,000 Btu/h[f]	80% *AFUE*	80% *AFUE*	10 CFR Part 430
	Gas fired—all, except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	79% E_t	79% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	79% E_t	79% E_t	
	Gas fired—natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	77% E_t	79% E_t	
		>2,500,000 Btu/h[a]	77% E_t	79% E_t	
	Oil fired[e]	<300,000 Btu/h	82% *AFUE*	82% *AFUE*	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	81% E_t	81% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	81% E_t	81% E_t	

a. These requirements apply to *boilers* with rated input of 8,000,000 Btu/h or less that are not packaged *boilers* and to all packaged *boilers*. Minimum

efficiency requirements for *boilers* cover all capacities of packaged *boilers*.
b. E_c = combustion *efficiency* (100% less flue losses). See reference document for detailed information.
c. E_t = thermal *efficiency*. See reference document for detailed information.
d. Maximum capacity—minimum and maximum ratings as provided for and allowed by the unit's *controls*.
e. Includes oil-fired (residual).
f. *Boilers* shall not be equipped with a constant burning pilot light.
g. A *boiler* not equipped with a tankless domestic water-heating coil shall be equipped with an *automatic* means for adjusting the temperature of the water such that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of the water supplied.

Table 6.8.1-7 Performance Requirements for Heat Rejection *Equipment*—Minimum *Efficiency* Requirements ~~*(Continued)*~~

***Equipment* Type**	**Total *System* Heat-Rejection Capacity at Rated Conditions**	**Subcategory or Rating Condition[h]**	**Performance Required[a,b,c,f,g]**	**Test Procedure[d,e]**
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥40.2 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥20.0 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Centrifugal closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥7.0 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Propeller or axial fan dry coolers (air cooled fluid coolers)	All	115°F entering water 105°F leaving water 95°F entering db	≥4.5 gpm/hp	CTI ATC-105DS
Propeller or axial fan evaporative condensers	All	R-448A ~~507A~~ test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥160,000 ~~157,000~~ Btu/h·hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	Ammonia test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥134,000 Btu/h·hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-448A ~~507A~~ test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥137,500 ~~135,000~~ Btu/h·hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	Ammonia test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥110,000 Btu/h·hp	CTI ATC-106
Air cooled condensers	All	125°F condensing temperature 190°F entering gas temperature 15°F subcooling 95°F entering db	≥176,000 Btu/h·hp	AHRI 460

a. For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 6.8.1-7 divided by the fan motor nameplate power.
b. For purposes of this table, closed-circuit cooling tower performance is defined as the process water flow rating of the tower at the thermal rating condition listed in Table 6.8.1-7 divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.
c. For purposes of this table, dry cooler performance is defined as the process water flow rating of the unit at the thermal rating condition listed in Table 6.8.1-7 divided by the total fan motor nameplate power of the unit ~~For purposes of this table,~~ and air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the total fan motor nameplate power of the unit.
d. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
e. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections. The certification requirements do not apply to field-erected cooling towers.
f. All cooling towers shall comply with the minimum *efficiency* listed in the table for that specific type of tower with the capacity effect of any project-specific accessories and/or options included in the capacity of the cooling tower.
g. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table, divided by the

sum of the fan motor nameplate power and the integral spray pump nameplate power.

h. Requirements for evaporative condensers are listed with ammonia (R-717) and R-~~448A~~507A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-~~448A~~507A must meet the minimum *efficiency* requirements listed above with R-~~448A~~507A as the test fluid. For ammonia, the condensing temperature is defined as the saturation temperature corresponding to the refrigerant pressure at the condenser entrance. For R-448A, which is a zeotropic refrigerant, the condensing temperature is defined as the arithmetic average of the Dew Point and the Bubble Point temperatures corresponding to the refrigerant pressure at the condenser entrance.

Table 6.8.1-8 Heat Transfer *Equipment*—Minimum *Efficiency* Requirements

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

a. NR = no requirement
b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

Table 6.8.1-9 Electrically Operated Variable-Refrigerant-Flow Air Conditioners—Minimum *Efficiency* Requirements

***Equipment* Type**	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**Minimum *Efficiency***	**Test Procedure**
VRF air conditioners, air cooled	<65,000 Btu/h	All	*VRF* multisplit *system*	13.0 *SEER*	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)	*VRF* multisplit *system*	11.2 *EER* 13.1 *IEER* (before 1/1/2017) 15.5 *IEER* (as of 1/1/2017)	
	≥135,000 Btu/h and <240,000 Btu/h	*Electric resistance* (or none)	*VRF* multisplit *system*	11.0 *EER* 12.9 *IEER* (before 1/1/2017) 14.9 *IEER* (as of 1/1/2017)	
	≥240,000 Btu/h	*Electric resistance* (or none)	*VRF* multisplit *system*	10.0 *EER* 11.6 *IEER* (before 1/1/2017) 13.9 *IEER* (as of 1/1/2017)	

Table 6.8.1-10 Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps—Minimum *Efficiency* Requirements

***Equipment* Type**	**Size Category**	**Heating Section Type**	**Subcategory or Rating Condition**	**Minimum *Efficiency***	**Test Procedure**
VRF air cooled (cooling mode)	<65,000 Btu/h	All	*VRF* multisplit *system*	13.0 *SEER*	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)		11.0 *EER* 12.9 *IEER* (before 1/1/2017) 14.6 *IEER* (as of 1/1/2017)	
			VRF multisplit *system* with heat recovery	10.8 *EER* 12.7 *IEER* (before 1/1/2017) 14.4 *IEER* (as of 1/1/2017)	
	≥135,000 Btu/h and <240,000 Btu/h		*VRF* multisplit *system*	10.6 *EER* 12.3 *IEER* (before 1/1/2017) 13.9 *IEER* (as of 1/1/2017)	
			VRF multisplit *system* with heat recovery	10.4 *EER* 12.1 *IEER* (before 1/1/2017) 13.7 *IEER*	

				(as of 1/1/2017)	
	≥240,000 Btu/h		*VRF* multisplit *system*	9.5 *EER* 11.0 *IEER* (before 1/1/2017) 12.7 *IEER* (as of 1/1/2017)	
			VRF multisplit *system* with heat recovery	9.3 *EER* 10.8 *IEER* (before 1/1/2017) 12.5 *IEER* (as of 1/1/2017)	
VRF water source (cooling mode)	<65,000 Btu/h	All	*VRF* multisplit *systems* 86°F entering water	12.0 *EER* 16.0 *IEER* (as of 1/1/2018)	AHRI 1230
			VRF multisplit *systems* with heat recovery 86°F entering water	11.8 *EER* 15.8 *IEER* (as of 1/1/2018)	
	≥65,000 Btu/h and <135,000 Btu/h		*VRF* multisplit *system* 86°F entering water	12.0 *EER* 16.0 *IEER* (as of 1/1/2018)	
			VRF multisplit *system* with heat recovery 86°F entering water	11.8 *EER* 15.8 *IEER* (as of 1/1/2018)	
	≥135,000 Btu/h and <240,000 Btu/h		*VRF* multisplit *system* 86°F entering water	10.0 *EER* 14.0 *IEER* (as of 1/1/2018)	
			VRF multisplit *system* with heat recovery 86°F entering water	9.8 *EER* 13.8 *IEER* (as of 1/1/2018)	
	≥240,000 Btu/h		*VRF* multisplit *system* 86°F entering water	10.0 *EER* (before 1/1/2018) 12.0 *IEER* (as of 1/1/2018)	
			VRF multisplit *system* with heat recovery 86°F entering water	9.8 *EER* (before 1/1/2018) 11.8 *IEER* (as of 1/1/2018)	
VRF groundwater source (cooling mode)	<135,000 Btu/h	All	*VRF* multisplit *system* with heat recovery[Errata9] 59°F entering water	16.2 *EER*	AHRI 1230
			VRF multisplit *system* with heat recovery 59°F entering water	16.0 *EER*	
	≥135,000 Btu/h		*VRF* multisplit *system* with heat recovery[Errata10] 59°F entering water	13.8 *EER*	
			VRF multisplit *system* with heat recovery 59°F entering water	13.6 *EER*	
VRF ground source (cooling mode)	<135,000 Btu/h	All	*VRF* multisplit *system* 77°F entering water	13.4 *EER*	AHRI 1230
			VRF multisplit *system* with heat recovery 77°F entering water	13.2 *EER*	
	≥135,000 Btu/h		*VRF* multisplit *system* 77°F entering water	11.0 *EER*	
			VRF multisplit *system* with heat recovery 77°F entering water	10.8 *EER*	

VRF air cooled (heating mode)	<65,000 Btu/h (cooling capacity)		*VRF* multisplit *system*	7.7 *HSPF*	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 47°F db/43°F wb *outdoor air*	3.3 COP_H	
			17°F db/15°F wb *outdoor air*	2.25 COP_H	
	≥135,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 47°F db/43°F wb *outdoor air*	3.2 COP_H	
			17°F db/15°F wb *outdoor air*	2.05 COP_H	
VRF water source (heating mode)	<65,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 68°F entering water	4.2 COP_H (before 1/1/2018) 4.3 COP_H (as of 1/1/2018)	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 68°F entering water	4.2 COP_H (before 1/1/2018) 4.3 COP_H (as of 1/1/2018)	
	≥135,000 Btu/h and <240,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 68°F entering water	3.9 COP_H (before 1/1/2018) 4.0 COP_H (as of 1/1/2018)	
	≥240,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 68°F entering water	3.9 COP_H	
VRF groundwater source (heating mode)	<135,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 50°F entering water	3.6 COP_H	AHRI 1230
	≥135,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 50°F entering water	3.3 COP_H	
VRF ground source (heating mode)	<135,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 32°F entering water	3.1 COP_H	AHRI 1230
	≥135,000 Btu/h (cooling capacity)		*VRF* multisplit *system* 32°F entering water	2.8 COP_H	

Table 6.8.1-11 Air Conditioners and *Condensing Units* Serving *Computer Rooms*—Minimum *Efficiency* Requirements

			Minimum Net Sensible COP_C			
			Return Air Dry-Bulb Temperature/Dew-Point Temperature			
			Class 1	**Class 2**	**Class 3**	
***Equipment* Type**	**Net Sensible Cooling Capacity**	**Standard Model**	**75°F/52°F**	**85°F/52°F**	**95°F/52°F**	**Test Procedure**
Air cooled	<65,000 Btu/h	Downflow unit		2.30		AHRI 1360
		Upflow unit—ducted		2.10		
		Upflow unit—nonducted	2.09			
		Horizontal-flow unit			2.45	
	≥65,000 and <240,000 Btu/h	Downflow unit		2.20		
		Upflow unit—ducted		2.05		
		Upflow unit—nonducted	1.99			
		Horizontal-flow unit			2.35	
	≥240,000 Btu/h	Downflow unit		2.00		

		Upflow unit—ducted		1.85		
		Upflow unit—nonducted	1.79			
		Horizontal-flow unit			2.15	
Water cooled	<65,000 Btu/h	Downflow unit		2.50		AHRI 1360
		Upflow unit—ducted		2.30		
		Upflow unit—nonducted	2.25			
		Horizontal-flow unit			2.70	
	≥65,000 and <240,000 Btu/h	Downflow unit		2.40		
		Upflow unit—ducted		2.20		
		Upflow unit—nonducted	2.15			
		Horizontal-flow unit			2.60	
	≥240,000 Btu/h	Downflow unit		2.25		
		Upflow unit—ducted		2.10		
		Upflow unit—nonducted	2.05			
		Horizontal-flow unit			2.45	
Water cooled with *fluid economizer*	<65,000 Btu/h	Downflow unit		2.45		AHRI 1360
		Upflow unit—ducted		2.25		
		Upflow unit—nonducted	2.20			
		Horizontal-flow unit			2.60	
	≥65,000 and <240,000 Btu/h	Downflow unit		2.35		
		Upflow unit—ducted		2.15		
		Upflow unit—nonducted	2.10			
		Horizontal-flow unit			2.55	
	≥240,000 Btu/h	Downflow unit		2.20		
		Upflow unit—ducted		2.05		
		Upflow unit—nonducted	2.00			
		Horizontal-flow unit			2.40	
Glycol cooled	<65,000 Btu/h	Downflow unit		2.30		AHRI 1360
		Upflow unit—ducted		2.10		
		Upflow unit—nonducted	2.00			
		Horizontal-flow unit			2.40	
	≥65,000 and <240,000 Btu/h	Downflow unit		2.05		
		Upflow unit—ducted		1.85		
		Upflow unit—nonducted	1.85			
		Horizontal-flow unit			2.15	
	≥240,000 Btu/h	Downflow unit		1.95		
		Upflow unit—ducted		1.80		
		Upflow unit—nonducted	1.75			
		Horizontal-flow unit			2.10	
Glycol cooled with *fluid economizer*	<65,000 Btu/h	Downflow unit		2.25		AHRI 1360
		Upflow unit—ducted		2.10		
		Upflow unit—nonducted	2.00			

		Horizontal-flow unit			2.35	
	≥65,000 and <240,000 Btu/h	Downflow unit		1.95		
		Upflow unit—ducted		1.80		
		Upflow unit—nonducted	1.75			
		Horizontal-flow unit			2.10	
	≥240,000 Btu/h	Downflow unit		1.90		
		Upflow unit—ducted		1.80		
		Upflow unit—nonducted	1.70			
		Horizontal-flow unit			2.10	

~~Table 6.8.1-12~~ Commercial Refrigerator and Freezers—Minimum *Efficiency* Requirements

***Equipment* Type**	**Application**	***Energy* Use Limits, kWh/day**	**Test Procedure**
Refrigerator with solid *doors*	Holding temperature	0.10 × *V* + 2.04	AHRI 1200
Refrigerator with transparent *doors*	Holding temperature	0.12 × *V* + 3.34	AHRI 1200
Freezers with solid *doors*	Holding temperature	0.40 × *V* + 1.38	AHRI 1200
Freezers with transparent *doors*	Holding temperature	0.75 × *V* + 4.10	AHRI 1200
Refrigerators/freezers with solid *doors*	Holding temperature	the greater of 0.12 × *V* + 3.34 or 0.70	AHRI 1200
Commercial refrigerators	Pulldown	0.126 × *V* + 3.51	AHRI 1200

V = the chiller or frozen compartment volume (ft^3) as defined in Association of Home Appliance Manufacturers Standard HRF-1.

~~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* 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

ANSI/ASHRAE/IES addenda t, v, y, al, an, ao, at, aw, ay, az, ba, bb, bd, bf, bh, bi, bj, bk, bl bq, bt, bx, bz, ca, cc, ce, cg, ch, ci, cj, cn, and co to ANSI/ASHRAE/IES Standard 90.1-2016

	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* over counter	Remote condensing	Low temperature	1.08 × TDA + 0.22	AHRI 1200
SOC.RC.I	*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* 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* 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.

Table 6.8.1-14 Vapor Compression Based *Indoor Pool Dehumidifiers*—Minimum *Efficiency* Requirements

***Equipment* Type**	**Subcategory or Rating Condition**	**Minimum *Efficiency***	**Test Procedure**
Single package indoor[a] (with or without economizer)	Rating Conditions: A, B, or C	3.5 *MRE*	AHRI 910
Single package indoor water-cooled (with or without economizer)		3.5 *MRE*	
Single package indoor air-cooled (with or without economizer)		3.5 *MRE*	
Split *system* indoor air-cooled (with or without economizer)		3.5 *MRE*	

a. Units without air-cooled condenser.

ANSI/ASHRAE/IES addenda t, v, y, al, an, ao, at, aw, ay, az, ba, bb, bd, bf, bh, bi, bj, bk, bl bq, bt, bx, bz, ca, cc, ce, cg, ch, ci, cj, cn, and co to ANSI/ASHRAE/IES Standard 90.1-2016

Table 6.8.1-15 Electrically Operated *DX-DOAS Units*, Single-Package and Remote Condenser, without *Energy* Recovery—Minimum *Efficiency* Requirements

Equipment Type	Subcategory or Rating Condition	Minimum *Efficiency*	Test Procedure
Air cooled (dehumidification mode)		4.0 *ISMRE*	AHRI 920
Air source heat pumps (dehumidification mode)		4.0 *ISMRE*	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	4.9 *ISMRE*	AHRI 920
	Chilled Water	6.0 *ISMRE*	
Air source heat pump (heating mode)		2.7 *ISCOP*	AHRI 920
Water source heat pump (dehumidification mode)	Ground source, closed loop	4.8 *ISMRE*	AHRI 920
	Ground-water source	5.0 *ISMRE*	
	Water source	4.0 *ISMRE*	
Water source heat pump (heating mode)	Ground source, closed loop	2.0 *ISCOP*	AHRI 920
	Ground-water source	3.2 *ISCOP*	
	Water source	3.5 *ISCOP*	

Table 6.8.1-18 Heat Pump and Heat Recovery Chiller Packages – Minimum Efficiency Requirements

Equipment Type	Size Category (tons)	Cooling only-Performance[a] (Air Cooled FL/IPLV-Btu/W) Water Source FL/IPLV-(kW/ton)		Heating Operation								Test Procedure
				Heating Source Conditions (F) (Entering/ leaving water) or OAT (db/wb)	Heat Pump Heating Full Load Efficiency (COP_H)[a](W/W)				Heat Reclaim Chiller Full Load Efficiency Full Load Efficiency (COP_{HR})[b,c](W/W) Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[b](W/W)				
					Leaving Heating Water Temperature				Leaving Heating Water Temperature				
					Low	Medium	High	Boost	Low	Medium	High	Boost	
		Path A	Path B		105°F	120°F	140°F	140°F	105°F	120°F	140°F	140°F	
Air Source	All sizes	≥9.595 FL ≥13.02 IPLV.IP	≥9.215 FL ≥15.01 IPLV.IP	47 db 43 wb[d]	≥3.290	≥2.770	≥2.310	NA	NA	NA	NA	NA	AHRI 550/590
		≥9.595 FL ≥13.30 IPLV.IP	≥9.215 FL ≥15.30 IPLV.IP	17 db 15 wb[d]	≥2.230	≥1.950	≥1.630	NA	NA	NA	NA	NA	
Water Source electrically operated positive displacement	<75	≤0.7885 FL ≤0.6316 IPLV.IP	≤0.7875 FL ≤0.5145 IPLV.IP	54/44[e]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	AHRI 550/590
				75/65[e]	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥75 and <150	≤0.7579 FL ≤0.5895 IPLV.IP	≤0.7140 FL ≤0.4620 IPLV.IP	54/44[e]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
				75/65[e]	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥150 and <300	≤0.6947 FL ≤0.5684 IPLV.IP	≤0.7140 FL ≤0.4620 IPLV.IP	54/44[e]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
				75/65[e]	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥300 and	≤0.6421 FL	≤0.6563 FL	54/44[e]	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA	
				75/65[e]	NA	NA	NA	≥3.900	NA	NA	NA	6.850	

	<600	≤0.5474 IPLV.IP	≤0.4305 IPLV.IP										
	≥600	≤0.5895 FL ≤0.5263 IPLV.IP	≤0.6143 FL ≤0.3990 IPLV.IP	54/44[e]	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA	
				75/65[e]	NA	NA	NA	≥3.900	NA	NA	NA	6.850	
Water source electrically operated centrifugal	<75	≤0.6421 FL ≤0.5789 IPLV.IP	≤0.7316 FL ≤0.4632 IPLV.IP	54/44[e]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	AHRI 550/590
				75/65[e]	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥75 and <150	≤0.5895 FL ≤0.5474 IPLV.IP	≤0.6684 FL ≤0.4211 IPLV.IP	54/44[e]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
				75/65[e]	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥150 and <300	≤0.5895 FL ≤0.5263 IPLV.IP	≤0.6263 FL ≤0.4105 IPLV.IP	54/44[e]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	
				75/65[e]	NA	NA	NA	≥3.550	NA	NA	NA	6.150	
	≥300 and <600	≤0.5895 FL ≤0.5263 IPLV.IP	≤0.6158 FL ≤0.4000 IPLV.IP	54/44[e]	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA	
				75/65[e]	NA	NA	NA	≥3.900	NA	NA	NA	6.850	
	≥600	≤0.5895 FL ≤0.5263 IPLV.IP	≤0.6158 FL ≤0.4000 IPLV.IP	54/44[e]	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA	
				75/65[e]	NA	NA	NA	≥3.900	NA	NA	NA	6.850	

a. Cooling only rating conditions are standard rating conditions defined in AHRI 550/590 table 1

b. Heating Full Load Rating conditions are at rating conditions defined in AHRI 550/590 table 1

c. For water cooled heat recovery chillers that have capabilities for heat rejection to a heat recovery condenser and a tower condenser the COP_{HR} applies to operation at full load with 100% heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of table 6.8.1-3.

d. Outdoor air entering dry bulb (db) temperature and wet (bulb) temperature

e. Source water entering and leaving water temperature

Table 6.8.1-20 Walk-In Cooler and Freezer Display Door Efficiency Requirements

Class Descriptor	Class	Maximum Energy Consumption (kWh/day)[a]	Test Procedure
Display door, medium temperature	DD, M	$0.04 \times A_{dd} + 0.41$	10 CFR 431
Display door, low temperature	DD, L	$0.15\ A_{dd} + 0.29$	

a. A_{dd} is the surface area (ft^2) of the display door.

Table 6.8.1-21 Walk-In Cooler and Freezer Non-display Door Efficiency Requirements

Class Descriptor	Class	Maximum Energy Consumption (kWh/day)[a]	Test Procedure
Passage door, medium temperature	PD, M	$0.05 \times A_{nd} + 1.7$	10 CFR 431
Passage door, low temperature	PD, L	$0.14 \times A_{nd} + 4.8$	
Freight door, medium temperature	FD, L	$0.04 \times A_{nd} + 1.9$	
Freight door, low temperature	FD, L	$0.12 A_{nd} + 5.6$	

a. A_{nd} is the surface area (ft^2) of the non-display door.

Table 6.8.1-22 Walk-In Cooler and Freezer Refrigeration System Efficiency Requirements

Class Descriptor	Class	Minimum Annual Walk-In Energy Factor AWEF (Btu/W-h)[a]	Test Procedure	Compliance Date: equipment manufactured starting on:
Dedicated condensing, medium temperature, indoor system	DC.M.I	5.61	AHRI 1250	June 5, 2017
Dedicated condensing, medium temperature, outdoor system	DC.M.O	7.60		
Dedicated condensing, low temperature, indoor system, net capacity (q_{net}) < 6,500 Btu/h	DC.L.I < 6,500 Btu/h	$9.091 \times 10^{-5} \times$ qnet + 1.81	AHRI 1250	July 10, 2020
Dedicated condensing, low temperature, indoor system, net capacity (q_{net}) ≥ 6,500 Btu/h	DC.L.I, ≥ 6,500 Btu/h	2.40		
Dedicated condensing, low temperature, outdoor system, net capacity (q_{net}) < 6,500 Btu/h	DC.L.O, < 6,500 Btu/h	$6.522 \times 10^{-5} \times$ qnet + 2.73		
Dedicated condensing, low temperature, outdoor system, net capacity (q_{net}) ≥ 6,500 Btu/h	DC.L.O, ≥ 6,500 Btu/h	3.15		
Unit cooler, medium	UC.M	9.00		
Unit cooler, low temperature, net capacity (q_{net}) < 15,500 Btu/h	UC.L, < 15,500 Btu/h	$1.575 \times 10^{-5} \times$ qnet + 3.91		
Unit cooler, low temperature, net capacity (q_{net}) ≥ 15,500 Btu/h	UC.L, ≥ 15,500 Btu/h	4.15		

a. q_{net} is net capacity (Btu/hr) as determined in accordance with AHRI Standard 1250.

~~9.3~~ ...

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 "REQ" are mandatory and shall be implemented. If a *space* type has *control* functions *labeled* "ADD1," then at least one of those functions shall be implemented. If a *space* type has *control* functions *labeled* "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 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 turned on, and none of the remaining lighting shall be automatically turned on.

Exception to 9.4.1.1(c)

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

d. *Bilevel lighting control:* The *general lighting* in the *space* shall be controlled so as to provide at least one intermediate step in lighting power or continuous dimming in addition to full ON and full OFF. At least one intermediate step shall be between 30% and 70% (inclusive) of full lighting power.

e. *Automatic daylight responsive controls for sidelighting:* In any *space* where the combined input power of all *general lighting* completely or partially within the *primary sidelighted areas* is 150 W or greater, the *general lighting* in the *primary sidelighted areas* shall be controlled by photocontrols.

In any *space* where the combined input power of all *general lighting* completely or partially within the *primary sidelighted area* and *secondary sidelighted area* is 300 W or greater, the *general lighting* in the *primary sidelighted area* and *secondary sidelighted area* shall be controlled by photocontrols. *General lighting* in the *secondary sidelighted area* shall be controlled independently of the *general lighting* in the *primary sidelighted area*.

The *control system* shall have the following characteristics:

1. The calibration adjustment *control* shall be located no higher than 11 ft above the finished *floor*.
2. The photocontrol shall reduce electric lighting in response to available daylight using continuous dimming or with at least one *control* point between 50% and 70% of design lighting power, a second *control* point between 20% and 40% of

design lighting power or the lowest dimming level the technology allows, and a third *control* point that turns off all the controlled lighting.

3. The calibration shall not require the physical presence of a person at the sensor while the calibration is processing.

Exception to 9.4.1.1(e)

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

1. *Primary sidelighted areas* where the top of any existing adjacent structure is twice as high above the windows as its distance away from the windows.
2. Sidelighted areas where the total glazing area is less than 20 ft^2.
3. Retail *spaces.*
4. *Primary sidelighted areas* adjacent to *vertical fenestration* that have external projections and no *vertical fenestration* above the external projection, where the external project has a *projection factor* greater than 1.0 for *north-oriented* projections or where the external projection has a *projection factor* greater than 1.5 for all other orientations (see Figure 3.2-6).

f. *Automatic daylight responsive controls for toplighting:* In any *space* where the combined input power for all *general lighting* completely or partially within *daylight area under skylights* and *daylight area under roof monitors* is 150 W or greater, *general lighting* in the *daylight area* shall be controlled by photocontrols. The *control system* shall have the following characteristics:

1. The photocontrol shall reduce electric lighting in response to available daylight using continuous dimming or with at least one *control* point that is between 50% and 70% of design lighting power, a second *control* point between 20% and 40% of design lighting power or the lowest dimming level the technology allows, and a third *control* point that turns off all the controlled lighting.
2. The calibration shall not require the physical presence of a person at the sensor while the calibration is processing.
3. *General lighting* in overlapping toplighted and sidelighted *daylight areas* shall be controlled together with *general lighting* in the *daylight area under skylights* or *daylight area under roof monitors*.

…

9.4.2 Exterior Building Lighting Power

The total *exterior lighting power allowance* for all exterior *building* applications is the sum of the base site allowance plus the individual allowances for areas that are designed to be illuminated and are permitted in Table 9.4.2-2 for the applicable lighting zone in Table 9.4.2-1.

The *installed exterior lighting power* identified in accordance with Section 9.1.3 shall not exceed the *exterior lighting power allowance* developed in accordance with this section. Trade-offs are allowed only among exterior lighting applications listed in the Table 9.4.2-2 "Tradable Surfaces" section. The lighting zone for the *building* exterior is determined from Table 9.4.2-1 unless otherwise specified by the local jurisdiction.

Table 9.4.2-1 Exterior Lighting Zones

Lighting Zone	Description
0	Undeveloped areas within national parks, state parks, forest land, rural areas, and other undeveloped areas as defined by the *authority having jurisdiction*
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of *residential* zoning, neighborhood business districts, light industrial with

	limited nighttime use and *residential* mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local jurisdiction

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	No allowance	No allowance	0.1 W/ft^2 of *façade area* or 2.5 W/linear foot[Errata11] 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

the entire façade area or facade length for that *orientation*.)					
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* 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
For areas that are not listed in this Table or are not comparable to areas listed in this Table, use the comparable interior *space* type from Table 9.6.1 as modified by the factors in this row.	No allowance	65% of the *interior lighting power allowance* value	65% of the *interior lighting power allowance* value	80% of the *interior lighting power allowance* value	100% of the *interior lighting power allowance* value

Exception to 9.4.2

1. Lighting used for the following exterior applications is exempt when equipped with a *control device* that complies with the requirements of Section 9.4.1.4 and is independent of the *control* of the nonexempt lighting:
   a. Lighting that is integral to signage and installed in the signage by the *manufacturer*.
   b. Lighting for athletic playing areas.
   c. Lighting for industrial production, material handling, transportation sites, and associated storage areas.
   d. Theme elements in theme/amusement parks.
   e. Lighting used to highlight features of public monuments, public art displays, and registered *historic* landmark structures or *buildings*.
   f. Lighting for water features.
2. Lighting used for the following exterior applications is exempt when controlled separately:
   a. Specialized signal, directional, and marker lighting associated with transportation.
   b. Lighting integral to *equipment* or instrumentation and installed by its *manufacturer*.
   c. Lighting for theatrical purposes, including performance, stage, film production, and video production.
   d. Temporary lighting.
   e. Lighting for hazardous locations.
   f. Lighting for swimming *pools*.
   g. Searchlights.

…

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 than 20% of the original *space* and less than 1000 ft^2 need not be broken out separately. Include the *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*.

Table 9.6.1 *Lighting Power Density* Allowances Using the Space-by-Space Method and Minimum *Control* Requirements Using Either Method

			The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each *space* type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.								
***Informative Note:* This table is divided into two sections; this first section covers *space* types that can be commonly found in multiple *building* types. The second part of this table covers *space* types that are typically found in a single *building* type.**			**Local *Control* (See Section 9.4.1.1[a])**	**Restricted to *Manual* ON (See Section 9.4.1.1[b])**	**Restricted to Partial *Automatic* ON (See Section 9.4.1.1[c])**	**Bilevel Lighting *Control* (See Section 9.4.1.1[d])**	***Automatic* Daylight Responsive *Controls* for Sidelighting (See Section 9.4.1.1[e][6])**	***Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section 9.4.1.1[f][6])**	***Automatic* Partial OFF (See Section 9.4.1.1[g] [Full Off complies])**	***Automatic* Full OFF (See Section 9.4.1.1[h])**	**Scheduled Shutoff (See Section 9.4.1.1[i])**
Common *Space* Types[1]	***LPD* Allowances, W/ft²**	***RCR* Threshold**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Atrium											
<20 ft in height	~~0.03/ft total height~~0.39	NA	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
≥20 ft and ≤40 ft in height	~~0.03/ft total height~~0.48	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
>40 ft in height	~~0.40 + 0.02/ft total height~~0.60	~~NA~~11	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Audience Seating Area											
Auditorium	~~0.63~~0.61	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
~~Convention center~~	~~0.82~~	~~4~~	~~REQ~~	~~ADD1~~	~~ADD1~~	~~REQ~~	~~REQ~~	~~REQ~~		~~ADD2~~	~~ADD2~~
Gymnasium	~~0.65~~0.23	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Motion picture theater	~~1.14~~0.27	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Penitentiary	~~0.28~~0.67	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Performing arts theater	~~2.03~~1.16	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Religious facility	~~1.53~~0.72	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Sports arena	~~0.43~~0.33	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
All other audience seating areas	~~0.43~~0.23	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Banking Activity Area	~~0.86~~0.61	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Breakroom (See Lounge/Breakroom)											
Classroom/Lecture Hall/Training Room											
Penitentiary	~~1.34~~0.89	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
All other classrooms/lecture halls/training rooms	~~0.92~~0.71	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
***Informative Note:* This table is divided into two sections; this first section covers**			**The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs**								

space **types that can be commonly found in multiple** ***building*** **types. The second part of this table covers** ***space*** **types that are typically found in a single** ***building*** **type.**			**within Section 9.4.1.1. For each** ***space*** **type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.**								
Common ***Space*** **Types[1]**	***LPD*****, W/ft²**	***RCR*** **Threshold**	**Local** ***Control*** **(See Section 9.4.1.1[a])**	**Restricted to** ***Manual*** **ON (See Section 9.4.1.1[b])**	**Restricted to Partial** ***Automatic*** **ON (See Section 9.4.1.1[c])**	**Bilevel Lighting** ***Control*** **(See Section 9.4.1.1[d])**	***Automatic*** **Daylight Responsive** ***Controls*** **for Sidelighting (See Section 9.4.1.1[e][6])**	***Automatic*** **Daylight Responsive** ***Controls*** **for** ***Toplighting*** **(See Section 9.4.1.1[f][6])**	***Automatic*** **Partial OFF (See Section 9.4.1.1[g] [Full Off complies])**	***Automatic*** **Full OFF (See Section 9.4.1.1[h])**	**Scheduled Shutoff (See Section 9.4.1.1[i])**
			a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Conference/Meeting/Multipurpose Room	~~1.07~~0.97	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Confinement Cells	~~0.81~~0.70	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Copy/Print Room	~~0.56~~0.31	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Corridor[2]											
Facility for the visually impaired (and not used primarily by the staff)[3]	~~0.92~~0.71	width <8 ft	REQ				REQ	REQ	REQ	ADD2	ADD2
Hospital	~~0.92~~0.71	width <8 ft	REQ				REQ	REQ	ADD2	ADD2	ADD2
~~Manufacturing facility~~	~~0.29~~	~~width <8 ft~~	~~REQ~~				~~REQ~~	~~REQ~~		~~ADD2~~	~~ADD2~~
All other corridors	~~0.66~~0.41	width <8 ft	REQ				REQ	REQ	REQ	ADD2	ADD2
Courtroom	~~1.39~~1.20	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Computer Room	~~1.33~~0.94	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Dining Area											
Penitentiary	~~0.96~~0.42	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Facility for the visually impaired (and not used primarily by staff)[3]	~~2.00~~1.27	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Bar/lounge or leisure dining	~~0.93~~0.86	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Cafeteria or fast food dining	~~0.63~~0.40	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Family dining	~~0.71~~0.60	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
All other dining areas	~~0.63~~0.43	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Informative Note: **This table is divided into two sections; this first section covers** ***space*** **types that can be commonly found in multiple** ***building*** **types. The second part of this table covers** ***space*** **types that are typically found in a single** ***building*** **type.**			**The** ***control*** **functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each** ***space*** **type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.**								
			Local ***Control*** **(See Section 9.4.1.1[a])**	**Restricted to** ***Manual*** **ON (See Section**	**Restricted to Partial** ***Automatic*** **ON (See**	**Bilevel Lighting** ***Control*** **(See**	***Automatic*** **Daylight Responsive** ***Controls*** **for**	***Automatic*** **Daylight Responsive** ***Controls*** **for**	***Automatic*** **Partial OFF (See Section**	***Automatic*** **Full OFF (See Section**	**Scheduled Shutoff (See Section**

Common *Space* Types[1]	*LPD*, W/ft²	*RCR* Threshold	a	9.4.1.1[b]) b	Section 9.4.1.1[c]) c	Section 9.4.1.1[d]) d	Sidelighting (See Section 9.4.1.1[e][6]) e	*Toplighting* (See Section 9.4.1.1[f][6]) f	9.4.1.1[g] [Full Off complies]) g	9.4.1.1[h]) h	9.4.1.1[i]) i
Electrical/Mechanical Room[7]	~~0.43~~0.43	6	REQ				REQ	REQ			
Emergency Vehicle Garage	~~0.41~~0.52	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Food Preparation Area	~~1.06~~1.09	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Guest Room	~~0.77~~0.41	6	See Section 9.4.1.3(b).								
Laboratory											
In or as a classroom	~~1.20~~1.11	6	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
All other laboratories	~~1.45~~1.33	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Laundry/Washing Area	~~0.43~~0.53	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Loading Dock, Interior	~~0.58~~0.88	6	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Lobby											
Facility for the visually impaired (and not used primarily by the staff)[3]	~~2.03~~1.69	4	REQ				REQ	REQ	REQ	ADD2	ADD2
Elevator	~~0.69~~0.65	6	REQ				REQ	REQ		ADD2	ADD2
Hotel	~~1.06~~0.51	~~4~~5	REQ				REQ	REQ		ADD2	ADD2
Motion picture theater	~~0.45~~0.23	4	REQ				REQ	REQ		ADD2	ADD2
Performing arts theater	~~1.70~~1.25	~~6~~8	REQ				REQ	REQ	REQ	ADD2	ADD2
All other lobbies	~~1.00~~0.84	4	REQ				REQ	REQ	REQ	ADD2	ADD2
Locker Room	~~0.48~~0.52	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Lounge/Breakroom											
Healthcare facility	~~0.78~~0.42	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
All other lounges/breakrooms	~~0.62~~0.59	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	

Informative Note: **This table is divided into two sections; this first section covers *space* types that can be commonly found in multiple *building* types. The second part of this table covers *space* types that are typically found in a single *building* type.**			**The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each *space* type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.**								
			Local *Control* (See Section 9.4.1.1[a])	**Restricted to *Manual* ON (See Section 9.4.1.1[b])**	**Restricted to Partial *Automatic* ON (See Section 9.4.1.1[c])**	**Bilevel Lighting *Control* (See Section 9.4.1.1[d])**	***Automatic* Daylight Responsive *Controls* for Sidelighting (See Section 9.4.1.1[e][6])**	***Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section 9.4.1.1[f][6])**	***Automatic* Partial OFF (See Section 9.4.1.1[g] [Full Off complies])**	***Automatic* Full OFF (See Section 9.4.1.1[h])**	**Scheduled Shutoff (See Section 9.4.1.1[i])**
Common *Space* Types[1]	***LPD*, W/ft²**	***RCR* Threshold**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Office											

Enclosed and ≤250 ft^2	~~0.93~~0.74	8	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Enclosed and >250 ft^2	~~0.93~~0.66	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Open plan	~~0.81~~0.61	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Parking Area, Interior	~~0.14~~0.15	4	See Section 9.4.1.2.								
Pharmacy Area	~~1.34~~1.66	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Restroom											
Facility for the visually impaired (and not used primarily by the staff)[3]	~~0.96~~1.26	8					REQ	REQ		REQ	
All other restrooms	~~0.85~~0.63	8					REQ	REQ		REQ	
Sales Area[4]	~~1.22~~1.05	6	REQ	ADD1	ADD1	REQ		REQ		ADD2	ADD2
Seating Area, General	~~0.42~~0.23	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Stairway	The *space* containing the stairway shall determine the *LPD* and *control* requirements for the stairway.										
Stairwell	~~0.58~~0.49	10				REQ	REQ	REQ	REQ	ADD2	ADD2
Storage Room											
<50 ft^2	~~0.97~~0.51	~~6~~9	REQ							ADD2	ADD2
≥50 ft^2 ~~and ≤1000 ft^2~~	~~0.46~~0.38	6	REQ	ADD1	ADD1		REQ	REQ		REQ	
~~All other storage rooms~~	~~0.46~~	6	REQ	ADD1	ADD1		REQ	REQ	REQ	ADD2	ADD2
Vehicular Maintenance Area	~~0.56~~0.60	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Workshop	~~1.14~~1.26	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2

			The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each *space* type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.								
***Informative Note:* This table is divided into two sections; this first section covers *space* types that can be commonly found in multiple *building* types. The second part of this table covers *space* types that are typically found in a single *building* type.**			**Local *Control* (See Section 9.4.1.1[a])**	**Restricted to *Manual* ON (See Section 9.4.1.1[b])**	**Restricted to Partial *Automatic* ON (See Section 9.4.1.1[c])**	**Bilevel Lighting *Control* (See Section 9.4.1.1[d])**	***Automatic* Daylight Responsive *Controls* for Sidelighting (See Section 9.4.1.1[e][6])**	***Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section 9.4.1.1[f][6])**	***Automatic* Partial OFF (See Section 9.4.1.1[g] [Full Off complies])**	***Automatic* Full OFF (See Section 9.4.1.1[h])**	**Scheduled Shutoff (See Section 9.4.1.1[i])**
***Building* Type Specific/*Space* Types[1]**	***LPD* W/ft^2**	***RCR* Threshold**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Facility for the Visually Impaired[3]											
Chapel (used primarily by residents)	~~1.06~~0.70	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Recreation room/common living room (and not used primarily by staff)	~~1.80~~1.77	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Automotive (See "Vehicular Maintenance Area")											
Convention Center—Exhibit *Space*	~~0.88~~0.61	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Dormitory—Living Quarters	~~0.54~~0.50	8	REQ								

Fire Station—Sleeping Quarters	0.~~20~~23	6	REQ								
Gymnasium/Fitness Center											
Exercise area	~~0.50~~0.90	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Playing area	~~0.82~~0.85	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Healthcare Facility											
Exam/treatment room	~~1.68~~1.40	8	REQ			REQ	REQ	REQ		ADD2	ADD2
Imaging room	~~1.06~~0.94	6	REQ			REQ				ADD2	ADD2
Medical supply room	~~0.54~~0.62	6	(See "Storage Room" under "Common *Space* Types" for *control* requirements.)								
Nursery	~~1.00~~0.92	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Nurse's station	~~0.81~~1.17	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Operating room	~~2.17~~2.26	6	REQ			REQ				ADD2	ADD2
Patient room	~~0.62~~0.68	6	REQ			REQ	REQ	REQ		ADD2	ADD2

			The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section ~~9.4.1.1~~. For each *space* type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.								
Informative Note: **This table is divided into two sections; this first section covers *space* types that can be commonly found in multiple *building* types. The second part of this table covers *space* types that are typically found in a single *building* type.**			**Local *Control* (See Section ~~9.4.1.1~~[a])**	**Restricted to *Manual* ON (See Section ~~9.4.1.1~~[b])**	**Restricted to Partial *Automatic* ON (See Section ~~9.4.1.1~~[c])**	**Bilevel Lighting *Control* (See Section ~~9.4.1.1~~[d])**	***Automatic* Daylight Responsive *Controls* for Sidelighting (See Section ~~9.4.1.1~~[e][6])**	***Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section ~~9.4.1.1~~[f][6])**	***Automatic* Partial OFF (See Section ~~9.4.1.1~~[g] [Full Off complies])**	***Automatic* Full OFF (See Section ~~9.4.1.1~~[h])**	**Scheduled Shutoff (See Section ~~9.4.1.1~~[i])**
***Building* Type Specific/*Space* Types[1]**	***LPD* W/ft²**	***RCR* Threshold**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Physical therapy room	~~0.84~~0.91	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Recovery room	~~1.03~~1.25	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Library											
Reading area	~~0.82~~0.96	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Stacks	~~1.20~~1.18	4	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
Manufacturing Facility											
Detailed manufacturing area	~~0.93~~0.80	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Equipment room	~~0.65~~0.76	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Extra high bay area (>50 ft *floor*-to-ceiling height)	~~1.05~~1.42	~~4~~8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
High bay area (25 to 50 ft *floor*-to-ceiling height)	~~0.75~~1.24	~~4~~6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Low bay area (<25 ft *floor*-to-ceiling height)	~~0.96~~0.86	~~4~~3	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2

Museum											
General exhibition area	~~1.05~~0.31	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Restoration room	~~0.85~~1.10	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Performing Arts Theater—Dressing Room	~~0.36~~0.41	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Post Office—Sorting Area	~~0.68~~0.76	4	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
Religious Facility											
Fellowship hall	~~0.55~~0.54	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Worship/pulpit/choir area	~~1.53~~0.85	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2

Informative Note: **This table is divided into two sections; this first section covers *space* types that can be commonly found in multiple *building* types. The second part of this table covers *space* types that are typically found in a single *building* type.**			**The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each *space* type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.**								
			Local *Control* (See Section 9.4.1.1[a])	**Restricted to *Manual* ON (See Section 9.4.1.1[b])**	**Restricted to Partial *Automatic* ON (See Section 9.4.1.1[c])**	**Bilevel Lighting *Control* (See Section 9.4.1.1[d])**	***Automatic* Daylight Responsive *Controls* for Sidelighting (See Section 9.4.1.1[e][6])**	***Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section 9.4.1.1[f][6])**	***Automatic* Partial OFF (See Section 9.4.1.1[g] [Full Off complies])**	***Automatic* Full OFF (See Section 9.4.1.1[h])**	**Scheduled Shutoff (See Section 9.4.1.1[i])**
***Building* Type Specific/*Space* Types[1]**	***LPD* W/ft²**	***RCR* Threshold**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**ie *Note:* This table is divided into two sections; this first section covers *space***
Retail Facilities											
Dressing/fitting room	~~0.5~~0.51	8	REQ	ADD1	ADD1	REQ		REQ		REQ	
Mall concourse	~~0.9~~0.82	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Sports Arena—Playing Area[8]											
Class I facility	~~2.47~~2.94	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Class II facility	~~1.96~~2.01	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Class III facility	~~1.70~~1.30	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Class IV facility	~~1.13~~0.86	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Transportation Facility											
Baggage/carousel area	~~0.45~~0.39	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Airport concourse	~~0.31~~0.25	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2

Terminal ticket counter	~~0.62~~0.51	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Warehouse—Storage Area											
Medium to bulky, palletized items	~~0.35~~0.33	4	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
Smaller, hand-carried items[5]	0.69	6	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2

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/state authorities for either senior long-term care, adult 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/ft^2 shall be allowed, provided that the additional lighting is controlled separately from the base allowance of 0.43 W/ft^2. The additional 0.52 W/ft^2 allowance shall not be used for any other purpose.
8. Class of play as defined by IES RP-6.

…

10.4.4 Escalators and Moving Walks

Escalators and moving walks shall 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 Air Curtains. Air curtain units shall be tested in accordance with ANSI/AMCA 220 or ISO 27327-1 and installed and commissioned in accordance with the manufacturer's instructions to ensure proper operation and shall have a jet velocity of not less than 6.6 feet per second at 6.0 in above the floor and direction not less than 20 degrees toward the opening. Automatic controls shall be provided that will operate the air curtain with the opening and closing of the door.

10.4.6 Whole-Building Energy Monitoring

Measurement devices shall be installed at the *building* site to monitor the *energy* use of each new *building*.

10.4.6.1 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. Chilled water.
f. Hot water.

10.4.6.2 Recording and Reporting

The *energy* use of each *building* on the *building* site shall be recorded at a minimum of every 60 minutes and reported at least hourly, daily, monthly, and annually. The *system* shall be capable of maintaining all data collected for a minimum of 36 months and creating user reports showing at least hourly, daily, monthly, and annual *energy* consumption and *demand*.

Exceptions to 10.4.~~5~~6.1 and 10.4.~~5~~6.2

1. *Buildings* or additions less than 25,000 ft^2.
2. Individual tenant *spaces* less than 10,000 ft^2.
3. *Dwelling units*.
4. *Residential buildings* with less than 10,000 ft^2 of common area.
5. *Fuel* used for on-site emergency *equipment*.

10.4.~~6~~7 Pumps

Clean water pumps meeting the following criteria shall comply with the requirements shown in Table 10.8-6:

1) A flow rate of 25 gallons per minute (0.0016 cubic meters per second) or greater at its *Best Efficiency Point (BEP)* at full impeller diameter;
2) Maximum head of 459 feet (140 meters) at its *Best Efficiency Point (BEP)* at full impeller diameter and the number of stages required for testing;

3) Design temperature range from 14 to 248°F (-10 to 120°C);

4) Designed to operate with either:

i. A 2- or 4-pole induction motor; or

ii. A non-induction motor with a speed of rotation operating range that includes speeds of rotation between 2,880 and 4,320 revolutions per minute and/or 1,440 and 2,160 revolutions per minute; and

iii. In either (i) or (ii), the driver and impeller must rotate at the same speed;

5) For *submersible turbine* pumps, a 6-inch (15 centimeters) or smaller bowl diameter; and

6) For *end suction close-coupled pumps* and *end suction frame mounted/own bearings pumps*, specific speed less than or equal to 5,000 rpm when calculated using U.S. customary units.

Exceptions to 10.4.~~6~~7

The standards in this section do not apply to the following *pumps*:

1. Fire pumps.
2. Self-priming pump.
3. Prime-assist pumps
4. Magnet driven pumps.
5. Pumps designed to be used in a nuclear facility subject to US 10 CFR part 50, "Domestic Licensing of Production and Utilization Facilities".
6. Pumps meeting the design and construction requirements set forth in US Military Specification MIL-P-17639F, "Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use" (as amended); MIL-P-17881D, "Pumps, Centrifugal, Boiler Feed, (Multi-Stage)" (as amended); MIL-P-17840C, "Pumps, Centrifugal, Close-Coupled, Navy Standard (For Surface Ship Application)" (as amended); MIL-P-18682D, "Pump, Centrifugal, Main Condenser Circulating, Naval Shipboard" (as amended); MIL-P-18472G, "Pumps, Centrifugal, Condensate, Feed Booster, Waste Heat Boiler, And Distilling Plant" (as amended).

Informative Note: Appendix E contains further information on pump nomenclature and definitions which are available from ANSI-HI 1.1-1.2-2014 and ANSI-HI 2.1-2.2-2014.

Prescriptive Compliance Path (Not Used)

10.6 Alternative Compliance Path (Not Used)

Submittals (Not Used)

10.8 Product Information

Table 10.8-1 Minimum Nominal Full-Load *Efficiency* for NEMA Design A, NEMA Design B, and *IEC Design N Motors* (Excluding Fire Pump Electric Motors) at 60 Hz[a,b]

	Nominal Full-Load *Efficiency*, %							
	2-Pole		4-Pole		6-Pole		8-Pole	
Motor Horsepower, hp (kW)	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5

3 (2.2)	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250 (186)	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300 (224)	95.8	95.4	96.2	95.8	95.8	95.8		
350 (261)	95.8	95.4	96.2	95.8	95.8	95.8		
400 (298)	95.8	95.8	96.2	95.8				
450 (336)	95.8	96.2	96.2	96.2				
500 (373)	95.8	96.2	96.2	96.2				

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

b. For purposes of determining the required minimum nominal full-load *efficiency* of an electric motor that has a horsepower or *kilowatt* rating between two horsepower or two *kilowatt* ratings listed in this table, each such motor shall be deemed to have a listed horsepower or *kilowatt* rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A *kilowatt* rating shall be directly converted from *kilowatts* to horsepower using the formula 1 *kilowatt* = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with paragraph (1) or (2), whichever applies.

Table 10.8-2 Minimum Nominal Full-Load *Efficiency* for NEMA Design C and *IEC Design H Motors* at 60 Hz[a,b]

	Nominal Full-Load *Efficiency*, %					
	4-Pole		**6-Pole**		**8-Pole**	
Motor Horsepower, hp (kW)	**Enclosed**	**Open**	**Enclosed**	**Open**	**Enclosed**	**Open**
1 (0.75)	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	91.7	91.0	91.0	90.2	86.5	89.5

10 (7.5)	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	96.2	95.8	95.8	95.4	94.5	94.1

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

b. For purposes of determining the required minimum nominal full-load *efficiency* of an electric motor that has a horsepower or *kilowatt* rating between two horsepower or two *kilowatt* ratings listed in this table, each such motor shall be deemed to have a listed horsepower or *kilowatt* rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A *kilowatt* rating shall be directly converted from *kilowatts* to horsepower using the formula 1 *kilowatt* = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with paragraph (1) or (2), whichever applies.

Table 10.8-3 Minimum Average Full-Load *Efficiency* for Polyphase Small Electric Motors[a]

	Full-Load *Efficiency*, %		
	Open Motors		
Number of Poles ⇒	**2**	**4**	**6**
Synchronous Speed (RPM) ⇒	**3600**	**1800**	**1200**
Motor Size, hp			
0.25	65.6	69.5	67.5
0.33	69.5	73.4	71.4
0.50	73.4	78.2	75.3
0.75	76.8	81.1	81.7
1	77.0	83.5	82.5
1.5	84.0	86.5	83.8
2	85.5	86.5	N/A
3	85.5	86.9	N/A

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

Table 10.8-4 Minimum Average Full-Load *Efficiency* for Capacitor-Start Capacitor-Run and Capacitor-Start Induction-Run Small Electric Motors[a]

	Full-Load *Efficiency*, %
Number of Poles ⇒	**Open Motors**

	2	4	6
Synchronous Speed (RPM) ⇒	**3600**	**1800**	**1200**
Motor Size, hp			
0.25	66.6	68.5	62.2
0.33	70.5	72.4	66.6
0.50	72.4	76.2	76.2
0.75	76.2	81.8	80.2
1	80.4	82.6	81.1
1.5	81.5	83.8	N/A
2	82.9	84.5	N/A
3	84.1	N/A	N/A

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

Table 10.8-5 Minimum Nominal Full-Load *Efficiency* for Fire Pump Electric Motors[a]

	Full-Load *Efficiency*, %							
	Open Drip-Proof Motors				Totally Enclosed Fan-Cooled Motors			
Number of Poles ⇒	**2**	**4**	**6**	**8**	**2**	**4**	**6**	**8**
Synchronous Speed (RPM) ⇒	**3600**	**1800**	**1200**	**900**	**3600**	**1800**	**1200**	**900**
Motor Size, hp								
1	NR	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1.5	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
5	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
7.5	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15	89.5	91.0	90.2	89.5	90.2	91.0	90.2	88.5
20	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
25	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
30	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
40	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0
50	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
60	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
75	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
100	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0
125	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
200	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
250	94.5	95.4	95.4	94.5	95.4	95.0	95.0	94.5

300	95.0	95.4	95.4	NR	95.4	95.4	95.0	NR
350	95.0	95.4	95.4	NR	95.4	95.4	95.0	NR
400	95.4	95.4	NR	NR	95.4	95.4	NR	NR
450	95.8	95.8	NR	NR	95.4	95.4	NR	NR
500	95.8	95.8	NR	NR	95.4	95.8	NR	NR

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

b. For purposes of determining the required minimum nominal full-load *efficiency* of an electric motor that has a horsepower or *kilowatt* rating between two horsepower or two *kilowatt* ratings listed in this table, each such motor shall be deemed to have a listed horsepower or *kilowatt* rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A *kilowatt* rating shall be directly converted from *kilowatts* to horsepower using the formula 1 *kilowatt* = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with paragraph (1) or (2), whichever applies.

NR—No requirement

Table 10.8-6 Maximum Pump Energy Index (PEI)

Maximum PEI for Pumps Manufactured on or after January 27, 2020

Pump Type	Nominal Speed of Rotation (rpm)	Operating Mode	Maximum PEI[a]	C-value[b]	Test Procedure
End Suction, Close Coupled	1800	Constant Load	1.00	128.47	10 CFR Part 431
End Suction, Close Coupled	3600	Constant Load	1.00	130.42	
End Suction, Close Coupled	1800	Variable Load	1.00	128.47	
End Suction, Close Coupled	3600	Variable Load	1.00	130.42	
End Suction, Frame Mounted	1800	Constant Load	1.00	128.85	
End Suction, Frame Mounted	3600	Constant Load	1.00	130.99	
End Suction, Frame Mounted	1800	Variable Load	1.00	128.85	
End Suction, Frame Mounted	3600	Variable Load	1.00	130.99	
In-Line	1800	Constant Load	1.00	129.30	
In-Line	3600	Constant Load	1.00	133.84	
In-Line	1800	Variable Load	1.00	129.30	
In-Line	3600	Variable Load	1.00	133.84	
Radially Split, Vertical	1800	Constant Load	1.00	129.63	
Radially Split, Vertical	3600	Constant Load	1.00	133.20	
Radially Split, Vertical	1800	Variable Load	1.00	129.63	

Radially Split, Vertical	3600	Variable Load	1.00	133.20	
Submersible Turbine	1800	Constant Load	1.00	138.78	
Submersible Turbine	3600	Constant Load	1.00	134.85	
Submersible Turbine	1800	Variable Load	1.00	138.78	
Submersible Turbine	3600	Variable Load	1.00	134.85	
a. For pumps with the Constant Load operating mode, the relevant PEI is PEI_{CL}. For pumps with the Variable Load operating mode, the relevant PEI is PEI_{VL}.					
b. The C-values shown in this table shall be used in the equation for PEI_{STD} when calculating PEI_{CL} or PEI_{VL}.					

…

11.4 Simulation General Requirements

11.4.1 Simulation Program

The *simulation program* shall be a computer-based program for the analysis of *energy* consumption in *buildings* (a program such as, but not limited to, DOE-2 or BLAST). The *simulation program* shall include calculation methodologies for the *building* components being modeled.

Informative Note

ASHRAE Standing Standard Project Committee 90.1 recommends that a compliance shell implementing the rules of a compliance supplement that controls inputs to and reports outputs from the required computer analysis program be adopted for the purposes of easier use and simpler compliance.

11.4.1.1

The *simulation program* shall be approved by the *adopting authority* and shall, at a minimum, have the ability to explicitly model all of the following:

a. A minimum of 1400 hours per year.
b. Hourly variations in occupancy, lighting power, miscellaneous *equipment* power, *thermostat set points*, and *HVAC system* operation, defined separately for each day of the week and holidays.
c. Thermal mass effects.
d. Ten or more thermal zones.
e. Part-load performance curves for mechanical *equipment*.
f. Capacity and *efficiency* correction curves for *mechanical heating* and *mechanical cooling equipment*.
g. *Air-side economizer* and *fluid economizer* with integrated *control*.
h. The *budget building design* characteristics specified in Section 11.4.5.

11.4.1.2

The *simulation program* shall have the ability to either

a. directly determine the *design energy cost* and *energy cost budget* or
b. produce hourly reports of *energy* use by *energy* source suitable for determining the *design energy cost* and *energy cost budget* using a separate calculation engine.

11.4.1.3

The *simulation program* shall be capable of performing design load calculations to determine required HVAC *equipment* capacities and air and water flow rates in accordance with Section 6.4.2 for both the *proposed design* and the *budget building design*.

11.4.1.4

The *simulation program* shall be tested according to ASHRAE Standard 140, except for Sections 7 and 8 of Standard 140.~~, and the results shall be furnished by the software provider.~~ The test results and modeler reports shall be posted on a publicly available website and shall include the test results of the simulation program alongside the results of the other simulation programs included in ASHRAE Standard 140 Annexes B8 and B16. The modeler report in Standard 140 Annex A2

Attachment A2.7 shall be completed for results exceeding the maximum or falling below the minimum of the reference values or for missing results.

Informative Note: There is no pass/fail criteria established by this requirement.

11.4.2 Climatic Data

The *simulation program* shall perform the simulation using hourly values of climatic data, such as temperature and humidity from representative climatic data, for the city in which the *proposed design* is to be located. For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the *construction* site. Such selected weather data shall be approved by the *authority having jurisdiction*.

11.4.3 Renewable, Recovered, and Purchased Energy

11.4.3.1 On-Site Renewable Energy and Site-Recovered Energy

Site-recovered energy shall not be considered *purchased energy* and shall be subtracted from the *proposed design energy* consumption prior to calculating the *design energy cost*. *On-site renewable energy*, generated by *systems* included on the *building* permit, and used directly by the *building* shall be subtracted from the *proposed design energy* consumption prior to calculating the *design energy cost*. The reduction in *design energy cost* associated with *on-site renewable energy* shall be no more than 5% of the calculated *energy cost budget*.

11.4.3.2 Annual Energy Costs

The *design energy cost* and *energy cost budget* shall be determined using rates for *purchased energy* (such as electricity, gas, oil, propane, steam, and chilled water) that are approved by the *adopting authority*. Where *on-site renewable energy* or *site-recovered energy* is used, the *budget building design* shall be based on the *energy* source used as the backup *energy* source, or electricity if no backup *energy* source has been specified. Where the proposed design includes *on-site electricity generation systems* other than *on-site renewable energy systems*, the baseline design shall include the same generation systems excluding its *site-recovered energy*.

11.4.4 Compliance Calculations

The *design energy cost* and *energy cost budget* shall be calculated using

a. the same *simulation program*,
b. the same weather data, and
c. the same *purchased energy rates*.

11.4.5 Exceptional Calculation Methods

Where no *simulation program* is available that adequately models a design, material, or device, the *authority having jurisdiction* may approve an exceptional calculation method to be used to demonstrate compliance with Section 11. Applications for approval of an exceptional method to include theoretical and empirical information verifying the method's accuracy shall include documentation to demonstrate that the exceptional calculation method and results

a. make no change in any input parameter values specified by this standard and the *adopting authority*,
b. provide input and output documentation that facilitates the enforcement agency's review and meets the formatting and content required by the *adopting authority*, and

c. are supported with instructions for using the method to demonstrate that the *energy cost budget* and *design energy cost* required by Section 11 are met.

11.5 Calculation of Design Energy Cost and Energy Cost Budget

11.5.1

The simulation model for calculating the *design energy cost* and the *energy cost budget* shall be developed in accordance with the requirements in Table 11.5.1.

Exception to 11.5.1

Energy used to recharge or refuel vehicles that are used for off-building site transportation purposes shall not be modeled for the *design energy cost* or the *energy cost budget*.

11.5.2 HVAC Systems

The *HVAC system* type and related performance parameters for the *budget building design* shall be determined from Figure 11.5.2, the *system* descriptions in Table 11.5.2-1 and accompanying notes, and the following rules:

a. **Budget *Building Systems* Not Listed.** Components and parameters not listed in Figure 11.5.2 and Table 11.5.2-1 or otherwise specifically addressed in this subsection shall be identical to those in the *proposed design*.

Exception to 11.5.2(a)

Where there are specific requirements in Sections 6.4 and 6.5, the component *efficiency* in the *budget building design* shall be adjusted to the lowest *efficiency* level allowed by the requirement for that component type.

b. **Minimum *Equipment Efficiency*.** All HVAC and *service water-heating equipment* in the *budget building design* shall be modeled at the minimum *efficiency* levels, both part load and full load, in accordance with Sections 6.4 and 7.4. Chillers shall use Path A efficiencies as shown in Table 6.8.1-3.

c. **Supply Fan *Energy* in Certain Package *Equipment*.** Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy*. For Budget *System* Types 3, 4, 6, 9, and 11, calculate the minimum *COPnfcooling* and *COPnfheating* using the equation for the applicable performance rating as indicated in Tables 6.8.1-1 through 6.8.1-4. Where a full- and part-load *efficiency* rating is provided in Tables 6.8.1-1 through 6.8.1-4, the full-load equation below shall be used:

$$COP_{nfcooling} = 7.84E\text{-}8 \times EER \times Q + 0.338 \times EER$$

$$COP_{nfcooling} = -0.0076 \times SEER^2 + 0.3796 \times SEER$$

$$COP_{nfheating} = 1.48E\text{-}7 \times COP_{47} \times Q + 1.062 \times COP_{47}$$

(applies to heat pump heating *efficiency* only)

$$COP_{nfheating} = -0.0296 \times HSPF^2 + 0.7134 \times HSPF$$

where $COP_{nfcooling}$ and $COP_{nfheating}$ are the packaged HVAC *equipment* cooling and heating *energy efficiency*, respectively, to be used in the *budget building design*, which excludes supply fan power, and Q is the AHRI-rated cooling capacity in Btu/h.

EER, *SEER*, *COP*, and *HSPF* shall be at AHRI test conditions. Fan *energy* shall be modeled separately according to Section 11.5.2(h). Supply and return/relief *system* fans shall be modeled as operating at least whenever the *spaces* served are occupied, except as specifically noted in Table 11.5.2-1.

1. **Minimum *Outdoor Air Ventilation* Rate.** Minimum *outdoor air ventilation* rates shall be the same for both the *budget building design* and *proposed design*.

Exhaust air heat recovery shall be modeled for the *budget building design* in accordance with Section 6.5.6.1.

e. **Economizers.** Budget *building systems* as listed in Table 11.5.2-1 shall have *air economizers* or *fluid economizers*, the same as in the *proposed design*, in accordance with Section 6.5.1. The high-limit shutoff shall be in accordance with Table 11.5.2-4.

f. **Preheat Coils.** If the *proposed design system* has a preheat coil, the *budget building design*'s *system* shall be modeled with a preheat coil controlled in the same manner.

h. **Supply Airflow Rates.** *System* design supply air rates for the *budget building design* shall be based on a supply-air-to-room-air temperature difference of 20°F. If return or relief fans are specified in the *proposed design*, the *budget building design* shall also be modeled with the same fan type sized for the budget *system* supply fan air quantity less the minimum *outdoor air*, or 90% of the supply fan air quantity, whichever is larger.**Fan *System Efficiency*.** Fan *system efficiency* (bhp per cfm of supply air, including the effect of belt losses but excluding motor and motor drive losses) shall be the same as the *proposed design* or up to the limit prescribed in Section 6.5.3.1, whichever is smaller. If this limit is reached, each fan shall be proportionally reduced in brake horsepower until the limit is met. Fan electrical power shall then be determined by adjusting the calculated fan hp by the minimum motor *efficiency* prescribed by Section 10.4.1 for the appropriate motor size for each fan.

i. ***Equipment* Capacities.** The *equipment* capacities for the *budget building design* shall be sized proportionally to the capacities in the *proposed design* based on sizing runs, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the *proposed design* and *budget building design*. *Unmet load hours* for the *proposed design* or *baseline building designs* shall not exceed 300 hours. The *unmet load hours* for the *proposed design* shall not exceed the *unmet load hours* for the *budget building design*. Alternatively, *unmet load hours* exceeding these limits may be approved by the *building official*, provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

j. **Determining the HVAC System.** Each *HVAC system* in a *proposed design* is mapped on a one-to-one correspondence with one of eleven *HVAC systems* in the *budget building design*. To determine the budget *building system*, do the following:

1. Enter Figure 11.5.2 at "Water" if the *proposed design system* condenser is water or evaporatively cooled; enter Figure 11.5.2 at "Air/None" if the condenser is air cooled. Closed-circuit dry coolers shall be considered air cooled. *Systems* utilizing district cooling shall be treated as if the condenser water type were "water." If no *mechanical cooling* is specified or the *mechanical cooling system* in the *proposed design* does not require heat rejection, the *system* shall be treated as if the condenser water type were "Air." For *proposed designs* with ground-source or groundwater-source heat pumps, the budget *system* shall be water-source heat pump (*System* 6).
2. Select the path that corresponds to the *proposed design* heat source: *electric resistance*, heat pump (including air source and water source), or *fuel*-fired. *Systems* utilizing district heating (steam or hot water) shall be treated as if the heating *system* type were "*Fossil Fuel*." *Systems* with no heating capability

shall be treated as if the heating *system* type were "*Fossil Fuel*." For *systems* with mixed *fuel* heating sources, the *system* or *systems* that use the secondary heating source type (the one with the smallest total installed output capacity for the *spaces* served by the *system*) shall be modeled identically in the *budget building design*, and the primary heating source type shall be used in Figure 11.5.2 to determine budget *system* type.

3. Select the *budget building design system* category. The *system* under "Single-Zone *Residential System*" shall be selected if the *HVAC system* in the *proposed design* is a *single-zone system* and serves a *residential space*. The *system* under "Single-Zone *Nonresidential System*" shall be selected if the *HVAC system* in the *proposed design* is a *single-zone system* and serves other than *residential spaces*. The *system* under "All Other" shall be selected for all other cases.

k. **Kitchen Exhaust.** For kitchens with a total exhaust hood airflow rate greater than 5000 cfm, use a *demand ventilation system* on 75% of the exhaust air. The *system* shall reduce exhaust and *replacement air system* airflow rates by 50% for one half of the kitchen occupied hours in the *baseline building design*. If the *proposed design* uses *demand ventilation*, the same airflow rate schedule shall be used. The maximum exhaust flow rate allowed for the hood or hood section shall meet the requirements of Section 6.5.7.2.2 for the numbers and types of hoods and appliances provided in the *proposed design*.

11.6 Alternative Compliance Path (Not Used)

11.7 Documentation Requirements

Compliance shall be documented and submitted to the *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. The reduction in *design energy cost* associated with *on-site renewable energy*.

f. The version of the software and the link to the website that contains the ASHRAE Standard 140 results for the version used in accordance with Section 11.4.1.4.

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12 Normative References

Reference	Title
Air Conditioning, Heating and Refrigeration Institute (AHRI) 2111 Wilson Blvd., Suite 500, Arlington, VA 22201	
AHRI 210/240-2008 with Addendum 1 and 2	Unitary Air Conditioning and Air-Source Heat Pump Equipment
AHRI 310/380-2004	Packaged Terminal Air-Conditioners and Heat Pumps
AHRI 340/360-2015 (I-P) and AHRI 341/361-2015 (SI)[Errata12]	Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
AHRI 365-2009	Commercial and Industrial Unitary Air-Conditioning Condensing Units
AHRI 390-2003	Performance Rating of Single Packaged Vertical Air-Conditioners and Heat Pumps
ANSI/AHRI 400-2015	Performance Rating of Liquid-to-Liquid Heat Exchangers
AHRI 460-2005	Remote Mechanical Draft Air Cooled Refrigerant Condensers
AHRI 550/590-2015 (I-P) and AHRI 551/591-2015 (SI)	Performance Rating of Water-Chilling and Heat-Pump Water-Heating Packages Using the Vapor Compression Cycle
AHRI 560-2000	Absorption Water Chilling and Water Heating Packages
AHRI Standard 910-2014 (I-P)	Performance Rating of Indoor Pool Dehumidifiers
AHRI Standard 910-2014 (SI)	Performance Rating of Indoor Pool Dehumidifiers
AHRI Standard 920-2015 (I-P)	Performance Rating of DX-Dedicated Outdoor Air System Units
AHRI Standard 921-2015 (SI)	Performance Rating of DX-Dedicated Outdoor Air System Units
AHRI 1160-2009	Performance Rating of Heat Pump Pool Heaters
AHRI 1200-2013	Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets
AHRI 1230-2010 with Addendum 1	Performance Rating of Variable Refrigerant Flow (VRF) Multi-split Air-Conditioning and Heat Pump Equipment
AHRI Standard 1250-2014 (I-P)	Performance Rating of Walk-In Coolers and Freezers
AHRI Standard 1251-2014 (SI)	Performance Rating of Walk-In Coolers and Freezers
ANSI/AHRI Standard 1360-2016 (I-P)	Performance Rating of Computer and Data Processing Room Air Conditioners
ANSI/AHRI Standard 1361-2016 (SI)	Performance Rating of Computer and Data Processing Room Air Conditioners
BTS 2000	Testing Standard Method to Determine Efficiency of Commercial Space Heating Boilers
Air Movement and Control Association International (AMCA) 30 West University Drive, Arlington Heights, IL 60004-1806	
~~AMCA 205-12~~AMCA 208-18	~~Energy Efficiency Classification for Fans~~Calculation of the Fan Energy Index
AMCA Standard 500-D-12	Laboratory Methods of Testing Dampers for Rating
American Architectural Manufacturers Association (AAMA) 1827 Walden Office Square, Suite 550, Schaumburg, IL 60173-4268	

Canadian Standards Association (CSA) 5060 Spectrum Way, Mississauga, Ontario, Canada L4W 5N6	
Window and Door Manufacturers Association (WDMA) 2025 M Street, NW, Washington, DC 20036	
AAMA/WDMA/CSA 101/I.S.2/A440-11	NAFS-North American Fenestration Standard/Specification for Windows, Doors, and Skylights
American National Standards Institute (ANSI), 11 West 42nd Street, New York, NY 10036	
ANSI Z21.10.3-2011	Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 Btu/h, Circulating and Instantaneous Water Heaters
ANSI Z21.47-2012/CSA 2.3-2012	Gas-Fired Central Furnaces
ANSI Z83.8-2013/CSA 2.6-2013	Gas Unit Heaters and Duct Furnaces
American Society of Mechanical Engineers (ASME) Three Park Avenue, New York, NY 10016-5990	
ASME A17.1-2013/CSA B44-13	Safety Code for Elevators and Escalators
ASHRAE 1791 Tullie Circle, NE, Atlanta, GA 30329	
ANSI/ASHRAE Standard 55-2013	Thermal Environmental Conditions for Human Occupancy
ANSI/ASHRAE Standard 62.1-2013	Ventilation for Acceptable Indoor Air Quality
ANSI/ASHRAE/IESNA Standard 90.1-2007	Energy Standard for Buildings Except Low-Rise Residential Buildings
ANSI/ASHRAE/IESNA Standard 90.1-2010	Energy Standard for Buildings Except Low-Rise Residential Buildings
ANSI/ASHRAE/IESNA Standard 90.1-2013	Energy Standard for Buildings Except Low-Rise Residential Buildings
ANSI/ASHRAE Standard 127-2012	Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners
ANSI/ASHRAE Standard 140-~~2014~~2017	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs
ANSI/ASHRAE Standard 154-2011	Ventilation for Commercial Cooking Operations
ANSI/ASHRAE Standard 169-2013	Climatic Data for Building Design Standards
ANSI/ASHRAE/ASHE Standard 170-2013	Ventilation of Health Care Facilities
ANSI/ASHRAE/ACCA Standard 183-2007 (RA 2014)	Peak Cooling and Heating Load Calculations in Buildings Except Low-Rise Residential Buildings
Association of Home Appliance Manufacturers (AHAM) 1111 19th Street NW, Suite 402, Washington, DC 20036	
ANSI/AHAM HRF-1-2008	Energy and Internal Volume of Refrigerating Appliances (including errata issued November 17, 2009)
ANSI/AHAM RAC-1-R2008	Room Air Conditioners
ASTM International 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959	
ASTM C90-14	Standard Specification for Loadbearing Concrete Masonry

	Units
ASTM C177-13	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmittance Properties by Means of the Guarded-Hot-Plate Apparatus
ASTM C272/C272M-12	Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
ASTM C518-10	Standard Test Method for Steady-State Thermal Transmittance Properties by Means of the Heat Flow Meter Apparatus
ASTM C835-06 (2013) el	Standard Test Method for Total Hemispherical Emittance of Surfaces up to 1400°C
ASTM C1224-11	Standard Specification for Reflective Insulation for Building Applications
ASTM C1363-11	Standard Test Method for the Thermal Performance of Building Assemblies by Means of a Hot Box Apparatus
ASTM D1003-13	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
ASTM E283-04 (2012)	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E779-10	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
ASTM E972-96 (2013)	Standard Test Method for Solar Photometric Transmittance of Sheet Materials Using Sunlight
ASTM E1677-2011	Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls
ASTM E1680-11	Standard Test Method for Rate of Air Leakage Through Exterior Metal Roof Panel Systems
ASTM E1827-2011	Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
ASTM E1980-11	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low Sloped Opaque Surfaces
ASTM E2178-13	Standard Test Method for Air Permeance of Building Materials
ASTM E2357-11	Standard Test Method for Determining Air Leakage of Air Barrier Assemblies
Cool Roof Rating Council (CRRC) 1610 Harrison Street, Oakland, CA 94612	
ANSI/CRRC-1 Standard-2012	Cool Roof Rating Council—ANSI/CRRC-1 Standard
Cooling Technology Institute (CTI) 3845 Cypress Creek Parkway, Suite 420, Houston, TX 77068; P.O. Box 681807	
CTI ATC-105 (00)	Acceptance Test Code for Water Cooling Towers
CTI ATC-105DS (18)	Acceptance Test Code for Dry Fluid Coolers
CTI ATC-105S (11)	Acceptance Test Code for Closed-Circuit Cooling Towers

CTI ATC-106 (11)	Acceptance Test Code for Mechanical Draft Evaporative Vapor Condensers
CTI STD-201 RS (~~15~~17)	Performance Rating of Evaporative Heat Rejection Equipment
Door and Access Systems Manufacturers Association (DASMA) 1300 Sumner Avenue, Cleveland, OH 44115-2851	
ANSI/DASMA 105-2012	Test Method for Thermal Transmittance and Air Infiltration of Garage Doors
Illuminating Engineering Society (IES) 120 Wall street, Floor 17, New York, NY 10005-4001	
ANSI/IES RP-28-2007	Lighting and the Visual Environment for Senior Living
International Organization for Standardization (ISO) ISO Central Secretariat BIBC II Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland	
ISO 9050 (2003)	Glass in Building—Determination of Light Transmittance, Solar Direct Transmittance, Total Solar Energy Transmittance, Ultraviolet Transmittance and Related Glazing Factors
ANSI/AHRI/ASHRAE/ISO 13256-1:1998 (R2012)	Water-Source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-Air and Brine-to-Air Heat Pumps
ANSI/AHRI/ASHRAE/ISO 13256-2:1998 (R2012)	Water-Source Heat Pumps—Testing and Rating for Performance—Part 2: Water-to-Water and Brine-to-Water Heat Pumps
ISO 25745-2:2015	Energy Performance of Lifts, Escalators and Moving Walks—Part 2: Energy Calculation and Classification for Lifts (Elevators)
National Electrical Manufacturers Association (NEMA) 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209	
ANSI/NEMA MG 1-2009	Motors and Generators
National Fenestration Rating Council (NFRC) 6305 Ivy Lane, Suite 140, Greenbelt, MD 20770-6323	
ANSI/NFRC 100-~~2014~~2017	Procedure for Determining Fenestration Product U-Factors
ANSI/NFRC 200-~~2014~~2017	Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence
NFRC 203-2017	Procedure for Determining Visible Transmittance of Tubular Daylighting Devices
NFRC 300-~~2014~~2017	Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems
NFRC 301-~~2014~~2017	Test Method for Emittance of Specular Surfaces Using Spectrometric Measurements
ANSI/NFRC 400-~~2014~~2017	Procedure for Determining Fenestration Product Air Leakage
National Fire Protection Association (NFPA) 1 Battery March Park, P.O. Box 9101, Quincy, MA 02269-9101	
NFPA 70-2014	National Electric Code
NFPA 96-2014	Ventilation Control and Fire Protection of Commercial

	Cooking Operations
Telecommunications Industry Association (TIA) 2500 Wilson Boulevard, Arlington, VA 22201	
ANSI/TIA-942-REV A, March 2014	Telecommunication Infrastructure Standard for Data Centers
Underwriters Laboratories, Inc. (UL) 333 Pfingsten Rd., Northbrook, IL 60062	
UL 181A-2013	Closure Systems for Use with Rigid Air Ducts and Air Connectors
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UL 727-06	UL Standard for Safety—Oil Fired Central Furnaces
UL 731-2012	UL Standard for Safety—Oil-Fired Unit Heaters
U.S. Department of Defense 3010 Defense Pentagon, Washington, DC 20301	
MIL-P-17639F (1996)	Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use
MIL-P-17840C (1986)	Pumps, Centrifugal, Close-Coupled, Navy Standard (For Surface Ship Application)
MIL-P-17881D (1972)	Pumps, Centrifugal, Boiler Feed (Multi-Stage)
MIL-P-18472 (1989)	Pumps, Centrifugal, Condensate, Feed Booster, Waste Heat Boiler, and Distilling Plant
MIL-P-18682D	Pump, Centrifugal, Main Condenser Circulating, Naval Shipboard
U.S. Department of Energy (DOE) 1000 Independence Avenue, SW, Washington, DC 20585	
10 CFR Part 430, App N	Uniform Test Method for Measuring the Energy Consumption of Furnaces
10 CFR Part 431.304	Uniform test method for the measurement of energy consumption of walk-in coolers and walk-in freezers.
10 CFR 431 Subpart K, App A	Uniform Test Method for Measuring the Energy Consumption of Distribution Transformers
10 CFR Part 431, Subpart B, App B	Uniform Test Method for Measuring Nominal Full-Load Efficiency of Electric Motors
10 CFR Part 431, Subpart Y	Pumps: Definitions, Energy Conservation Standards, and Uniform Test Method of the Measurement of Energy Consumption of Pumps
42 USC 6831, et seq., Public Law 102-486	Energy Policy Act of 1992, EPACT 2005, and EISA 2007
U.S. Security and Exchange Commission (SEC) 100 F Street, NE, Washington, DC 2-549	
The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System	The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System, April 7, 2003
U.S. Nuclear Regulatory Commission	

One White Flint North 11555 Rockville Pike Rockville, MD 20852-2738	
10 CFR Part 50	Domestic Licensing of Production and Utilization Facilities

This is a normative appendix and is part of this standard

Normative Appendix A

Rated R-Value of Insulation and Assembly U-Factor, C-Factor, and F-Factor Determinations

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A3.2 Metal Building Walls

A3.2.1 General

For the purpose of Section A1.2, the base assembly is a *wall* with metal *wall* panels and a metal structure. Insulation is installed in accordance with this section. Insulation exposed to a *conditioned space* or *semiheated space* shall have a facing with seams overlapped or sealed.

A3.2.2 Rated R-Value of Insulation for Metal Building Walls

A3.2.2.1 Single-Layer Compressed

The first *rated R-value of insulation* is for insulation compressed between metal *wall* panels and the steel structure.

A3.2.2.2 Continuous Insulation

For assemblies with *continuous insulation*, the *continuous insulation* is installed on the outside or inside of the girts, uncompressed and uninterrupted by the framing members.

A3.2.2.3 Single-Layer in Cavity

The insulation is installed in the cavity between the girts, not compressed by the framing. A membrane or facing, installed separately or adhered to the insulation, is installed inside of the girts to form a continuous layer. A thermal spacer block or thermal break strip between the girts and metal *wall* panels is required when specified in Table A3.2.3.

Table A3.2.3 Assembly *U-Factors* for *Metal Building Walls*

Insulation *System*	Rated *R-Value* of Insulation	Overall *U-Factor* for Entire Base *Wall* Assembly	Overall *U-Factor* for Assembly of Base *Wall* Plus *Continuous Insulation* (Uninterrupted by Framing)								
			R-6.5	R-9.8	R-13	R-15.8	R-19	R-22.1	R-25	R-32	R-38
Continuous insulation only	R-0	1.180	0.136	0.094	0.072	0.060	0.050	0.044	0.039	0.030	0.026
Single compressed layer	R-10	0.186	0.084	0.066	0.054	0.047	0.041	0.036	0.033	0.027	0.023
	R-11	0.185	0.084	0.066	0.054	0.047	0.041	0.036	0.033	0.027	0.023
	R-13	0.162	0.079	0.063	0.052	0.046	0.040	0.035	0.032	0.026	0.023
	R-16	0.155	0.077	0.062	0.051	0.045	0.039	0.035	0.032	0.026	0.022
	R-19	0.147	0.075	0.060	0.050	0.044	0.039	0.035	0.031	0.026	0.022
Single layer in cavity	R-25[a]	0.059	0.044	0.039	0.035	0.032	0.029	0.027	0.025	0.021	0.019
	R-30[b]	0.052	0.042	0.037	0.033	0.031	0.028	0.026	0.024	0.021	0.019
Double layer	R-25 + R-10	0.047	0.038	0.034	0.031	0.028	0.026	0.024	0.023	0.020	0.018
	R-25 + R-16	0.042	0.036	0.032	0.029	0.027	0.025	0.023	0.022	0.019	0.018
	R-25 + R-10[c]	0.039	0.032	0.029	0.027	0.025	0.023	0.022	0.021	0.018	0.017
	R-30 + R-16	0.039	0.036	0.032	0.029	0.027	0.025	0.023	0.022	0.019	0.017

(Multiple *R-values* are listed in order from inside to outside.)
a. A minimum R-0.375 thermal spacer block or thermal break strip is required when installed without *continuous insulation*.
b. A minimum R-0.75 thermal spacer block or thermal break strip is required when installed without *continuous insulation*.
c. A minimum R-3 thermal spacer block is required.

A3.2.2.4 Double-Layer

The first *rated R-value of insulation* is for insulation installed in the cavity between the girts, not compressed by the framing. The second *rated R-value of insulation* is for in-

sulation compressed between metal *wall* panels and the steel structure. A membrane or facing, installed separately or adhered to the insulation, is installed inside of the girts to form a continuous layer. A thermal spacer block or thermal break strip between the girts and metal *wall* panels is required when specified in Table A3.2.3.

A3.2.3 U-Factors for Metal Building Walls

U-factors for *metal building walls* shall be taken from Table A3.2.3 or determined in accordance with Section A9.2, provided the average girt spacing is at least 52 in. *U-factors* for *metal building wall* assemblies with average girt spacing less than 52 in. shall be determined in accordance with Section A9.2.

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A6 SLAB-ON-GRADE FLOORS

A6.1 General

For the purpose of Section A1.2, the base assembly is a *slab 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~~ five 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.

d. Under-Slab Insulation only: Insulation installed under the entire slab. The slab edge remains uninsulated.

e. Uninsulated: Slabs without insulation under the slab and at the slab edge.

Table A5.4.3.1 Assembly *U-Factors* for Wood-Joist *Floors*

Framing Type and Spacing Width (Actual Depth)	Cavity Insulation *R-Value*: Rated (Effective Installed)	Overall *U-Factor* for Entire Base *Floor* Assembly	Overall *U-Factor* for Assembly of Base *Floor* Plus *Continuous Insulation* (Uninterrupted by Framing)																			
			Rated *R-Value* of *Continuous Insulation*																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Wood-Joist																						
5.5 in.	None (0.0)	0.282	0.220	0.180	0.153	0.132	0.117	0.105	0.095	0.087	0.080	0.074	0.069	0.064	0.060	0.057	0.054	0.042	0.035	0.030	0.026	0.023
	R-11 (11.0)	0.074	0.069	0.064	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.030	0.026	0.023	0.020	0.019
	R-13 (13.0)	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.028	0.025	0.022	0.020	0.018
	R-15 (15.0)	0.060	0.057	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.027	0.024	0.021	0.019	0.017
	R-19 (18.0)	0.051	0.048	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.025	0.022	0.020	0.018	0.017
	R-21 (21.0)	0.046	0.043	0.042	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.023	0.021	0.019	0.017	0.016
7.25 in.	R-25 (25.0)	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.025	0.025	0.024	0.022	0.019	0.018	0.016	0.015
	R-30C (30.0)	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.020	0.018	0.016	0.015	0.014
9.25 in.	R-30 (30.0)	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.020	0.018	0.016	0.015	0.014
11.25 in.	R-38C (38.0)	0.027	0.026	0.025	0.025	0.024	0.024	0.023	0.022	0.022	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.017	0.016	0.015	0.014	0.013
13.25 in.	R-38 (38.0)	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.021	0.021	0.020	0.020	0.019	0.019	0.019	0.017	0.016	0.015	0.014	0.013

A6.2 Rated R-Value of Insulation for Slab-on-Grade Floors

A6.2.1

The *rated R-value of insulation* shall be installed around the perimeter of the *slab-on-grade floor* to the distance specified.

Exception to A6.2.1

For a monolithic *slab-on-grade floor*, the insulation shall extend from the top of the slab-on-*grade* to the bottom of the footing.

A6.2.2

Insulation installed inside the foundation *wall* shall extend downward from the top of the slab a minimum of the distance specified or to the top of the footing, whichever is less.

A6.2.3

Insulation installed outside the foundation *wall* shall extend from the top of the slab or downward to at least the bottom of the slab and then horizontally to a minimum of the distance specified. In all climates, the horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 10 in. thick.

A6.3 F-Factors for Slab-on-Grade Floors

A6.3.1

F-factors for *slab-on-grade floors* shall be taken from Table A6.3.1-1 or A6.3.1-2.

A6.3.2

These *F-factors* are acceptable for all *slab-on-grade floors*.

Table A6.3.1-1 Assembly *F-Factors* for *Slab-on-Grade Floors*

	Rated R-Value of Insulation												
Insulation Description	**R-0R-3.5**	**R-5**	**R-7.5**	**R-10**	**R-15**	**R-20**	**R-25**	**R-30**	**R-35**	**R-40**	**R-45**	**R-50**	**R-55**
Unheated Slabs													
NoneUninsulated: 0.73	0.73												
12 in. horizontal		0.72	0.71	0.71	0.71								
24 in. horizontal		0.70	0.70	0.70	0.69								
36 in. horizontal		0.68	0.67	0.66	0.66								
48 in. horizontal		0.67	0.65	0.64	0.63								
12 in.vertical		0.61	0.60	0.58	0.57	0.567	0.565	0.564					
24 in. vertical		0.58	0.56	0.54	0.52	0.510	0.505	0.502					
36 in. vertical		0.56	0.53	0.51	0.48	0.472	0.464	0.460					
48 in. vertical		0.54	0.51	0.48	0.45	0.434	0.424	0.419					
Fully insulated slab		0.46	0.41	0.36	0.30	0.261	0.233	0.213	0.198	0.186	0.176	0.168	0.161
Heated Slabs													
NoneUninsulated: 1.35	1.35												
12 in. horizontal		1.31	1.31	1.30	1.30								
24 in. horizontal		1.28	1.27	1.26	1.25								
36 in. horizontal		1.24	1.21	1.20	1.18								
48 in. horizontal		1.20	1.17	1.13	1.11								
12 in. vertical		1.06	1.02	1.00	0.98	0.968	0.964	0.961					
24 in. vertical		0.99	0.95	0.90	0.86	0.843	0.832	0.827					

36 in. vertical		0.95	0.89	0.84	0.79	0.762	0.747	0.740					
48 in. vertical		0.91	0.85	0.78	0.72	0.688	0.671	0.659					
Fully insulated slab		0.74	0.64	0.55	0.44	0.373	0.326	0.296	0.273	0.255	0.239	0.227	0.217
Under-slab insulation only	1.06	1.01	0.95	0.90	0.82	0.76							

Table A6.3.1-2 Assembly *F-Factors* for Fully Insulated Heated *Slab-on-Grade Floors*

	Rated R-Value of Edge Insulation							
Insulation Description	**R-3.5**	**R-5**	**R-7.5**	**R-10**	**R-15**	**R-20**	**R-25**	**R-30**
Heated Slabs								
R-3.5 under slab	0.81	0.78	0.74	0.71	0.69	0.671	0.670	0.669
R-5 under slab	0.77	0.74	0.69	0.66	0.62	0.602	0.602	0.601
R-7.5 under slab	0.71	0.67	0.64	0.60	0.58	0.566	0.564	0.563
R-10 under slab	0.66	0.62	0.58	0.55	0.51	0.496	0.494	0.493
R-15 under slab	0.57	0.54	0.50	0.47	0.45	0.433	0.432	0.431
R-20 under slab	0.51	0.48	0.44	0.41	0.39	0.371	0.370	0.369

…

A9.4.6 Metal Building U-Factor Equations

The calculation procedures in this section shall use a fixed purlin and girt spacing of 60 inches and the results shall be permitted to be used in accordance with Section A2.3.3 and A3.2.3. For single-layer *metal building roof* and single-layer compressed *metal building wall systems*, the calculation procedure outlined in Section A9.4.6.1 shall be used to calculate the assembly *U-factor*. For double-layer *metal building roof systems*, the calculation procedure outlined in Section A9.4.6.2 shall be used to calculate the assembly *U-factor*. For single-layer in cavity and double-layer *metal building wall systems*, the calculation procedure outlined in Section A9.4.6.3 shall be used to calculate the assembly *U-factor*. Each of the above insulation methods and calculation procedures also shall be used where *continuous insulation* is applied to the assembly. The calculation procedures outlined in this section shall not be used for other *metal building roof* and *wall systems*.

…

This is a normative appendix and is part of this standard

Normative Appendix C

Methodology for Building Envelope Trade-Off Option in Section 5.6

C1 MINIMUM INFORMATION

The following minimum information shall be specified for the *proposed design*.

C1.1 At the Building Level

The *floor* area, broken down by *space-conditioning categories* and *building* area type, shall be specified. Each *building* area type shall be chosen from Table 9.5.1.

C1.2 At the Exterior and Semiexterior Surface Level

The *building envelope* assembly type, gross area, *orientation*, tilt, and associated *space-conditioning category* and *building* area type shall be specified. The surface shall be designated as exterior or semiexterior. A semiexterior surface separating a *conditioned space* from a *semiheated space* shall be specified with two associated *space-conditioning categories*. A semiexterior surface separating a *conditioned space* from an *unconditioned space* shall be specified with an associated *space-conditioning category* and with an adjacency to an *unconditioned space*. Exterior surfaces with the same *building envelope* assembly type and associated *space-conditioning category* and *building* area type whose orientations differ by no more than 22.5 degrees and whose tilts differ by no more than 22.5 degrees are allowed to be described as a single surface.

C1.2.1 For Roofs

The *class of construction*, *opaque* area, *U-factor*, *HC*, and insulation position shall be specified. Where three-year-aged test data for the solar *reflectance* and three-year-aged thermal *emittance* of the exterior *roof* surface are available, the three-year-aged solar *reflectance* and three-year-aged thermal *emittance* shall be specified.

C1.2.2 For Above-Grade Walls

The *class of construction*, *opaque* area, *U-factor*, *HC*, and insulation position shall be specified.

C1.2.3 For Below-Grade Walls

The *opaque* area, average depth to the bottom of the *wall*, *C-factor*, *HC*, and insulation position shall be specified.

C1.2.4 For Floors

The *class of construction*, *opaque* area, *U-factor*, *HC*, and insulation position shall be specified.

C1.2.5 For Slab-on-Grade Floors

The *class of construction*, perimeter length, *F-factor*, and *HC* shall be specified.

C1.2.6 For Uninsulated Assemblies

a. 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.

C1.3 For Opaque Doors

The *class of construction*, area, and *U-factor* shall be specified. Each *opaque door* shall be associated with a surface as described in Section C1.2 and shall have the *orientation* of that surface.

C1.4 For Fenestration

The *class of construction*, area, assembly *U-factor*, assembly *SHGC*, *VT*, and *PF* shall be specified for *fenestration*. ~~For *skylight wells*, the width, depth, and height shall be~~

~~defined as shown in Figure C1.4.~~ Each *fenestration* element shall be associated with a surface as defined in Section C1.2 and shall have the *orientation* of that surface.

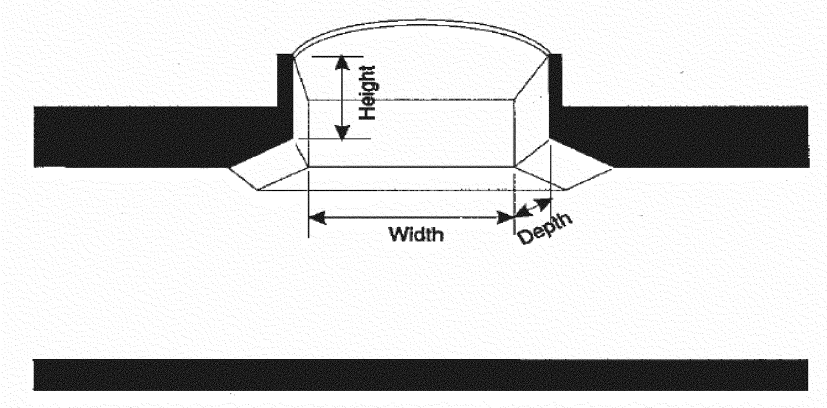

Figure C1.4 *Skylight well* dimensions.

C2 OUTPUT REQUIREMENTS

Output reports shall contain the following information.

C2.1

Name and contact information of the entity executing the simulation, and date of report.

C2.2

Location of the *building*, including street address and climate zone.

C2.3

Location corresponding to the weather data used to perform the simulation.

C2.4

Simulation program used to perform the simulation.

C2.5

Tables summarizing the minimum information described in Section C1.

C2.6

All differences between the *proposed envelope performance factor* and the *base envelope performance factor*.

C2.7

Peak heating and cooling loads for *building classes of constructions*.~~Total conductive heat gain and conductive heat loss through all *opaque classes of construction*.~~

~~**C2.8**~~

a. ~~Total conductive heat gain, conductive heat loss, and solar heat gain through all *fenestration classes of construction*.~~8

C2.~~8~~9

The version of the software and the link to the website that contains the ASHRAE Standard 140 results for the version used in accordance with Section C3.1.4.

C3 SIMULATION GENERAL REQUIREMENTS

C3.1 Simulation Program

The *simulation program* shall be a computer-based software program for the analysis of *energy* consumption in *buildings*. The *simulation program* shall include calculation methodologies for the *building* components being modeled.

Informative Note

Examples of simulation programs include, but are not limited to, EnergyPlus and DOE-2.

C3.1.1

The *simulation program* shall be approved by the *adopting authority* and shall, at minimum, have the ability to explicitly model all of the following:

a. The *base envelope performance factor*, using only the input for the *proposed envelope performance factor*. The calculation procedure shall not allow the user to directly modify the *building* component characteristics of the base design.
b. 8760 hours per year.
c. Hourly variations in occupancy, lighting power, miscellaneous *equipment* power, *thermostat set points*, and *HVAC system* operation, defined separately for each day of the week and holidays.
d. Thermal mass effects.
e. The number of thermal zones in the *proposed design* or nine thermal zones, whichever is greater.
f. *Air economizers* with integrated *control*.
g. *Continuous daylight dimming controls* and *photosensors*.

C3.1.2

The *simulation program* shall have the ability to determine the *proposed envelope performance factor* and *base envelope performance factor* by calculating annual *energy* costs.

Informative Note

Neither the *proposed envelope performance factor* nor the *base envelope performance factor* are predictions of actual energy consumption or costs for 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 procedure, changes in energy rates between design of the building and occupancy, and the precision of the calculation tool.

C3.1.3

The *simulation program* shall be capable of performing design load calculations to determine required HVAC *equipment* capacities and airflow rates in accordance with Section 6.4.2 for both the *proposed design building envelope* and the *base design building envelope*.

C3.1.4

The *simulation program* shall be tested according to ASHRAE Standard 140, except for Sections 7 and 8 of Standard 140.~~, and the results shall be furnished by the software provider.~~ The test results and modeler reports shall be posted on a publicly available website and shall include the test results of the simulation program alongside the results of the other simulation programs included in ASHRAE Standard 140 Annexes B8 and B16. The modeler report in Standard 140 Annex A2 Attachment A2.7 shall be completed for results exceeding the maximum or falling below the minimum of the reference values or for missing results.

Informative Note: There are no pass/fail criteria established by this requirement.

C3.2 Climatic Data

The *simulation program* shall perform the simulation using hourly values of climatic data, including temperature, humidity, solar radiation, and wind speed and direction from representative climatic data, for the *proposed design building envelope* location. For cities or urban regions for which several climatic data sources are available and for locations for which weather data are not available, the designer shall select available weather data that represent the climate at the *construction* site. Selected weather data shall be approved by the *authority having jurisdiction*.

C3.2.1 Surface Exposure

Semiexterior surfaces separating *conditioned spaces* from *unconditioned spaces* shall be simulated as exterior surfaces with no exposure to wind or solar radiation.

C3.3 Purchased Energy Rates

The following rates for *purchased energy* shall be used to determine the *proposed envelope performance factor* and the *base envelope performance factor*:

a. Electricity: ~~0.1032~~$0.1063/kWh
b. Heating: ~~0.99~~$0.98/therm

Exception to C3.3

Where approved by the *authority having jurisdiction*, actual annual rates for *purchased energy* or state average *energy* prices published by the Department of Energy's Energy Information Administration shall be permitted. The same rates shall be used for both the *proposed envelope performance factor* and the *base envelope performance factor*.

C3.4 Compliance Calculations

The *proposed envelope performance factor* and *base envelope performance factor* shall be calculated using the same

a. *simulation program*,
b. climatic data, and
c. *purchased energy rates*.

C3.5 Calculation of Proposed Envelope Performance Factor

The simulation model for calculating the *proposed envelope performance factor* shall be developed in accordance with Sections C3.5.1 through C3.5.11.

C3.5.1 Space-Conditioning

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 *control set points* and schedules shall be consistent with those in the *building envelope trade-off schedules and loads* for the applicable *building* area type. All *semiheated spaces* shall be simulated as being heated and not cooled. The heating temperature *control set point* shall be 50°F for all hours.

C3.5.2 Model Geometry and Thermal Zones

The *building* model shall be divided into thermal zones described as follows:

a. Determine the ratio (R_c) of the *floor* area to the *gross wall area* for each unique combination of *space-conditioning category* and *building* area type. The index "c" refers to a combination of *space-conditioning category* and *building* area type as defined for each surface.
b. Create a perimeter zone for each unique combination of *building* area type, *above-grade-wall orientation*, and *space-conditioning category*. If there is more than one *above-grade-wall* assembly for a *building* area type and *orientation*, each *above-grade-wall* assembly shall be placed end-to-end in the order it is defined. The area of each perimeter zone shall be the *gross wall area* of the zone times R_c or 1.25, whichever is smaller.
c. For each unique combination of *space-conditioning category* and *building* area type with R_c greater than 1.25, interior zones shall be created and used in the trade-off procedure. The area of the interior zone shall be the total area for the unique combination of *space-conditioning category* and *building* area type less the area of the perimeter zones for that combination of *space-conditioning category* and *building* area type.

d. Create a below-*grade* zone for each unique combination of *space-conditioning category* and *building* area type associated with *below-grade walls*. If there is more than one *below-grade-wall* assembly for a *building* area type, each below-*grade-wall* assembly shall be placed end-to-end in the order it is defined. The area of each below-*grade* zone shall be the *gross wall area* of the zone times R_c or 1.25, whichever is smaller.

e. The *wall* height and the height of each thermal zone shall be 15 ft.

f. *Roof* area and *floor* area associated with each *building* area type shall be prorated among all zones of the corresponding *building* area type in proportion to the zone area of each zone. *Roof* area and *floor* area in each zone shall be centered in the horizontal plane of the zone with the same aspect ratio as the horizontal plane of the zone.

g. *Slab-on-grade floor* perimeter associated with each *building* area type shall be prorated among perimeter zones of the corresponding *building* area type in proportion to the area of each zone.

h. *Vertical fenestration area* shall be assigned to the associated surface as described in Section C1.4. *Vertical fenestration* shall be centered on the associated surface with the same aspect ratio as the associated surface. Windows with equivalent *U-factor*, *SHGC*, and *VT* that do not include fins may be combined into a single window on the associated surface.

i. *Skylight* area shall be assigned to the associated surface as described in Section C1.4, prorated among interior zones containing the *roof* area with which the *skylight* area is associated, in proportion to the associated *roof* area. If the total *skylight* area exceeds the associated *roof* area in interior zones, the remaining *skylight* area shall be prorated among perimeter zones containing the *roof* area with which the *skylight* area is associated, in proportion to the associated *roof* area.

j. Each zone shall be modeled as being fully enclosed. Zone boundaries not created as described above shall be modeled as adiabatic interior surfaces.

C3.5.3 Daylight Area and Photosensor Location

Daylight areas and *photosensors* shall not be modeled in *residential* zones. In each *nonresidential* zone, *daylight areas* and *photosensor* locations shall be modeled in accordance with the following:

a. For each *nonresidential* zone associated with *vertical fenestration*, the *daylight area* shall be modeled as directly adjacent to the *vertical fenestration* with a width equal to the width of the *vertical fenestration* and a depth equal to the head height of the *vertical fenestration*.

b. In each *nonresidential* zone associated with *skylights*, the *daylight area under skylights* shall be modeled as bounded, in each direction, by the edge of the *skylight* area plus 10 ft or the distance to the edge of the zone, whichever is less.

c. For each *daylight area* associated with *vertical fenestration*, a *photosensor* shall be modeled as located at the center of the width of the *daylight area*, at the depth of the *daylight area* and at a height of 3 ft.

d. For each *daylight area* associated with a *skylight*, a *photosensor* shall be modeled as located at the center of the horizontal plane of the *skylight* and at a height of 5 ft.

C3.5.4 Schedules

The schedule types listed in Section C3.1.1(c) shall be required input. The schedules shall be consistent with those in the *building envelope trade-off schedules and loads*[1] for the applicable *building* area type.

C3.5.5 Building Envelope

The *building envelope* shall reflect the information specified in Section C1.

Exception to C3.5.5

Where three-year-aged test data for the solar *reflectance* and three-year-aged thermal *emittance* of the exterior *roof* surface are unavailable, the exterior *roof* surface shall be modeled with a solar *reflectance* of 0.30 and a thermal *emittance* of 0.90.

C3.5.5.1 Shading

Manually operated interior shades shall be modeled on all *vertical fenestration*. Shades shall be modeled to be in the lowered position when either the transmitted luminance~~luminous intensity~~ is greater than 200 cd/ft^2 or the direct solar transmitted *energy* exceeds 30 Btu/h·ft^2 and then remain lowered for rest of the day. Shades shall be modeled with visible light transmittance of 0.10, visible light *reflectance* of 0.40, solar transmittance of 0.21, and solar *reflectance* of 0.23. Permanent shading devices such as fins and overhangs shall be modeled.

C3.5.5.2 Dynamic Glazing

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/ft^2 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 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

Exception to C3.5.5.3

If the *simulation program* cannot simulate air leakage as a function of the area of *walls* that separate *conditioned spaces* and *semiheated spaces* from the exterior, the air leakage of the *building envelope* shall be converted to the appropriate units to describe the air leakage as a function of *gross floor area* as follows:

$$I_{FLR} = 0.112 \times I_{75Pa} \times S/A_{FLR}$$

where

I_{FLR} = adjusted air leakage rate of the *building envelope* (cfm/ft^2) at a reference

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

wind speed of 10 mph and relative to the *gross floor area*

A_{FLR} = *gross floor area*, ft^2

C3.5.5.3.1 Infiltration Schedule

1. *Infiltration* shall be adjusted in accordance with the *infiltration* schedule in the *building envelope trade-off schedules and loads* for the applicable *building* area type.

C3.5.6 Interior Surfaces

Interior surfaces shall be modeled with visible light reflectances of 0.80 for ceilings, 0.50 for *walls*, and 0.20 for *floors*. Interior surfaces shall be modeled with a thermal *emittance* of 0.90.

C3.5.7 Lighting

The modeled lighting power shall be determined using the *lighting power density* allowances in Table 9.5.1 for the applicable *building* area type. The modeled lighting power shall be adjusted in accordance with the lighting schedule in the *building envelope trade-off schedules and loads* for the applicable *building* area type. Fifty percent (50%) of lighting in *daylight areas* shall be modeled with *continuous daylight dimming controls* such that when sufficient daylight is available at the corresponding *photosensor*, lighting power is reduced to maintain a minimum 50 fc for *conditioned spaces* and 30 fc for *semiheated spaces*. The minimum light output for the *continuous daylight dimming* shall be 6% of peak light output. Power input shall be modeled as 20% of lighting power at the minimum light output and scaled linearly to 100% of lighting power at peak light output.

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 EER from Table 6.8.1-1, based on requirements for split system air conditioners with heating section type “all other” between 65,000 Btu/h and 135,000 Btu/h. ~~with constant *COP*, excluding the indoor fan power equal to 4.4.~~ The EER shall be adjusted to remove the fan power in accordance with Section 11.5.2c.

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* 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.

C3.5.9 Miscellaneous Loads

Miscellaneous loads shall be modeled as included in the *building envelope trade-off schedules and loads* for the applicable *building* area type.

C3.5.10 Occupant Density

The occupant density shall be modeled according to the peak occupant density and the occupancy rate schedule in the *building envelope trade-off schedules and loads* for the applicable *building* area type.

C3.5.11 Heat Gain from Occupants

The sensible and latent heat gain due to occupants shall be modeled as included in the *building envelope trade-off schedules and loads* for the applicable *building* area type.

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.

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*.

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*.

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.

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 D

(Retained for Future Use)

Climatic data are no longer contained in this appendix. See Section 5.1.4 for requirements. Annex 1 of this standard contains extracts of material from ASHRAE Standard 169.

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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.

Address/Contact Information

AABC
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1518 K Street Northwest, Suite 503
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AMCA
30 West University Drive
Arlington Heights, IL 60004

BLAST
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University of Illinois
1206 West Green Street
Urbana, IL 61801
www.bso.uiuc.edu/BLAST/index.html

Cooling Technology Institute (CTI)
2611 FM 1960 West
Suite A-101, Houston, TX 77068-3730
P.O. Box 73383, Houston, TX 77273-3383

CWEC Data
Environment Canada
http://climate.weather.gc.ca/prods_servs/engineering_e.html

DOE-2
Building Energy Simulation news
http://simulationresearch.lbl.gov/un.html

Hydraulic Institute (HI)
6 Campus Drive, First Floor North,
Parsippany, NJ 07054-4405
(T) 973-267-9700
http://pumps.org

MICA
Midwest Insulation Contractors Association
16712 Elm Circle
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www.micainsulation.org

The Green Grid Administration
3855 SW 153rd Drive
Beaverton, Oregon 97006 USA
(T) 503-619-0653
(F) 503-644-6708
IWEC2 Data

IWEC2 Data
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
(T) 404-636-8400
(F) 404-321-5478
http://www.techstreet.com/ashrae
(Direct link: http://www.techstreet.com/ashrae/products/1876209)

NEBB
National Environmental Balancing Bureau
8575 Grovemont Circle
Gaithersburg, MD 20877

SMACNA
Sheet Metal & Air Conditioning Contractors'
National Association
4201 Lafayette Center Drive
Chantilly, VA 20151
info@smacna.org
www.smacna.org

TMY3 Data
National Renewable Energy Laboratory
NREL/RReDC
Attn: Pamela Gray-Hann
1617 Cole Blvd., MS-1612
Golden, Colorado, USA 80401
http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3

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

Subsection No.	Reference	Title/Source
3.2 IT Equipment Energy	Recommendations for Measuring and Reporting Overall Data Center Efficiency v2 17 May 2011	The Green Grid
3.2 Power Usage Effectiveness	Recommendations for Measuring and Reporting Overall Data Center Efficiency v2 17 May 2011	The Green Grid
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	AABC 2002	Associated Air Balance Council, National Standards for Total System Balance
6.7.2.3	ASHRAE Standard 111-2008	Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
6.7.2.4	ASHRAE Guideline 1.1-2007	HVAC&R Technical Requirements for the Commissioning Process
6.7.2.3	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
10.4.5	ISO 27327-1:209 (R2014) — Air curtain units — Part 1: Laboratory Methods of Testing for Aerodynamic Performance Rating	AMCA
10.4.5	ANSI/AMCA Standard 220-05 (R2012) Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating	ISO
10.4.~~6~~7	ANSI/HI 1.1-1.2-2014	Rotodynamic Centrifugal Pumps for Nomenclature and Definitions
10.4.~~6~~7	ANSI/HI 2.1-2.2-2014	Rotodynamic Vertical Pumps or Radial, Mixed, and Axial Flow Types for Nomenclature and Definitions
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

Subsection No.	Reference	Title/Source
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 layer fiberglass batt insulation assemblies	ASHRAE Transactions 116(1):10–018
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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Informative Appendix F

U.S. Department of Energy Minimum Energy Efficiency Requirements

In the United States, the U.S. Department of Energy establishes *efficiency* standards for products that it defines as "residential covered products." Since these products are used in *buildings* covered by this standard, the DOE *efficiency* requirements are shown here for convenience. All DOE *efficiency* requirements for *residential* products are found in the U.S. *Code of Federal Regulations*, 10 CFR Part 430 Subpart C, Section 430.32.

Note

The values listed in this appendix are in I-P units, as the DOE requirements are only published in I-P units.

F1 DOE Minimum Energy Efficiency Requirements for Single-Phase Air Conditioners and Heat Pumps

These standards became effective on January 1, 2015. In the United States, some of the standards are regional in nature. The U.S. has been divided into 3 regions: (a) the north, comprising states with a population weighted heating *degree days* (*HDD*) equal to or greater than 5000; (b) the southeast, comprising states with a population weighted *HDD* less than 5000; and (c) the southwest, comprising Arizona, California, Nevada, and New Mexico. The regions are shown in Figure F-1.

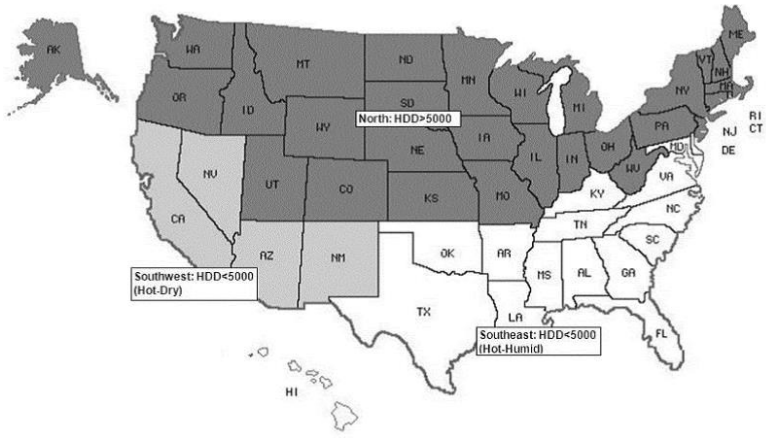

Figure F-1 Map of the regions for the analysis of central air conditioners and heat pumps.
(Source: *Federal Register* 76 FR 37431, June 27, 2011)

The U.S. federal minimum *energy efficiency* standards for single-phase air conditioners and heat pumps are shown in Table F-1. The standards apply to *residential* single-phase air conditioners and heat pumps that are rated at less than 65,000 Btu/hof cooling capacity.

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-constrained products—air conditioners[a]	*SEER* = 12	*SEER* = 12	*SEER* = 12
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.

F2 DOE Minimum Energy Efficiency Requirements for Water Heaters

These standards became effective on April 16, 2015, and apply to products manufactured on or after that dates (Table F-2).

Table F-2 Minimum *Energy Efficiency* Requirements for *Water Heaters*
(Source: 10 CFR Part 430, *Energy* Conservation Program: *Energy* Conservation Standards for Water Heating Pumps)

Product Class	Minimum *Energy Factor* (*EF*)
Gas-fired *water heater*	For tanks with a Rated Storage Volume at or below 55 gallons: *EF* = 0.675 − (0.0015 × Rated Storage Volume [gal]) For tanks with a Rated Storage Volume above 55 gal: *EF* = 0.8012 − (0.00078 × Rated Storage Volume [gal])
Oil-fired *water heater*	*EF* = 0.68 − (0.0019 × Rated Storage Volume [gal])
Electric *water heater*	For tanks with a Rated Storage Volume at or below 55 gal: *EF* = 0.960 − (0.0003 × Rated Storage Volume [gal]) For tanks with a Rated Storage Volume above 55 gal: *EF* = 2.057 − (0.00113 × Rated Storage Volume [gal])
Tabletop *water heater*	*EF* = 0.93 − (0.00132 × Rated Storage Volume [gal])
Instantaneous gas-fired *water heater*	*EF* = 0.82 − (0.0019 × Rated Storage Volume [gal])
Instantaneous electric *water heater*	*EF* = 0.93 − (0.00132 × Rated Storage Volume [gal])

Note: The Rated Storage Volume equals the water storage capacity of a *water heater* in gallons as specified by the *manufacturer*.

F3 DOE Minimum Energy Efficiency Requirements for Pool Heaters

Gas-fired *pool* heaters manufactured on or after April 16, 2013, shall have a thermal *efficiency* not less than 82%.

This is a normative appendix and is part of this standard

Normative Appendix G

Performance Rating Method

G1 GENERAL

G1.1 Performance Rating Method Scope

This appendix offers an alternative path for minimum standard compliance in accordance with Section 4.2.1.1 when administered by a *building official*. It is also provided for those who wish to use this appendix to quantify performance that exceeds the requirements of this standard when administered by a *rating authority* and not seeking minimum standard compliance in accordance with Section 4.2.1.1. It shall be used for evaluating the performance of all such *proposed designs*, including *alterations* and additions to *existing buildings*, except designs with no mechanical *systems*. In the case where this appendix is administered solely by a *building official* to determine compliance with this standard in accordance with Section 4.2.1.1, all references to "*rating authority*" shall be replaced with "*building official*."

G1.2 Performance Rating

G1.2.1 Mandatory Provisions

This *performance rating method* requires conformance with 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.

G1.2.2 The interior lighting power shall not exceed the *interior lighting power allowance* determined using either Tables G3.7 or G3.8 and the methodology described in Sections 9.5.1 and 9.6.1.Performance Rating Calculation

The performance of the *proposed design* is calculated in accordance with provisions of this appendix using the following formula:

$$\text{Performance Cost Index} = \frac{\textit{Proposed building performance}}{\textit{Baseline building performance}}$$

Both the *proposed building performance* and the *baseline building performance* shall include all end-use load components within and associated with the *building* when calculating the Performance Cost Index.

Informative Note

Neither the *proposed building performance* nor the *baseline building performance* are predictions of actual *energy* consumption or costs for 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 procedure, changes in *energy* rates between design of the *building* and occupancy, and the precision of the calculation tool.

Exception to G1.2.2

Energy used to recharge or refuel vehicles that are used for off-building site transportation purposes shall not be modeled in the *baseline building performance* or the *proposed building performance*.

G1.3 Documentation Requirements

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*.

~~p.~~q. The version of the software and the link to the website that contains the ASHRAE Standard 140 results for the version used in accordance with Section G2.2.4.

G2 SIMULATION GENERAL REQUIREMENTS

G2.1 Performance Calculations

The *proposed building performance* and *baseline building performance* shall be calculated using the following:

a. The same *simulation program.*
b. The same weather data.
c. The same *energy* rates.

G2.2 Simulation Program

The *simulation program* shall be a computer-based program for the analysis of *energy* consumption in *buildings* (a program such as, but not limited to, DOE-2, BLAST, or EnergyPlus). The *simulation program* shall include calculation methodologies for the *building* components being modeled. For components that cannot be modeled by the *simulation program*, the exceptional calculation methods requirements in Section G2.5 shall be used.

G2.2.1

The *simulation program* shall be approved by the *rating authority* and shall, at a minimum, have the ability to explicitly model all of the following:

a. 8760 hours per year.
b. Hourly variations in occupancy, lighting power, miscellaneous *equipment* power, *thermostat set points*, and *HVAC system* operation, defined separately for each day of the week and holidays.
c. Thermal mass effects.
d. Ten or more thermal zones.
e. Part-load performance curves for mechanical *equipment.*
f. Capacity and *efficiency* correction curves for *mechanical heating* and *mechanical cooling equipment*.
g. *Air economizers* with integrated *control*.
h. *Baseline building design* characteristics specified in Section G3.

G2.2.2

The *simulation program* shall have the ability to either directly determine the *proposed building performance* and *baseline building performance* or produce hourly reports of *energy* use by an *energy* source suitable for determining the *proposed building performance* and *baseline building performance* using a separate calculation engine.

G2.2.3

The *simulation program* shall be capable of performing design load calculations to determine required HVAC *equipment* capacities and air and water flow rates in accordance with *generally accepted engineering standards* and handbooks (for example, *ASHRAE Handbook—Fundamentals*) for both the *proposed design* and *baseline building design*.

G2.2.4

The *simulation program* shall be tested according to ASHRAE Standard 140, except for Sections 7 and 8 of Standard 140.~~, and the results shall be furnished by the software provider.~~ The test results and modeler reports shall be posted on a publicly available website and shall include the test results of the simulation program alongside the results of the other simulation programs included in ASHRAE Standard 140 Annexes B8 and B16. The modeler report in Standard 140 Annex A2 Attachment A2.7 shall be completed for results exceeding the maximum or falling below the minimum of the reference values or for missing results.

Informative Note: There are no pass/fail criteria established by this requirement.

G2.3 Climatic Data

The *simulation program* shall perform the simulation using hourly values of climatic data, such as temperature and humidity from representative climatic data, for the site in which the *proposed design* is to be located. For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the *construction* site. The selected weather data shall be approved by the *rating authority*.

G2.4 Renewable, Recovered, and Purchased Energy

G2.4.1 On-Site Renewable Energy and Site-Recovered Energy

Site-recovered energy shall not be considered *purchased energy* and shall be subtracted from the *proposed design energy* consumption prior to calculating the *proposed building performance*. *On-site renewable energy* generated by *systems* included on the *building* permit that is used by the *building* shall be subtracted from the *proposed design energy* consumption prior to calculating the *proposed building performance*.

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 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*. c. 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 modeled with the same number of *floors* and identical *conditioned floor area* as the *proposed design*. 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*. Where the *baseline building systems* and *equipment* are permitted to be different from the proposed design but are not prescribed in this appendix, the baseline must be determined based on the following, in the order of priority: a. Requirements in Sections 5-10 b. Requirements of other efficiency or equipment codes or standards applicable to the design of the building systems and equipment.
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.	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.

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.	
3. *Space* Use Classification	
~~Use~~ The space use classification within each thermal block shall be determined ~~specified~~ using the ~~*building* type or~~ *space* type lighting classifications in accordance with Section ~~9.5.1~~ or 9.6.1. **Exception:** Where space types neither exist nor are designated in design documents, use type shall be specified in accordance with 9.5.1. ~~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 category may be used in a *building* if it is a mixed-use facility. If *space* type categories are used, t~~The user may simplify the placement of the various *space* types within the *building* model, provided that *building* total areas and orientation of glazed exterior walls for each *space* type are accurate.	Same as proposed design.
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 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). ~~2.~~3. Fan schedules may be allowed to differ when G3.1.1(c) applies.
5. *Building Envelope*	
a. All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural draw-	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*

ings or as built for *existing building envelopes*.

Exceptions: The following *building* elements are permitted to differ from architectural drawings:

b. All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate *floor* stabs, 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.

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.

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.

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:
- 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 controlled *fenestration* shades or blinds shall be modeled. Permanent shading devices, such as fins, overhangs, and light shelves shall be modeled.
5. 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 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.
Roof Albedo. All *roof* surfaces shall be modeled with a reflectivity of 0.30.

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 complete *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*).

e. 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~~, on *design documents*, ~~assume identical lighting power for the *proposed design* and *baseline building design* in the simulations.~~ lighting power used in the simulation shall be equal to the lighting power allowance in Table 9.6.1 for the appropriate space type or as designed, whichever is greater. For the dwelling units, lighting power used in the simulation shall be equal to 0.60 W/ft^2 or as designed, whichever is greater.

Exception: Lighting use can be reduced for the portion of the space illuminated by the specified fixtures provided that they maintain the same illuminance level as in the baseline. Such reduction shall be demonstrated by calculations.

~~**Exceptions:**~~

f~~e~~. Lighting power for parking garages and *building* facades shall be modeled.

g~~f~~. For lighting *controls*, at a minimum, the proposed design shall be modeled to comply with the requirements of Section 9.4.1.1.

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 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 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*.

shall contain the mandatory *automatic* lighting *controls* specified in Section 9.4.1 (e.g., *automatic* daylight responsive *controls*, occupancy sensors, programmable *controls*, etc.). These *controls* shall be modeled in accordance with (g) and (h).

~~g.~~h. *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.~~i. 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 reduction factors in Table G3.7 for the applicable *space* type. This reduction shall be taken only for lighting controlled by the 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%.

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 that all of the following conditions are met: 1. The *space* use classification is the same throughout the *thermal block* or all of the zones have peak internal loads that differ by less than 10 Btu/h•ft^2 from the average. 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*. ~~3.~~4. All of the zones have schedules that differ by 40 or less equivalent full-load hours per week.	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 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 *ori-*	Same as *proposed design*.

entation 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.

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 *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.	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* 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 *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 *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.	the *proposed design*. Each *system* shall meet the minimum *efficiency* requirements of Section 7.4.2 and be modeled identically to the *proposed design*.
d. For *buildings* that will have no *service water-heating* loads, no *service water-heating system* shall be modeled.	c. For *buildings* that will have no *service water-heating* loads, no *service water-heating* shall be modeled.
e. f. 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.	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.
	e. d. 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*.
	f. e. *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.
	g. f. 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.
	h. g. 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* water required. Examples include but are not limited to low-flow shower heads and dishwashers. Such reduction shall be demonstrated by calculations. The baseline flow rates shall be determined as described in Table G3.1 #1 and the calculation methodology shall be approved by the *authority having jurisdiction*.
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* 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 tem-

	perature. Such reduction shall be demonstrated by calculations.
	i. h. Gas storage *water heaters* shall be modeled using natural gas as their *fuel*.
	Exceptions: i. 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	
a. **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.** 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.	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*. **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 described in G3.1 #1 Design Model or 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 tem-	Same as *proposed design.*

peratures are not available from the local water utility, annual average ground temperatures may be used.

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*.

G2.4.2 Annual Energy Costs

The *design energy cost* and baseline *energy* cost shall be determined using either actual rates for *purchased energy* or state average *energy* prices published by DOE's Energy Information Administration (EIA) for commercial *building* customers, but rates from different sources may not be mixed in the same project. Where *on-site renewable energy* or *site-recovered energy* is used, the *baseline building design* shall be based on the *energy* source used as the backup *energy* source, or the baseline *system energy* source in that category if no backup *energy* source has been specified. Where the proposed design includes *on-site electricity generation systems* other than *on-site renewable energy systems*, the baseline design shall include the same generation systems excluding its *site-recovered energy*.

Informative Note

The above provision allows users to gain credit for features that yield load management benefits. Where such features are not present, users can simply use state average unit prices from EIA, which are updated annually and readily available on EIA's web site (http://www.eia.gov).

G2.5 Exceptional Calculation Methods

When the *simulation program* does not model a design, material, or device of the *proposed design*, an exceptional calculation method shall be used as approved by the *rating authority*. Where there are multiple designs, materials, or devices that the *simulation program* does not model, each shall be calculated separately and exceptional savings determined for each. At no time shall the total exceptional savings constitute more than half of the difference between the *baseline building performance* and the *proposed building performance*. All applications for approval of an exceptional method shall include the following:

a. Step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.

b. 1. Copies of all spreadsheets used to perform the calculations.

c. A sensitivity analysis of *energy* consumption when each of the input parameters is varied from half to double the value assumed.

d. The calculations shall be performed on a time-step basis consistent with the *simulation program* used.

e. The performance rating calculated with and without the exceptional calculation method.

…

G3.1.2 General Baseline HVAC System Requirements

HVAC systems in the *baseline building design* shall conform with the general provisions in this section.

G3.1.2.1 Equipment Efficiencies

All HVAC *equipment* in the *baseline building design* shall be modeled at the minimum *efficiency* levels, both part load and full load, in accordance with Tables G3.5.1 through G3.5.6. Chillers shall use Path A efficiencies as shown in Table 6.8.1-3. Where *efficiency* ratings include supply fan *energy*, the *efficiency* rating shall be adjusted to remove the supply fan *energy*. For Baseline *HVAC Systems* 1, 2, 3, 4, 5, and 6, calculate the minimum $COP_{nfcooling}$ and $COP_{nfheating}$ using the equation for the applicable performance rating as indicated in Tables 6.8.1-1 through 6.8.1-4. Where a full- and part-load *efficiency* rating is provided in Tables 6.8.1-1 through 6.8.1-4, the full-load equation below shall be used:

$$COP_{\text{nfcooling}} = 7.84\text{E-}8 \times EER \times Q + 0.338 \times EER$$

$$COP_{\text{nfcooling}} = -0.0076 \times \text{SEER}^2 + 0.3796 \times SEER$$

$$COP_{\text{nfheating}} = 1.48\text{E-}7 \times COP_{47} \times Q + 1.062 \times COP_{47}$$

(applies to heat pump heating *efficiency* only)

$$COP_{\text{nfheating}} = -0.0296 \times \text{HSPF}^2 + 0.7134 \times HSPF$$

where $COP_{nfcooling}$ and $COP_{nfheating}$ are the packaged HVAC *equipment* cooling and heating *energy efficiency*, respectively, to be used in the *baseline building design*, which excludes supply fan power, and Q is the AHRI-rated cooling capacity in Btu.

EER, *SEER*, *COP*, and *HSPF* shall be at AHRI test conditions. Fan *energy* shall be modeled separately according to Section G3.1.2.9.

G3.1.2.2 Equipment Capacities

~~The *equipment* capacities (i.e. *system* *System* coil capacities)~~ for the *baseline building design* shall be based on sizing runs for each *orientation* ~~(per~~in accordance with Table G3.1, No. 5[a] and Section G3.1.2.2.1~~),~~ and shall be oversized by 15% for cooling and 25% for heating. ~~; i.e.,~~ ~~T~~the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating. Plant capacities shall be based on coincident loads.

G3.1.2.2.1 Sizing Runs

Weather conditions used in sizing runs to determine baseline *equipment* capacities shall be based ~~either on hourly historical weather files containing typical peak conditions or~~ on design days developed using ~~99.6%~~ *heating design temperatures*, ~~and 1% dry bulb and 1% wet bulb~~ *cooling design temperature*~~s~~, and *cooling design wet-bulb temperature*. For cooling sizing runs, schedules for internal loads including those used for infiltration, occupants, lighting, gas and electricity using *equipment* shall be equal to the highest hourly value used in the annual simulation runs and applied to the entire design day. For heating sizing runs, schedules for internal loads including those used for occupants, lighting, gas and electricity using *equipment* shall be equal to the lowest hourly value used in the annual simulation runs and schedules for infiltration shall be equal to the highest hourly value used in the annual simulation runs and applied to the entire design day.

Exception: For cooling sizing runs in *residential dwelling units*, the infiltration, occupants, lighting, gas and electricity using *equipment* hourly schedule shall be the same as the most used hourly weekday schedule from the annual simulation.

G3.1.2.3 Unmet Loads

Unmet load hours for the *proposed design* or *baseline building design* shall not exceed 300 (of the 8760 hours simulated). Alternatively, *unmet load hours* exceeding these limits shall be permitted to be accepted upon approval of the *rating authority*, provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

G3.1.2.4 Fan System Operation

Supply and return fans shall operate continuously whenever ~~*spaces*~~ *HVAC zones* are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours. Supply, return, and/or exhaust fans will remain on during occupied and unoccupied hours in ~~*spaces*~~ *HVAC zones* that have health and safety mandated minimum *ventilation* requirements during unoccupied hours.

Exception to G3.1.2.4

For *Systems* 6 and 8, only the *terminal*-unit fan and *reheat* coil shall be energized to meet heating *set point* during unoccupied hours.

…

Table G3.7 *Performance Rating Method Lighting Power Density* Allowances and Occupancy Sensor Reductions Using the Space-by-Space Method

Common *Space* Types[a]	*Lighting Power Density*, W/ft^2	Occupancy 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 Reduction[b]**
Dwelling Unit	1.07	None
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 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 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 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, the occupancy sensor reduction factor shall be multiplied by 1.25.
c. For occupancy sensors controlling individual workstation lighting, occupancy sensor reduction factor shall be 30%.

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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