ADDENDA

ANSI/ASHRAE/IES Addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw, cy to ANSI/ASHRAE/IES Standard 90.1-2016

Energy Standard for Buildings Except Low-Rise Residential Buildings

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

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3 DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

• • •

Combined Energy Efficiency Ratio (CEER): a ratio of the total cooling one year divided by the total energy from active, standby, and off modes (see CCOP_C for SI equivalent) as specified in 10 CFR 430.23.

Combined Coefficient of Performance (CCOP_C): a ratio of the total cooling one year divided by the total energy from active, standby, and off modes (see CEER for I-P equivalent).

computer room: a room whose primary function is to house *equipment* for the processing and storage of electronic data and that has a design electronic data *equipment* power density exceeding 20 W/ft² of conditioned *floor area*

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

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

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

conditioned space: see space.

conductance: see thermal conductance.

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

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

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

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

continuous dimming: a lighting control strategy that varies the light output of a *lighting system* over a continuous range from full light output to a minimum light output in imperceptible steps without flickering.

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

control: to regulate the operation of equipment.

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

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

cooled space: see space, conditioned space.

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

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

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

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

D

daylight area:

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

- a. the width of the vertical fenestration above the ceiling level plus, on each side, the smallest of
 - 1. 2 ft,
 - 2. the distance to any 5 ft or higher vertical obstruction, or
 - 3. the distance to the edge of any *primary sidelighted area*

and

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



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

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

- a. 70% of the ceiling height $(0.7 \times CH)$ or
- 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 $(0.7 \times [CH OH])$, where CH = the height of the ceiling at the lowest edge of the *skylight* and OH = the height to the top of the obstruction).



Figure 3.2-2 Computing the daylight area under skylights.

primary sidelighted area: the total *primary sidelighted area* is the combined *primary sidelighted area* within each space. Each *primary sidelighted area* is directly adjacent to *vertical fenestration* below the ceiling (see Figure 3.2-4).

- 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.

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

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 3.2-5):

- a. The secondary sidelighted area width is the width of the vertical fenestration plus, on each side, the smaller of
 - 1. one half of the vertical fenestration head height or
 - 2. the distance to any 5 ft or higher opaque vertical obstruction.
- b. The *secondary sidelighted area* depth is the horizontal distance perpendicular to the *vertical fenestration*, which begins at the edge of the *primary sidelighted area* depth and ends at the smaller of
 - 1. one vertical fenestration head height or
 - 2. the distance to any 5 ft or higher opaque vertical obstruction.

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



Figure 3.2-5 Computing the secondary sidelighted area.

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.

Е

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

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

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

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

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

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

fenestration: all areas (including the frames) in the *building envelope* that let in light, including windows, plastic panels, clerestories, *roof monitors, skylights, doors* that are more than one-half glass, and glass block walls. (See *building envelope* and *door.*)

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

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

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

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

fixed: see *vertical fenestration*.

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

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

mass floor: a *floor* with a *heat capacity* that exceeds (a) 7 Btu/ft². °F or (b) 5 Btu/ft². °F, provided that the *floor* has a material unit mass not greater than 120 lb/ft³.

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

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

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

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

gross building envelope floor area: the gross floor area of the building envelope, but excluding slabon-grade floors.

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

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

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

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

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

fluid economizer: see economizer, fluid.

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

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

G

general lighting: see lighting, general.

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

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

gross floor area: see floor area, gross.

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

gross roof area: see roof area, gross.

gross wall area: see wall area, gross.

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

Н

heat capacity (HC): the amount of heat necessary to raise the temperature of a given mass $1^{\circ}F$. Numerically, the *HC* per unit area of surface (Btu/ft². $^{\circ}F$) is the sum of the products of the mass per unit area of each individual material in the *roof, wall*, or *floor* surface multiplied by its individual specific heat.

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

heated space: see space.

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

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

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

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

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

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

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

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

hydronic system balancing: see balancing, hydronic system.

Ι

IEC Design H motor: an electric motor that

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

IEC Design N motor: an electric motor that

- a. is an induction motor designed for use with three-phase power;
- b. contains a cage rotor;
- c. is capable of direct-on-line starting;
- d. has 2, 4, 6, or 8 poles;
- e. is rated from 0.4 to 1600 kW at a frequency of 60 Hz; and
- f. conforms to Sections 6.1, 6.2, and 6.3 of IEC 60034-12, edition 2.1, requirements for torque characteristics, locked rotor apparent power, and starting.

indirectly conditioned space: see space.

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

ineffective panel surface: see thermally ineffective panel surface.

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

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

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

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

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

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

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

interior lighting power allowance: see lighting power allowance.

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

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

J

joist, steel: any structural steel member of a building or structure made of hot-rolled or cold-rolled solid or

open-web sections.

K

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

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

L

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

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

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

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

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

lighting, general: lighting that provides a substantially uniform level of illumination throughout an area. *General lighting* shall not include *decorative lighting* or lighting that provides a dissimilar level of illumination to serve a specialized application or feature within such area.

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

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

lighting power density (LPD): the lighting power per unit area of a *building*, *space*, or outdoor area expressed in W/ft².

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

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

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

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

М

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

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

manufacturer: the company engaged in the original production and assembly of products or equipment or

a company that purchases such products and *equipment* manufactured in accordance with company specifications.

mass floor: see floor.

mass wall: see wall.

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

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

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

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

metal building roof: see roof.

metal building wall: see wall.

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

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

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

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

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

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

Ν

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

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

NEMA Design A motor: a squirrel-cage motor that

- a. is designed to withstand full-voltage starting and developing locked-rotor torque as shown in NEMA MG 1, paragraph 12.38.1;
- b. has pull-up torque not less than the values shown in NEMA MG 1, paragraph 12.40.1;
- c. has breakdown torque not less than the values shown in NEMA MG 1, paragraph 12.39.1;
- d. has a locked-rotor current higher than the values shown in NEMA MG 1, paragraph 12.35.1, for 60 Hz, and NEMA MG 1, paragraph 12.35.2, for 50 Hz; and
- e. has a slip at rated load of less than 5% for motors with fewer than 10 poles.

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

- a. designed to withstand full-voltage starting;
- b. develops locked-rotor, breakdown, and pull-up torques adequate for general application as

specified in NEMA MG1, paragraphs 12.38, 12.39, and 12.40;

- c. draws locked-rotor current not to exceed the values shown in NEMA MG1, paragraph 12.35.1, for 60 Hz, and paragraph 12.35.2 for 50 Hz; and
- d. has a slip at rated load of less than 5% for motors with fewer than 10 poles.

NEMA Design C motor: a squirrel-cage motor that

- a. is designed to withstand full-voltage starting and developing locked-rotor torque for high-torque applications up to the values shown in NEMA MG1, paragraph 12.38.2 (incorporated by reference; see §431.15);
- b. has pull-up torque not less than the values shown in NEMA MG1, paragraph 12.40.2;
- c. has breakdown torque not less than the values shown in NEMA MG1, paragraph 12.39.2;
- d. has a locked-rotor current not to exceed the values shown in NEMA MG1, paragraph 12.35.1, for 60 Hz, and paragraph 12.35.2 for 50 Hz; and
- e. has a slip at rated load of less than 5%.

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

nonautomatic: see manual.

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

nonrenewable energy: energy derived from a fossil fuel source.

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

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

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

- a. Is for indoor use only
- b. Has rated cooling capacities no greater than 36,000 Btu/h
- c. Is a single-package unit requiring opening in an *exterior wall* or *semiexterior wall* with overall exterior dimensions that requires or uses an existing sleeve that meets one of the following criteria:
 - 1. Has a width of less than 32 in. and height of less than 45 in.
 - 2. Fits inside an existing 1310 in.^2 opening
- d. Is commonly installed in site-built commercial buildings
- e. Is of a similar cooling capacity and, if a heat pump, similar heating capacity
- f. Draws *outdoor air* for heat exchange directly through an existing opening, used for both inlet and outlet, in the *exterior wall* or *semiexterior wall*
- g. Is restricted to applications where an existing air conditioner, heat pump, or gas/electric unit, installed in an existing *exterior wall* or *semiexterior wall* opening, is to be replaced
- h. Bears a permanent "Replacement" marking, conspicuously placed, and clearly indicating that its application is limited to installations where an existing air conditioner or heat pump is to be replaced

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

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.

off-mode power consumption (Pw, oFF): the power consumption when the unit is connected to its main power source but is neither providing cooling nor heating to the building it serves.

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.

Р

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.

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 system power: the sum of the nominal power *demand (nameplate horsepower)* of motors of all pumps that are required to operate at *design conditions* to supply fluid from the heating or cooling source to all heat transfer devices (e.g., coils, heat exchanger) and return it to the source.

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

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

R

R-value: see thermal resistance.

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

rated motor power: see motor power, rated.

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

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

readily accessible: installed in a manner and location that allows it to be reached quickly for operation, renewal, or inspection without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. In public facilities, accessibility may be limited to certified personnel through locking covers or by placing *equipment* in locked rooms.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

attic and other roofs: all other *roofs*, including *roofs* with insulation entirely below (inside of) the *roof* structure (i.e., attics, cathedral ceilings, and single-rafter ceilings), *roofs* with insulation both above and below the *roof* structure, and *roofs* without insulation but excluding *metal building roofs*.

metal building roof: a *roof* that

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

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

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

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

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

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

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

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

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

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

S

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

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

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

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

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

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

semiexterior building envelope: see building envelope.

semiexterior wall: see building envelope and wall.

semiheated floor area: see floor area, gross.

semiheated space: see space.

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

natural convection.

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

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

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

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

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

service water heating: heating water for domestic or commercial purposes other than *space* heating and *process* requirements.

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

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

SHGC: see solar heat gain coefficient.

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

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

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

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

simulation program: a computer program, <u>including the simulation engine and the corresponding user</u> <u>interface</u>, that is capable of simulating the *energy* performance of *building systems*.

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

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

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

water, or gas.

single-rafter roof: see roof.

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

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

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

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

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

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

where

skylight area	=	total fenestration area of skylights
skylight VT	=	area-weight average visible transmittance of skylights as determined in
		accordance with Section 5.8.2.5.
WF	=	area-weighted average skylight well factor, where skylight well factor is 0.9 if
		skylight well depth is less than 2 ft, or 0.7 if skylight well depth is 2 ft or greater.
		Skylight well depth is measured vertically from the underside of the lowest point
		on the <i>skylight</i> glazing to the ceiling plane under the <i>skylight</i> .

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

slab-on-grade floor: that portion of a slab *floor* of the *building envelope* that is in contact with the ground and that is either above *grade* or is less than or equal to 24 in. below the final elevation of the nearest exterior *grade*.

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

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

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

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

solar heat gain coefficient (SHGC): the ratio of the solar heat gain entering the *space* through the *fenestration area* to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space. (See *fenestration area*.)

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

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

a. *cooled space:* an *enclosed space* within a *building* that is cooled by a cooling *system* whose sensible output capacity is \Box 3.4 Btu/h·ft² of *floor* area.

- b. *heated space:* an *enclosed space* within a *building* that is heated by a heating *system* whose output capacity relative to the *floor* area is greater than or equal to the criteria in Table 3.2.
- c. *indirectly conditioned space:* an *enclosed space* within a *building* that is not a *heated space* or a *cooled space*, which is heated or cooled indirectly by being connected to adjacent *spaces*, provided:
 - 1. the product of the *U*-factors and surface areas of the space adjacent to connected spaces exceeds the combined sum of the product of the *U*-factors and surface areas of the space adjoining the outdoors, *unconditioned spaces*, and to or from *semiheated spaces* (e.g., corridors) or
 - 2. that air from heated or *cooled spaces* is intentionally transferred (naturally or mechanically) into the *space* at a rate exceeding 3 ach (e.g., atria).

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

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

Climate Zone	Heating Output, Btu/h·ft ²
0	>5
1	>5
2	>5
3A, 3B	>9
3C	>7
4A, 4B	>10
4C	>8
5	>12
6	>14
7	>16
8	>19

 Table 3.2 Heated Space Criteria

space-conditioning category:

- a. nonresidential conditioned space (see nonresidential).
- b. residential conditioned space (see residential).
- c. *nonresidential* and *residential semiheated space* (see *space*).

standby power mode consumption (P_W, s_B): the power used by a product or appliance when enabled but in the standby operating mode (Refer to 10 CFR 430).

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6 HEATING, VENTILATING, AND AIR CONDITIONING

6.1 General

- 6.1.1 Scope
 - 6.1.1.1 New Buildings

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

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

6.1.1.2 Additions to Existing Buildings

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

Exception to 6.1.1.2

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

6.1.1.3 Alterations to Heating, Ventilating, Air Conditioning, and Refrigeration in Existing Buildings

6.1.1.3.1

New HVACR *equipment* as a direct replacement of existing HVACR *equipment* shall comply with the following sections as applicable for the *equipment* being replaced:

- a. 6.3, "Simplified Approach Option for HVAC Systems"
- b. 6.4.1, "Equipment Efficiencies, Verification, and Labeling Requirements"
- c. 6.4.3.1, "Zone Thermostatic Controls"
- d. 6.4.3.2, "Set-Point Overlap Restrictions"
- e. 6.4.3.3, "Off-Hour Controls" except for Section 6.4.3.3.4, "Zone Isolation"
- f. 6.4.3.4, "Ventilation System Controls"
- g. 6.4.3.7, "Freeze Protection and Snow/Ice Melting Systems"
- h. 6.4.3.8, "Ventilation Controls for High-Occupancy Areas" only for single-zone equipment
- i. 6.4.3.9, "Heated or Cooled Vestibules"
- j. 6.4.5, "Walk-In Coolers and Walk-In Freezers"
- k. 6.5.1.1, "Air Economizers" for units located outdoors
- 1. 6.5.1.3, "Integrated Economizer *Control*"
- m. 6.5.1.4, "Economizer Heating System Impact"
- n. 6.5.3.1.3, "Fan Efficiency"
- o. 6.5.3.2.1, "Supply Fan Airflow Control"
- p. 6.5.3.6, "Fractional Horsepower Fan Motors"
- q. 6.5.4.1, "Boiler Turndown"
- r. 6.5.4.3, "Chiller and Boiler Isolation"
- s. 6.5.5.2, "Fan Speed Control"

6.1.1.3.2

New cooling *systems* installed to serve previously uncooled *spaces* shall comply with this section as described in Section 6.2.

6.1.1.3.3

Alterations to existing cooling *systems* shall not decrease economizer capability unless the *system* complies with Section 6.5.1.

6.1.1.3.4

New and replacement *ductwork* shall comply with Sections 6.4.4.1 and 6.4.4.2.

6.1.1.3.5

New and replacement *piping* shall comply with Section 6.4.4.1.

Exceptions to 6.1.1.3

Compliance shall not be required

- 1. for *equipment* that is being modified or repaired but not replaced, provided that such modifications and/or *repairs* will not result in an increase in the annual *energy* consumption of the *equipment* using the same *energy* type;
- 2. where a replacement or *alteration* of *equipment* requires extensive revisions to other *systems*, *equipment*, or elements of a *building*, and such replaced or altered *equipment* is a like-for-like replacement;
- 3. for a refrigerant change of *existing equipment*;
- 4. for the relocation of *existing equipment*; or
- 5. for ducts and *piping* where there is insufficient *space* or access to meet these requirements.

6.1.2 Climate

Climate zones shall be determined in accordance with Section 5.1.4.

6.2 Compliance Paths

6.2.1 Compliance

Compliance with Section <u>6</u> shall be achieved by meeting all requirements for Sections 6.2, "General"; Section 6.7, "Submittals"; Section 6.8, "Minimum *Equipment Efficiency* Tables"; and one of the following:

- a. Section 6.3, "Simplified Approach Option for HVAC Systems"
- b. Sections 6.4, "Mandatory Provisions" and 6.5, "Prescriptive Path"

Exception to 6.2.2b

HVAC systems only serving the heating, cooling, or ventilating needs of a *computer room* with IT *equipment* load greater than 10 kW shall be permitted to comply with Sections 6.4, "Mandatory Provisions" and 6.6, "Alternative Compliance Path"

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

6.3 Simplified Approach Option for HVAC Systems

6.3.1 Scope

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

- a. The *building* is two stories or fewer in height.
- b. Gross floor area is less than $25,000 \text{ ft}^2$.
- c. Each HVAC system in the building complies with the requirements listed in Section 6.3.2.

6.3.2 Criteria

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

- a. The system serves a single HVAC zone.
- b. The *equipment* must meet the variable flow requirements of Section 6.5.3.2.1.
- c. Cooling (if any) shall be provided by a unitary packaged or split-*system* air conditioner that is either air cooled or evaporatively cooled, with *efficiency* meeting the requirements shown in Table 6.8.1-1 (air conditioners), Table 6.8.1-2 (heat pumps), or Table 6.8.1-4 (packaged *terminal* and *room air conditioners* and heat pumps) for the applicable *equipment* category.
- d. The system shall have an air economizer meeting the requirements of Sections 6.5.1 and 6.4.3.12.
- e. Heating (if any) shall be provided by a unitary packaged or split-system heat pump that meets the applicable *efficiency* requirements shown in Table 6.8.1-2 (heat pumps) or Table 6.8.1-4 (packaged *terminal* and *room air conditioners* and heat pumps), a *fuel*-fired furnace that meets the applicable *efficiency* requirements shown in Table 6.8.1-5 (furnaces, duct furnaces, and unit heaters), an *electric resistance* heater, or a baseboard *system* connected to a *boiler* that meets the applicable *efficiency* requirements shown in Table 6.8.1-6 (*boilers*).
- f. The system shall meet the exhaust air energy recovery requirements of Section 6.5.6.1.

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

Exception to 6.3.2(h)

Heat pumps that comply with the following:

- 1. Have a minimum *efficiency* regulated by NAECA.
- 2. Meet the requirements in Table 6.8.1-2.
- 3. Include all usage of internal *electric resistance* heating.
- i. The *system controls* shall not permit *reheat* or any other form of simultaneous heating and cooling for humidity *control*.
- j. *Systems* serving *spaces* other than hotel/motel guest rooms, and other than those requiring continuous operation, which have both a cooling or heating capacity greater than 15,000 Btu/h and a supply fan motor power greater than 0.75 hp, shall be provided with a time clock that (1) can start and stop the *system* under different schedules for seven different day types per week, (2) is capable of retaining programming and time setting during a loss of power for a period of at least ten hours, (3) includes an accessible *manual* override that allows temporary operation of the *system* for up to two hours, (4) is capable of and configured with temperature *setback* down to 55°F during off hours, and (5) is capable of capable of and configured with temperature setup to 90°F during off hours.
- k. Systems serving hotel/motel guest rooms shall comply with Section 6.4.3.3.5.
- 1. Except for *piping* within *manufacturers*' units, HVAC *piping* shall be insulated in accordance with Tables 6.8.3-1 and 6.8.3-2. Insulation exposed to weather shall be suitable for outdoor *service*, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation.
- m. *Ductwork* and plenums shall be insulated in accordance with Table 6.8.2 and shall be sealed in accordance with Section 6.4.4.2.1.
- n. *Construction documents* shall require a ducted *system* to be air balanced in accordance with industry accepted procedures.
- o. Outdoor air intake and exhaust systems shall meet the requirements of Section 6.4.3.4.
- p. Where separate heating and cooling *equipment* serves the same temperature zone, *thermostats* shall be interlocked to prevent simultaneous heating and cooling.
- q. Systems with a design supply air capacity greater than 10,000 cfm shall have optimum start controls.
- r. The *system* shall comply with the *demand control ventilation* requirements in Section 6.4.3.8 and the *ventilation* design requirements in Section 6.5.3.7.
- s. The *system* complies with the *door* switch requirements in Section 6.5.10.

6.4 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 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 <u>Air Cooled</u> Unitary and <u>Applied</u>-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"
- <u>i-h.</u> Table 6.8.1-9, "Electrically Operated Variable-Refrigerant-Flow Air Conditioners—Minimum *Efficiency* Requirements"
- j.i. Table 6.8.1-10, "Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps-Minimum *Efficiency* Requirements
- k-j. Table 6.8.1-11, "Floor Mounted Air Conditioners and Condensing Units Serving Computer Rooms"
- I. Table 6.8.1-12, "Commercial Refrigerators and Freezers Minimum Efficiency Requirements"
- m.k. Table 6.8.1-13, "Commercial <u>Refrigerators, Commercial Freezers, and Refrigeration</u>—Minimum *Efficiency* Requirements"
- n.<u>l.</u> Table 6.8.1-14, "Vapor-Compression-Based Indoor Pool Dehumidifiers—Minimum Efficiency Requirements"
- o.m. Table 6.8.1-15, "Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without Energy Recovery—Minimum Efficiency Requirements"
- p.n. Table 6.8.1-16, "Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, with Energy Recovery—Minimum Efficiency Requirements"
- q.o. Table 6.8.1-17, "Electrically Operated Water Source Heat Pumps—Minimum Efficiency Requirements"

<u>r.p.</u>

s.q. Table 6.8.1-19, Ceiling Mounted Computer Room Air Conditioners – Minimum Efficiency Requirements

- 6.4.1.2 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 11. All other air conditioners shall meet the requirements in Table 6.8.1 11. Minimum Equipment Efficiencies—Listed Equipment—Nonstandard Conditions
 - 6.4.1.2.1 Water-Cooled Centrifugal Chilling Packages

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Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44.00°F leaving and 54.00°F entering chilled-fluid temperatures, and with 85.00°F entering and 94.30°F leaving condenser-fluid temperatures, shall have maximum full-load kW/ton (FL) and part-load rating requirements adjusted using the following equations:

$$FL_{adj} = FL/K_{adj}$$
$$PLV_{adj} = IPLV.IP/K_{adj}$$
$$K_{adj} = A \times B$$

where

Fl	=	full-load kW/ton value from Table 6.8.1-3		
FL _{adj}	=	Maximum full-load kW/ton rating, adjusted for nonstandard conditions		
IPLV.IP	=	<i>IPLV</i> .IP value from Table 6.8.1-3		
PLV _{adj}	=	Maximum NPLV rating, adjusted for nonstandard conditions		
Α	=	$\begin{array}{l} 0.00000014592 \times {\rm (LIFT)}^4 - 0.0000346496 \times {\rm (LIFT)}^3 + 0.00314196 \times \\ {\rm (LIFT)}^2 - 0.147199 \times {\rm (LIFT)} + 3.93073 \end{array}$		
В	=	$0.0015 \times LvgEvap + 0.934$		
LIFT	=	LvgCond – LvgEvap		
LvgCond	=	full-load condenser leaving fluid temperature (°F)		
LvgEvap	=	full-load evaporation leaving temperature (°F)		

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

- $36.00^{\circ}F \le LvgEvap \le 60.00^{\circ}F$
- LvgCond $\leq 115.00^{\circ}$ F
- $\bullet \qquad 20.00^\circ F \leq LIFT \leq 80.00^\circ F$

Manufacturers shall calculate the FL_{adj} and PLV_{adj} before determining whether to label the chiller per Section 6.4.1.5. Compliance with 90.1-2007, 2010, 2013, 2016 or combinations thereof, shall be *labeled* on chillers within the scope of the standard.

Centrifugal chillers designed to operate outside of these ranges are not covered by this standard.

Example (Section 6.4.1.2.1)

Path A 600-ton centrifugal chiller Table 6.8.1-3 efficiencies effective 1/1/2015:

FL	=	0.5600 kW/ton
IPLV.IP	=	0.5000 kW/ton
LvgCond	=	91.16°F
LvgEvap	=	42.00°F
LIFT	=	$91.16 - 42 = 49.16^{\circ}F$
Α	=	$\begin{array}{l} 0.00000014592 \times {(49.16)}^4 - 0.0000346496 \times {(49.16)}^3 + 0.00314196 \times \\ {(49.16)}^2 - 0.147199 \times {(49.16)} + 3.93073 = 1.02331 \end{array}$
В	=	$0.0015 \times 42.00 + 0.934 = 0.99700$
<i>K_{adj}</i>	=	$1.02331 \times 0.99700 = 1.02024$

FL _{adj}	=	0.5600/1.02024 = 0.5489 kW/ton
PLV _{adj}	=	0.5000/1.02024 = 0.4901 kW/ton

6.4.1.2.2 Positive Displacement (Air- and Water-Cooled) Chilling Packages

Equipment with an evaporator leaving fluid temperature higher than 32.00° F and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature below 115.00° F shall show compliance with Table 6.8.1-3 when tested or certified with water at standard rating conditions, per the referenced test procedure.

6.4.1.3 Equipment Not Listed

Equipment not listed in the tables referenced in Sections 6.4.1.1 and 6.4.1.2 may be used.

6.4.1.4 Verification of Equipment Efficiencies

Equipment efficiency information supplied by manufacturers shall be verified by one of the following:

- a. *Equipment* covered under EPACT shall comply with U.S. Department of Energy certification requirements.
- b. If a certification program exists for a covered product, and it includes provisions for verification and challenge of *equipment efficiency* ratings then the product shall be listed in the certification program.
- c. If a certification program exists for a covered product, and it includes provisions for verification and challenge of *equipment efficiency* ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.
- d. If no certification program exists for a covered product, the *equipment efficiency* ratings shall be supported by data furnished by the *manufacturer*.
- e. Where components such as indoor or outdoor coils from different *manufacturers* are used, the *system* designer shall specify component efficiencies whose combined *efficiency* meets the minimum *equipment efficiency* requirements in Section 6.4.1.
- f. Requirements for plate type liquid to liquid heat exchangers are listed in Table 6.8.1 8.

6.4.1.5 Labeling

6.4.1.5.1 Mechanical Equipment

Mechanical *equipment* that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the *manufacturer* stating that the *equipment* complies with the requirements of Standard 90.1.

6.4.1.5.2 Packaged Terminal Air Conditioners

Nonstandard-size *packaged terminal air conditioners* and heat pumps with 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 shall be factory *labeled* as follows: *Manufactured for nonstandard-size applications only: Not to be installed in new construction projects.*

6.4.2 Calculations

6.4.2.1 Load Calculations

Heating and cooling *system* design loads for the purpose of sizing *systems* and *equipment* shall be determined in accordance with ANSI/ASHRAE/ACCA Standard 183.

6.4.2.2 Pump Head

Pump differential pressure (head) for the purpose of sizing pumps shall be determined in accordance with *generally accepted engineering standards* and handbooks acceptable to the *adopting authority*. The pressure drop through each device and pipe segment in the *critical circuit* at *design conditions* shall be calculated.

6.4.3 Controls and Diagnostics

6.4.3.1 Zone Thermostatic Controls

6.4.3.1.1 General

The supply of heating and cooling *energy* to each zone shall be individually controlled by

thermostatic controls responding to temperature within the zone. For the purposes of this section, a *dwelling unit* shall be permitted to be considered a single zone.

Exceptions to 6.4.3.1.1

Independent perimeter *systems* that are designed to offset only *building envelope* loads shall be permitted to serve one or more zones also served by an interior *system*, provided that

- 1. the perimeter *system* includes at least one *thermostatic control* zone for each *building* exposure having *walls* facing only one *orientation* for 50 contiguous feet or more and
- 2. the perimeter *system* heating and cooling supply is controlled by *thermostatic controls* located within the zones served by the *system*.

Exterior walls and *semiexterior walls* are considered to have different orientations if the exposures they face differ by more than 45 degrees.

6.4.3.1.2 Dead Band

Where used to *control* both heating and cooling, zone *thermostatic controls* shall be capable of and configured to provide a temperature range or *dead band* of at least 5°F within which the supply of heating and cooling *energy* to the zone is shut off or reduced to a minimum.

Exceptions to 6.4.3.1.2

- 1. Thermostats that require manual changeover between heating and cooling modes.
- 2. Special occupancy or special applications where wide temperature ranges are not acceptable (such as retirement homes, process applications, museums, some areas of hospitals) and are approved by the *authority having jurisdiction*.

6.4.3.2 Set-Point Overlap Restriction

Where heating and cooling to a zone are controlled by separate zone *thermostatic controls* located within the zone, means (such as limit switches; mechanical stops; or, for *DDC systems*, software programming) shall be provided to prevent the heating *set point* from exceeding the cooling *set point*, minus any applicable proportional band.

6.4.3.3 Off-Hour Controls

HVAC systems shall have the off-hour controls required by Sections 6.4.3.3.1 through 6.4.3.3.5.

Exceptions to 6.4.3.3

- 1. *HVAC systems* intended to operate continuously.
- 2. *HVAC systems* having a design heating capacity and cooling capacity less than 15,000 Btu/h that are equipped with *readily accessible manual* on/off *controls*.

6.4.3.3.1 Automatic Shutdown

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

- a. *Controls* that can start and stop the *system* under different time schedules for seven different day types per week, are capable of retaining programming and time setting during loss of power for a period of at least ten hours, and include an accessible *manual* override or equivalent function that allows temporary operation of the *system* for up to two hours.
- b. An *occupant sensor* that is capable of shutting the *system* off when no occupant is sensed for a period of up to 30 minutes.
- c. A manually operated timer capable of being adjusted to operate the system for up to two hours.
- d. An interlock to a security system that shuts the system off when the security system is activated.

Exception to 6.4.3.3.1

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

6.4.3.3.2 Setback Controls

Heating systems shall be equipped with controls capable of and configured to automatically restart

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

Exception to 6.4.3.3.2

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

6.4.3.3.3 Optimum Start Controls

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

6.4.3.3.4 Zone Isolation

HVAC systems serving zones that are intended to operate or be occupied nonsimultaneously shall be divided into isolation areas. Zones may be grouped into a single isolation area provided it does not exceed 25,000 ft² of *conditioned floor area* nor include more than one floor. Each isolation area shall be equipped with *isolation devices* capable of and configured to automatically shut off the supply of conditioned air and *outdoor air* to and exhaust air from the area. Each isolation area shall be controlled independently by a device meeting the requirements of Section 6.4.3.3.1. For central *systems* and plants, *controls* and devices shall be provided to allow stable *system* and *equipment* operation for any length of time while serving only the smallest isolation area served by the *system* or plant.

Exceptions to 6.4.3.3.4

Isolation devices and controls are not required for

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

6.4.3.3.5 Automatic Control of HVAC in Hotel/Motel Guest Rooms

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

Guest Room HVAC Set-Point Control

Within 30 minutes of all occupants leaving the guest room, HVAC set points shall be automatically raised by at least 4°F from the occupant set point in the cooling mode and automatically lowered by at least 4°F from the occupant set point in the heating mode.**nrented and unoccupied** HVAC set points shall be reset to 80°F or higher in the cooling mode and to 60°F or lower in the heating mode. Unrented and unoccupied guest room control system indicates the guest room is unrented, and When the guest room is unrented **and unoccupied**, HVAC set points shall be automatically reset to 80°F or higher in the cooling mode and to 60°F or higher in the cooling mode and to 60°F or higher in the cooling mode and to 60°F or lower is unrented and unoccupied, HVAC set points shall be automatically reset to 80°F or higher in the cooling mode and to 60°F or lower in the following:

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

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

Exceptions to 6.4.3.3.5.1

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

6.4.3.3.5.1 Guest Room Ventilation Control

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

Exception to 6.4.3.3.5.2

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

6.4.3.3.5.2 Automatic Control

Captive key card systems shall be permitted to be used to comply with Section 6.4.3.3.5.

	Ventilation Air Intake		Exhaust/Relief	
Climate Zone	Nonmotorized ^a	Motorized	Nonmotorized ^a	Motorized
0, 1, 2				
Any height	20	4	20	4
3				
Any height	20	10	20	10
4, 5B, 5C				
Fewer than three stories	NA	10	20	10
Three or more stories	NA	10	NA	10
5A, 6, 7, 8				
Fewer than three stories	NA	4	20	4
Three or more stories	NA	4	NA	4

Table 6.4.3.4.3 Maximum Damper Leakage, cfm per ft² at 1.0 in. of water (I-P)

ac. Dampers smaller than 24 in. in either dimension may have leakage of 40 cfm/ft².

NA = Not allowed

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

Table 6.4.3.4.3 Maximum Damper Leakage, L/s per m² at 250 Pa (SI)

a. Dampers smaller than 600 mm in either dimension may have leakage of 200 L/s per m².

NA = Not allowed

6.4.3.4 Ventilation System Controls

6.4.3.4.1 Stair and Shaft Vents

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

6.4.3.4.2 Shutoff Damper Controls

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

Exceptions to 6.4.3.4.2

- 1. Back-draft gravity (non-motorized) dampers are acceptable for exhaust and relief in *buildings* less than three stories in height and for *ventilation air* intakes and exhaust and relief dampers in *buildings* of any height located in Climate Zones 0, 1, 2, and 3. Back-draft dampers for *ventilation air* intakes must be protected from direct exposure to wind.
- 2. Back-draft gravity (non-motorized) dampers are acceptable in *systems* with a design *outdoor air* intake or exhaust capacity of 300 cfm or less.
- 3. Dampers are not required in *ventilation* or exhaust *systems* serving *unconditioned spaces*.
- 6.4.3.4.3 Dampers are not required in exhaust *systems* serving Type 1 kitchen exhaust hoods.Damper Leakage

Where *outdoor air* supply and exhaust/relief dampers are required by Section 6.4.3.4, they shall have a maximum leakage rate as indicated in Table 6.4.3.4.3 when tested in accordance with AMCA 500D.

6.4.3.4.4 Ventilation Fan Controls

Fans with motors greater than 0.75 hp shall have *automatic controls* complying with Section 6.4.3.3.1 that are capable of and configured to shut off fans when not required.

Exception to 6.4.3.4.4

HVAC systems intended to operate continuously.

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

Exceptions to 6.4.3.4.5

- 1. Garages less than 30,000 ft² with *ventilation systems* that do not utilize *mechanical cooling* or mechanical heating.
- 2. Garages that have a garage area to *ventilation system motor nameplate horsepower* ratio that exceeds $1500 \text{ ft}^2/\text{hp}$ and do not utilize *mechanical cooling* or mechanical heating.
- 3. Where not permitted by the *authority having jurisdiction*.

6.4.3.5 Heat Pump Auxiliary Heat Control

Heat pumps equipped with internal *electric resistance* heaters shall have *controls* that prevent supplemental heater operation when the heating load can be met by the heat pump alone during both steady-state operation and *setback* recovery. Supplemental heater operation is permitted during outdoor coil defrost cycles.

Exception to 6.4.3.5

Heat pumps whose minimum *efficiency* is regulated by NAECA and whose ratings meet the requirements shown in Table 6.8.1-2 and include all usage of internal *electric resistance* heating.

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

Exceptions to 6.4.3.6

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

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

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

6.4.3.6 Freeze Protection and Snow/Ice Melting Systems

Freeze protection *systems*, such as heat tracing of outdoor *piping* and heat exchangers, including selfregulating heat tracing, shall include *automatic controls* capable of and configured to shut off the *systems* when *outdoor air* temperatures are above 40°F or when the conditions of the protected fluid will prevent freezing. Snow and ice melting *systems* shall include *automatic controls* capable of and configured to shut off the *systems* when the pavement temperature is above 50°F and no precipitation is falling, and an *automatic* or *manual control* that will allow shutoff when the outdoor temperature is above 40°F so that the potential for snow or ice accumulation is negligible.

6.4.3.7 Ventilation Controls for High-Occupancy Areas

Demand control ventilation (*DCV*) is required for *spaces* larger than 500 ft² and with a design occupancy for *ventilation* of \Box 25 people per 1000 ft² of *floor* area and served by *systems* with one or more of the following:

a. Air economizer.

- b. Automatic modulating control of outdoor air damper.
- c. Design outdoor airflow greater than 3000 cfm.

Exceptions to 6.4.3.8

- 1. Systems with exhaust air energy recovery complying with Section 6.5.6.1.
- 2. Multiple-zone *systems* without *DDC* of individual zones communicating with a central *control* panel.
- 3. Systems with a design outdoor airflow less than 750 cfm.
- 4. *Spaces* where >75% of the *space* design outdoor airflow is required for *makeup air* that is exhausted from the *space* or *transfer air* that is required for *makeup air* that is exhausted from other *spaces*.
- 5. *Spaces* with one of the following occupancy categories as defined in ASHRAE Standard 62.1: correctional cells, daycare sickrooms, science labs, barbers, beauty and nail salons, and bowling alley seating.

6.4.3.8 Heated or Cooled Vestibules

Heating for vestibules and for air curtains with integral heating shall include *automatic controls* capable of and configured to shut off the heating *system* when *outdoor air* temperatures are above 45°F. Vestibule heating and cooling *systems* shall be controlled by a *thermostat* in the vestibule capable of and configured to limit heating to a maximum of 60°F and cooling to a minimum of 85°F.

Exception to 6.4.3.9

Heating or cooling provided by *site-recovered energy* or by *transfer air* that would otherwise be exhausted.

6.4.3.9 Direct Digital Control (DDC) Requirements

Direct digital control shall be required as follows.

6.4.3.9.1.1 DDC Applications

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

Exception to 6.4.3.10.1

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

6.4.3.9.2 DDC Controls

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

- a. Monitoring zone and *system demand* for fan pressure, pump pressure, heating, and cooling.
- b. Transferring zone and *system demand* information from zones to air *distribution system* controllers and from air *distribution systems* to heating and cooling plant controllers.
- c. *Automatically* detecting those zones and *systems* that may be excessively driving the *reset* logic and generate an alarm or other indication to the *system* operator
- d. Readily allowing operator removal of zones from the *reset* algorithm.

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

 Table 6.4.3.10.1
 DDC Applications and Qualifications

6.4.3.9.3 DDC Display

Where *DDC* is required by Section 6.4.3.10.1 for new *buildings*, the *DDC system* shall be capable of trending and graphically displaying input and output points.

6.4.3.10 Chilled-Water Plant Monitoring

6.4.3.10.1 Monitoring

For electric-motor-driven chilled-water plants in new buildings, or for new plants in existing buildings, measurement devices shall be installed and shall measure the electric energy use and efficiency of the chilled-water plant for

- a. water-cooled chilled-water plants larger than 1500 tons peak cooling capacity for Climate Zones 5 through 8, 3C, and 4C, and larger than 1000 tons peak cooling capacity for all other zones; and
- b. air-cooled chilled-water plants larger than 860 tons peak cooling capacity for Climate Zones 5 through 8, 3C, and 4C, and larger than 570 tons peak cooling capacity for all other zones.

The *efficiency* shall be calculated in tons (*COP*) (see Appendix E).

6.4.3.10.2 Electric-Motor-Driven Chiller System Recording and Reporting

The electrical *energy* use *efficiency* shall be trended every 15 minutes and graphically displayed and include hourly, daily, monthly, and annual data. The *system* shall maintain all data collected for a minimum of 36 months.

6.4.3.11 Economizer Fault Detection and Diagnostics (FDD)

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

- a. The following temperature sensors shall be *permanently installed* to monitor *system* operation:
 - 1. Outdoor air

- 2. Supply air
- 3. Return air, where required for economizer control
- b. The system shall have the capability of displaying the value of each sensor.
- c. The FDD *system* or unit *controls* shall be capable of and configured to provide *system* status by indicating the following:
 - 1. Free cooling available
 - 2. Economizer enabled
 - 3. Compressor enabled
 - 4. Heating enabled
 - 5. Mixed-air low-limit cycle active
- d. The FDD *system* or unit *controls* shall have provisions to manually initiate each operating mode so that the operation of compressors, economizers, fans, and the heating *system* can be independently tested and verified.
- e. The FDD *system* shall be capable of and configured to detect the following faults:
 - 1. Air temperature sensor failure/fault
 - 2. Not economizing when the unit should be economizing
 - 3. Economizing when the unit should not be economizing
 - 4. Damper not modulating
 - 5. Excess outdoor air
- f. The FDD *system* shall be capable of and configured to report faults to a fault management application or *DDC system* accessible by operating or *service* personnel, or annunciated locally on zone *thermostats*.

6.4.4 HVAC System Construction and Insulation

6.4.4.1 Insulation

6.4.4.1.1 General

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

- a. Insulation exposed to weather shall be suitable for outdoor *service*, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.
- b. Insulation covering chilled-water *piping*, refrigerant suction *piping*, or cooling ducts located outside the *conditioned space* shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant), all penetrations and joints of which shall be sealed.

6.4.4.1.2 Duct and Plenum Insulation

All supply and return ducts and plenums installed as part of an HVAC air *distribution system* shall be thermally insulated in accordance with Table 6.8.2.

Exceptions to 6.4.4.1.2

- 1. Factory-installed plenums, casings, or *ductwork* furnished as a part of HVAC *equipment* tested and rated in accordance with Section 6.4.1.
- 2. Ducts or plenums located in *heated spaces*, *semiheated spaces*, or *cooled spaces*.
- 3. For runouts less than 10 ft in length to air *terminals* or air outlets, the *rated R-value of insulation* need not exceed R-3.5.
- 4. Backs of air outlets and outlet plenums exposed to *unconditioned space* or *indirectly conditioned space* with face areas exceeding 5 ft^2 need not exceed R-2; those 5 ft^2 or

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smaller need not be insulated.

6.4.4.1.3 Piping Insulation

Piping shall be thermally insulated in accordance with Tables 6.8.3-1 and 6.8.3-2.

Exceptions to 6.4.4.1.3

- 1. Factory-installed *piping* within HVAC *equipment* tested and rated in accordance with Section 6.4.1.
- 2. *Piping* that conveys fluids having a design operating temperature range between 60°F and 105°F, inclusive.
- 3. *Piping* that conveys fluids that have not been heated or cooled through the use of *fossil fuels* or electricity (such as *roof* and condensate drains, domestic cold-water supply, and natural-gas *piping*).
- 4. Where heat gain or heat loss will not increase *energy* use (such as liquid refrigerant *piping*).
- 5. In *piping* 1 in. or less, insulation is not required for strainers, *control* valves, and balancing valves.

6.4.4.1.4 Sensible Heating Panel Insulation

All *thermally ineffective panel surfaces* of *sensible heating panels*, including U-bends and headers, shall be insulated with a minimum of R-3.5. Adjacent *building envelope* insulation counts toward this requirement.

6.4.4.1.5 Radiant Floor Heating

The bottom surfaces of *floor* structures incorporating radiant heating shall be insulated with a minimum of R-3.5. Adjacent *building envelope* insulation counts toward this requirement.

Exception to 6.4.4.1.5

See Section 5 requirements for *heated slab-on-grade floors* incorporating radiant heating.

6.4.4.2 Ductwork and Plenum Leakage

6.4.4.2.1 Duct Sealing

Ductwork and all plenums with pressure class ratings shall be constructed to *Seal Class A*. Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage. Pressure-sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory, and the tape is used in accordance with that certification. All connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access *doors*, access panels, and duct connections to *equipment*. Sealing that would void product listings is not required. Spiral lock seams need not be sealed. All duct pressure class ratings shall be designated in the design documents.

6.4.4.2.2 Duct Leakage Tests

Ductwork that is designed to operate at static pressures in excess of 3 in. of water and all *ductwork* located outdoors shall be leak-tested according to industry-accepted test procedures (see Informative Appendix E). Representative sections totaling no less than 25% of the total installed duct area for the designated pressure class shall be tested. All sections shall be selected by the *building* owner or the designated representative of the *building* owner. Positive pressure leakage testing is acceptable for negative pressure *ductwork*. The maximum permitted duct leakage shall be

$$L_{max} = C_L P^{0.65}$$

where

Lmax	=	maximum permitted leakage, cfm/100 ft ² duct surface area
C_L	=	4, duct leakage class, $cfm/100 ft^2$ duct surface area at 1 in. of water
D	=	test pressure, which shall be equal to the design duct pressure class rating, in.

of water

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 triplepane glass, either filled with inert gas or with heat-reflective treated glass, or vacuum insulating glazing.

Informative Note: For applications in the US, alternate innovative component technologies (e.g., vacuum insulating glazing for transparent reach-in doors) are allowable only if the manufacturer has obtained a waiver from the US DOE.

h. Transparent reach-in *doors* for *walk-in coolers*, and windows in *walk-in cooler doors*, shall be doublepane 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<u>. or vacuum insulating glazing</u>.

Informative Note: For applications in the US, alternate innovative component technologies (e.g., vacuum insulating glazing for transparent reach-in doors) are allowable only if the manufacturer has obtained a waiver from the US DOE.

- i. Antisweat heaters without antisweat heater *controls* shall have a total *door* rail, glass, and frame heater power draw of □7.1 W/ft² of *door* opening for *walk-in freezers* and 3.0 W/ft² 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.
- 1. 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)

6.4.6 *Walk-in coolers* and *walk-in freezers* combined in a single enclosure greater than 3000 ft². Refrigerated Display Case

- a. All refrigerated display cases shall conform to Section 6.4.1.1 and Tables 6.8.1-12 and 6.8.1-13.
- b. Lighting in refrigerated display cases and glass *doors* installed on *walk-in coolers* and *walk-in freezers* shall be controlled by one of the following:
 - 1. *Automatic* time-switch *controls* to turn off lights during nonbusiness hours: Timed overrides for display cases or *walk-in coolers* and *walk-in freezers* may be used to turn the lights on for up to one hour and shall automatically time out to turn the lights off.
 - 2. Motion sensor *controls* on each display case or walk-in *door* section that reduce lighting power by at least 50% within three minutes after the area within the sensor range is vacated.
- c. All low-temperature display cases shall incorporate temperature-based defrost termination *control* with a time-limit default. The defrost cycle shall terminate first on an upper temperature limit breach and second on a time limit breach.
- d. Antisweat heater *controls* shall reduce the *energy* use of the antisweat heater as a function of the relative humidity in the air outside the *door* or to the condensation on the inner glass pane.

6.4.7 Liquid-to-Liquid Heat Exchangers

<u>Plate type liquid to liquid heat exchangers shall be rated in accordance with AHRI 400. Section 12 contains a complete specification of the referenced test procedure.</u>

6.5 Prescriptive Path

6.5.1 Economizers

Each cooling system shall include either an air economizer or fluid economizer meeting the requirements of Sections 6.5.1.1 through 6.5.1.5.

Exceptions to 6.5.1

Economizers are not required for the following systems:

- 1. Individual fan-cooling units with a supply capacity less than the minimum listed in Table 6.5.1-1.
- 2. Chilled-water cooling *systems* without a fan or that use induced airflow, where the total capacity of these *systems* is less than 1,000,000 Btu/h in Climate Zones 0, 1B, and 2 through 4; less than 1,400,000 Btu/h in Climate Zones 5 through 8; or any size in Climate Zone 1A.
- 3. Systems that include nonparticulate air treatment as required by Section 6.2.1 in Standard 62.1.
- 4. In hospitals and ambulatory surgery centers, where more than 75% of the air designed to be supplied by the *system* is to *spaces* that are required to be humidified above 35°F dew-point temperature to comply with applicable codes or accreditation standards; in all other *buildings*, where more than 25% of the air designed to be supplied by the *system* is to *spaces* that are designed to be humidified above 35°F dew-point temperature to satisfy *process* needs. This exception does not apply to *computer rooms*.
- 5. *Systems* that include a condenser heat recovery *system* with a minimum capacity as defined in Section 6.5.6.2.2.
- 6. *Systems* that serve *residential spaces* where the *system* capacity is less than five times the requirement listed in Table 6.5.1-1.
- 7. *Systems* that serve *spaces* whose sensible cooling load at *design conditions*, excluding transmission and *infiltration* loads, is less than or equal to transmission and *infiltration* losses at an outdoor temperature of 60° F.
- 8. Systems expected to operate fewer than 20 hours per week.
- 9. Where the use of *outdoor air* for cooling will affect supermarket open refrigerated casework *systems*.
- 10. For comfort cooling where the cooling *efficiency* meets or exceeds the *efficiency* improvement requirements in Table 6.5.1-2.
- 11. Systems primarily serving computer rooms where
 - a. the total design cooling load of all *computer rooms* in the *building* is less than 3,000,000 Btu/h and the *building* in which they are located is not served by a centralized chilled water plant;

- b. the room total design cooling load is less than 600,000 Btu/h and the *building* in which they are located is served by a centralized chilled water plant;
- c. the local water authority does not allow cooling towers; or
- d. less than 600,000 Btu/h of *computer-room* cooling *equipment* capacity is being added to an *existing building*.

 Table 6.5.1-1
 Minimum Fan-Cooling Unit Size for which an Economizer is Required

Climate Zone	Cooling Capacity for which an Economizer is Required
0A, 0B, 1A, 1B	No economizer requirement
2A, 2B, 3A, 4A, 5A, 6A, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	≥54,000 Btu/h

Table 6.5.1-2 Eliminate Required Economizer for Comfort Cooling by Increasing Cooling Efficiency

Climate Zone	Efficiency Improvement ^a
2A	17%
2B	21%
3A	27%
3B	32%
3C	65%
4A	42%
4B	49%
4C	64%
5A	49%
5B	59%
5C	74%
6A	56%
6B	65%
7	72%
8	77%

a. If a unit is rated with an IPLV, IEER, or SEER, then to eliminate the required economizer, the minimum cooling efficiency of the HVAC unit must be increased by the percentage shown. If the HVAC unit is only rated with a full-load metric like EER cooling then these must be increased by the percentage shown.

12. Dedicated systems for computer rooms, where a minimum of 75% of the design load serves

- a. those spaces classified as an essential facility,
- b. those spaces having a design of Tier IV as defined by ANSI/TIA-942,
- c. those *spaces* classified under NFPA 70 Article 708—*Critical Operations Power Systems* (COPS), or
- d. those *spaces* where core clearing and settlement *services* are performed such that their failure to settle pending financial transactions could present systemic risk as described in "The Interagency Paper on Sound Practices to Strengthen the Resilience of the U.S. Financial System" (April 7, 2003).

6.5.1.1 Air Economizers

6.5.1.1.1 Design Capacity

Air economizer systems shall be capable of and configured to modulate *outdoor air* and return air dampers to provide up to 100% of the design supply air quantity as *outdoor air* for cooling.

6.5.1.1.2 Control Signal

Economizer *controls* shall be capable of and configured to sequence the dampers with the *mechanical cooling equipment* and shall not be controlled by only mixed-air temperature.

Exception to 6.5.1.1.2

The use of mixed-air temperature limit *control* shall be permitted for *systems* controlled from *space* temperature (such as *single-zone systems*).

	Table 6.5.1.1.3	High-Limit Shutoff	Control Settings for	Air Economizers ^b ((I-P)
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	Allowed Only in Climate Zone at	Required High-Limit Set Points (Economizer Off when):	
Control Type	Listed Set Point	Equation	Description
Fixed dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	$T_{OA} > 75^{\circ}\mathrm{F}$	Outdoor air temperature exceeds 75°F
	5A, 6A	$T_{OA} > 70^{\circ} \mathrm{F}$	Outdoor air temperature exceeds 70°F
	0A, 1A, 2A, 3A, 4A	$T_{OA} > 65^{\circ}\mathrm{F}$	Outdoor air temperature exceeds 65°F
Differential dry-bulb temperature	All	$T_{OA} > T_{RA}$	<i>Outdoor air</i> temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperature	A11	$h_{OA} > 28 \text{ Btu/lb}^{a}$ or $T_{OA} > 75^{\circ}\text{F}$	<i>Outdoor air</i> enthalpy exceeds 28 Btu/lb ^a of dry air ^a or <i>outdoor air</i> temperature exceeds 75°
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or $T_{OA} > 75^{\circ}$ F	<i>Outdoor air</i> enthalpy exceeds return air enthalpy or <i>outdoor air</i> temperature exceeds 75°F

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

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

6.5.1.1.3 High-Limit Shutoff

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

6.5.1.1.4 Dampers

1. Return, exhaust/relief, and *outdoor air* dampers shall meet the requirements of Section 6.4.3.4.3.

6.5.1.1.5 Relief of Excess Outdoor Air

Systems shall provide a means to relieve excess *outdoor air* during *air economizer* operation to prevent overpressurizing the *building*. The relief air outlet shall be located so as to avoid recirculation into the *building*.

6.5.1.1.6 Sensor Accuracy

Outdoor air, return air, mixed air, and supply air sensors shall be calibrated within the following accuracies:

- a. Dry-bulb and wet-bulb temperatures shall be accurate to $\pm 2^{\circ}$ F over the range of 40° F to 80° F.
- b. Enthalpy and the value of a differential enthalpy sensor shall be accurate to ± 3 Btu/lb over the range of 20 to 36 Btu/lb.
- c. Relative humidity shall be accurate to $\pm 5\%$ over the range of 20% to 80% rh.

6.5.1.2 Fluid Economizers

6.5.1.2.1 Design Capacity

Fluid economizer systems shall be capable of providing up to 100% of the expected system cooling

load at *outdoor air* temperatures of 50°F dry bulb/45°F wet bulb and below.

Exceptions to 6.5.1.2.1

- 1. *Systems* primarily serving *computer rooms* in which 100% of the expected *system* cooling load at the dry-bulb and wet-bulb temperatures listed in Table 6.5.1.2.1 is met with water-cooled *fluid economizers*
- 2. Systems primarily serving *computer rooms* in which 100% of the expected system cooling load at the dry-bulb temperatures listed in Table 6.5.1.2.1 is met with air-cooled *fluid* economizers.
- 3. *Systems* where dehumidification requirements cannot be met using *outdoor air* temperatures of 50°F dry-bulb/45°F wet-bulb and where 100% of the expected *system* cooling load at 45°F dry-bulb/40°F wet-bulb is met with water-cooled *fluid economizers*.

		Water	Air Cooled	
Climate	Zone	Dry Bulb, °F	Wet Bulb, °F	Dry Bulb, °F
0	А	NR	NR	NR
0	В	NR	NR	NR
1	А	NR	NR	NR
1	В	NR	NR	NR
2	А	40.0	35.0	30.0
2	В	35.0	30.0	30.0
3	А	40.0	35.0	25.0
3	В	30.0	25.0	25.0
3	С	30.0	25.0	30.0
4	А	40.0	35.0	25.0
4	В	30.0	25.0	25.0
4	С	30.0	25.0	25.0
5	А	40.0	35.0	20.0
5	В	30.0	25.0	20.0
5	С	30.0	25.0	25.0
6	А	35.0	30.0	20.0
6	В	30.0	25.0	20.0
7		30.0	25.0	20.0
8		30.0	25.0	20.0

 Table 6.5.1.2.1
 Fluid Economizer Sizing Dry-Bulb and Wet-Bulb Requirements for Computer Rooms (I-P)

NR-Not required

6.5.1.2.2 Maximum Hydronic Pressure Drop

Precooling coils and fluid-to-water heat exchangers used as part of a *fluid economizer system* shall either have a water-side pressure drop of less than 15 ft of water, or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the *system* is in the normal cooling (noneconomizer) mode.

6.5.1.3 Integrated Economizer Control

Economizer *systems* shall be integrated with the *mechanical cooling system* and be capable of and configured to provide partial cooling even when additional *mechanical cooling* is required to meet the remainder of the cooling load. *Controls* shall not false load the *mechanical cooling systems* by limiting or disabling the economizer or by any other means, such as hot-gas bypass, except at the lowest stage of

mechanical cooling.

Units that include an *air economizer* shall comply with the following:

- a. Unit *controls* shall have the *mechanical cooling* capacity *control* interlocked with the *air economizer controls* such that the *outdoor air* damper is at the 100% open position when *mechanical cooling* is on, and the *outdoor air* damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F.
- b. DX units with a rated capacity no less than 65,000 Btu/h that *control* the capacity of the *mechanical cooling* directly based on occupied *space* temperature shall have a minimum of two stages of *mechanical cooling* capacity.
- c. All other DX units, including those that *control space* temperature by modulating the airflow to the *space*, shall comply with the requirements of Table 6.5.1.3.

Table 6.5.1.3	DX Cooling Stage	Requirements for	Modulating Airflow	Units
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Rating Capacity, Btu/h	Minimum Number of Mechanical Cooling Stages	Minimum Compressor Displacement ^a
≥65,000 and <240,000	3	$\leq 35\%$ of full load
≥240,000	4	$\leq 25\%$ of full load

a. For mechanical cooling stage *control* that does not use variable compressor displacement the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

6.5.1.4 Economizer Heating System Impact

HVAC system design and economizer *controls* shall be such that economizer operation does not increase the *building* heating *energy* use during normal operation.

Exception to 6.5.1.4

Economizers on VAV systems that cause zone-level heating to increase due to a reduction in supply air temperature

6.5.1.5 Economizer Humidification System Impact

Systems with hydronic cooling and humidification *systems* designed to maintain inside humidity at a dew-point temperature greater than 35°F shall use a *fluid economizer* if an economizer is required by Section 6.5.1.

6.5.2 Simultaneous Heating and Cooling Limitation

6.5.2.1 Zone Controls

Zone thermostatic controls shall prevent

- a. reheating;
- b. recooling;
- c. mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems; and
- d. other simultaneous operation of heating and cooling systems to the same zone.

Exceptions to 6.5.2.1

- 1. Zones for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:
 - a. Twenty percent For systems without DDC, 30% of the zone design peak supply for systems with DDC and 30% for other systems.
 - b. <u>For systems with DDC, The the minimum primary outdoor</u> airflow rate required to meet the <u>Simplified Procedure</u> *ventilation* requirements of ASHRAE Standard 62.1 for the zone and is permitted to be the average airflow rate as allowed by ASHRAE Standard 62.1.
 - c. Any higher rate that can be demonstrated, to the satisfaction of the authority having

jurisdiction, to reduce overall *system* annual *energy* use by offsetting *reheat/recool energy* losses through a reduction in *outdoor air* intake for the *system*.

- d. The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.
- 2. Zones with *DDC* that comply with all of the following:
 - a. The airflow rate in *dead band* between heating and cooling does not exceed the larger of the following:
 - (1) Twenty percent of the zone design peak supply rate.
 - The outdoor airflow rate required to meet the *ventilation* requirements of ASHRAE Standard 62.1 for the zone.
 - Any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall *system* annual *energy* use by offsetting *reheat/recool energy* losses through a reduction in *outdoor air* intake.
 - The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.
 - b. The airflow rate that is reheated, recooled, or mixed shall be less than 50% of the zone design peak supply rate.
 - c. The first stage of heating consists of modulating the zone supply air temperature *set point* up to a maximum *set point* while the airflow is maintained at the *dead band* flow rate.
 - d. The second stage of heating consists of modulating the airflow rate from the *dead band* flow rate up to the heating maximum flow rate.
- 3. Laboratory exhaust systems that comply with Section 6.5.7.3.
- 4. Zones where at least 75% of the *energy* for *reheating* or for providing warm air in mixing *systems* is provided from *site-recovered energy* (including condenser heat) or *site-solar energy*.

6.5.2.1.1 Supply Air Temperature Reheat Limit

Where *reheating* is permitted by other parts of this standard, zones that have both supply and return/exhaust air openings greater than 6 ft above *floor* shall not supply heating air more than 20°F above the *space* temperature *set point*.

Exceptions to 6.5.2.1.1

- 1. Laboratory exhaust systems that comply with Section 6.5.7.3.
- 2. During preoccupancy *building warm-up* and *setback*.

6.5.2.2 Hydronic System Controls

The heating of fluids in hydronic *systems* that have been previously mechanically cooled, and the cooling of fluids that have been previously mechanically heated, shall be limited in accordance with Sections 6.5.2.2.1 through 6.5.2.2.3.

6.5.2.2.1 Three-Pipe System

Hydronic systems that use a common return system for both hot water and chilled water shall not be used.

6.5.2.2.2 Two-Pipe Changeover System

Systems that use a common *distribution system* to supply both heated and chilled water are acceptable provided all of the following are met:

- a. The *system* is designed to allow a *dead band* between changeover from one mode to the other of at least 15°F *outdoor air* temperature.
- b. The *system* is designed to operate and is provided with *controls* that will allow operation in one mode for at least four hours before changing over to the other mode.
- c. *Reset controls* are provided that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F apart.

6.5.2.2.3 Hydronic (Water Loop) Heat Pump Systems

Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower) and heat addition (e.g., *boiler*) shall have the following:

- a. *Controls* that are capable of and configured to provide a heat pump water supply temperature *dead band* of at least 20°F between initiation of heat rejection and heat addition by the central devices (e.g., tower and *boiler*).
- b. For Climate Zones 3 through 8, if a closed-circuit cooling tower (fluid cooler) is used, either an *automatic* valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection) or low-leakage positive closure dampers shall be provided. If an open-circuit cooling tower is used directly in the heat pump loop, an *automatic* valve shall be installed to bypass all heat pump water flow around the tower. If an open-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the tower from the heat pump loop then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

Exception to 6.5.2.2.3

6.5.2.3 Where a *system* loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of *demand* and capacity, *dead bands* of less than 20°F shall be allowed.**Dehumidification**

Where humidity controls are provided, such controls shall prevent *reheating*, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.

Exceptions to 6.5.2.3

- 1. The *system* is capable of and configured to reduce supply air volume to 50% or less of the design airflow rate or the minimum *outdoor air ventilation* rate specified in ASHRAE Standard 62.1 or other applicable federal, state, or local code or recognized standard, whichever is larger, before simultaneous heating and cooling takes place.
- 2. The individual fan cooling unit has a design cooling capacity of 65,000 Btu/h or less and is capable of and configured to unload to 50% capacity before simultaneous heating and cooling takes place.
- 3. The individual *mechanical cooling* unit has a design cooling capacity of 40,000 Btu/h or less. An individual *mechanical cooling* unit is a single *system* comprising a fan or fans and a cooling coil capable of providing *mechanical cooling*.
- 4. *Systems* serving *spaces* where specific humidity levels are required to satisfy *process* needs, such as vivariums; museums; surgical suites; pharmacies; and *buildings* with refrigerating *systems*, such as supermarkets, refrigerated warehouses, and ice arenas, and where the *building* includes *site-recovered energy* or *site-solar energy* that provide *energy* equal to at least 75% of the annual *energy* for *reheating* or for providing warm air in mixing *systems*. This exception does not apply to *computer rooms*.
- 5. At least 90% of the annual *energy* for *reheating* or for providing warm air in mixing *systems* is provided from *site-recovered energy* (including condenser heat) or *site-solar energy*.
- 6. *Systems* where the heat added to the airstream is the result of the use of a desiccant *system*, and 75% of the heat added by the desiccant *system* is removed by a heat exchanger, either before or after the desiccant *system*, with *energy* recovery.

6.5.2.4 Humidification

6.5.2.4.1

Humidifiers with preheating jackets mounted in the airstream shall be provided with an *automatic* valve to shut off preheat when humidification is not required.

6.5.2.4.2

Humidification *system* dispersion-tube hot surfaces in the airstreams of ducts or air-handling units shall be insulated with a product with an insulating value of at least R-0.5.

Exception to 6.5.2.4.2

Systems where *mechanical cooling*, including economizer operation, does not occur simultaneously with humidification.

6.5.2.5 Preheat Coils

Preheat coils shall have *controls* that stop their heat output whenever *mechanical cooling*, including economizer operation, is occurring.

6.5.2.6 Ventilation Air Heating Control

Units that provide *ventilation* air to multiple zones and operate in conjunction with zone heating and cooling *systems* shall not use heating or heat recovery to warm supply air above 60°F when representative *building* loads or *outdoor air* temperature indicate that the majority of zones require cooling.

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 Motor Nameplate Horsepower

For each fan, the selected fan motor shall be no larger than the first available motor size greater than 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. 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.
- 3. *Systems* complying with Section 6.5.3.1.1, Option 1.
- 4. Fans with motor *nameplate horsepower* of less than 1 hp.
- 5.

6.5.3.1.3 Fan Efficiency

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

Exceptions to 6.5.3.1.3

- 1. Individual fans with a motor *nameplate horsepower* of 5 hp or less that are not part of a group operated as the functional equivalent of a single fan.
- 2. Multiple fans in series or parallel (e.g., fan arrays) that have a combined motor *nameplate horsepower* of 5 hp or less and are operated as the functional equivalent of a single fan.

- 3. Fans that are part of *equipment* listed under Section 6.4.1.1.
- 4. 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).
- 6. Fans outside the scope of AMCA 205.
- 7. Fans that are intended to only operate during emergency conditions.

 Table 6.5.3.1-1
 Fan Power Limitation^a (I-P)

	Limit	Constant Volume	Variable Volume
Option 1: Fan <i>system</i> motor nameplate hp	Allowable motor nameplate hp	$hp \le cfm_S \times 0.0011$	$hp \le cfm_S \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \le cfm_S \times 0.00094 + A$	$bhp \le cfm_S \times 0.0013 + A$

a. where

 $cfm_S = maximum design supply airflow rate to$ *conditioned spaces*served by the*system*in cubic feet per minute

hp = maximum combined motor nameplate horsepower

bhp = maximum combined fan-brake horsepower

 $A = \operatorname{sum of} (\operatorname{PD} \times \operatorname{cfm}_D/4131)$

where

PD = each applicable pressure drop adjustment from Table 6.5.3.1-2 in in. of water

 cfm_D = the design airflow through each applicable device from Table 6.5.3.1-2 in cubic feet per minute

Device	Adjustment
Credits	
Return or exhaust <i>systems</i> required by code or accreditation standards to be fully ducted, or <i>systems</i> required to maintain air pressure differentials between adjacent rooms.	0.5 in. of water (2.15 in. of water for laboratory and vivarium <i>systems</i>)
Return and/or exhaust airflow control devices	0.5 in. of water
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at <i>fan system design</i> condition
Particulate Filtration Credit: MERV 9 through 12	0.5 in. of water
Particulate Filtration Credit: MERV 13 through 15	0.9 in. of water
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at <i>fan</i> system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy recovery device, other than coil runaround loop	For each airstream [$(2.2 \times Enthalpy Recovery Ratio) - 0.5$] in. of water
Coil runaround loop	0.6 in. of water for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design condition
Sound attenuation section (fans serving <i>spaces</i> with design background noise goals below NC35)	0.15 in. of water
Exhaust system serving fume hoods	0.35 in. of water
Laboratory and vivarium exhaust <i>systems</i> in high-rise <i>buildings</i>	0.25 in. of water/100 ft of vertical duct exceeding 75 ft
Deductions	
Systems without central cooling device	-0.6 in. of water
Systems without central heating device	-0.3 in. of water
Systems with central electric resistance heat	-0.2 in. of water

Table 6.5.3.1-2 Fan Power Limitation Pressure Drop Adjustment (I-P)

6.5.3.2 Fan Control

6.5.3.2.1 Supply Fan Airflow Control

Each cooling *system* listed in Table 6.5.3.2.1 shall be designed to vary the supply fan airflow as a function of load and shall comply with the following requirements:

- a. DX and chilled-water cooling units that *control* the capacity of the *mechanical cooling* directly based on *space* temperature shall have a minimum of two stages of fan *control*. Low or minimum speed shall not exceed 66% of full speed. At low or minimum speed, the fan *system* shall draw no more than 40% of the fan power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and *ventilation*-only operation.
- b. All other units, including DX cooling units and chilled-water units that *control* the *space* temperature by modulating the airflow to the *space*, shall have modulating fan *control*. Minimum speed shall not exceed 50% of full speed. At minimum speed, the fan *system* shall draw no more than 30% of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and *ventilation*-only operation.

Cooling System Type	Fan Motor Size, hp	Mechanical Cooling Capacity, Btu/h
DX Cooling	Any	≥65,000
Chilled-water and evaporative cooling	$\geq 1/4$	Any

Table 6.5.3.2.1 Fan Airflow Control

c. Units that include an *air economizer* to meet the requirements of Section 6.5.1 shall have a minimum of two speeds of fan *control* during economizer operation.

Exceptions to 6.5.3.2.1

- 1. Modulating fan *control* is not required for chilled-water and evaporative cooling units with <1 hp fan motors if the units are not used to provide *ventilation* air and if the indoor fan cycles with the load.
- 2. If the volume of *outdoor air* required to meet the *ventilation* requirements of Standard 62.1 at low speed exceeds the air that would be delivered at the speed defined in Section 6.5.3.2.1(a) or 6.5.3.2.1(b) then the minimum speed shall be selected to provide the required *ventilation* air.

6.5.3.2.2 VAV Static Pressure Sensor Location

Static pressure sensors used to *control VAV* fans shall be located such that the controller *set point* is no greater than 1.2 in. of water. If this results in the sensor being located downstream of major duct splits, sensors shall be installed in each major branch to ensure that static pressure can be maintained in each.

Exception to 6.5.3.2.2

Systems complying with Section 6.5.3.2.3.

6.5.3.2.3 VAV Set-Point Reset

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

- a. Monitor zone damper positions or other indicator of need for static pressure.
- b. Automatically detect those zones that may be excessively driving the *reset* logic and generate an alarm to the *system* operator.
- c. Readily allow operator removal of zones from the *reset* algorithm.

6.5.3.2.4 Return and Relief Fan Control

Return and relief fans used to meet Section 6.5.1.1.5 shall comply with all of the following:

- a. Relief air rate shall be controlled to maintain *building* pressure either directly, or indirectly through differential supply-return airflow tracking. *Systems* with constant speed or multispeed supply fans shall also be allowed to *control* the relief *system* based on *outdoor air* damper position.
- b. Fans shall have variable-speed *control* or other devices that will result in total return/relief fan *system demand* of no more than 30% of total design power at 50% of total design fan flow.

Exceptions to 6.5.3.2.4

- 1. Return or relief fans with total motor size less than or equal to 0.5 hp.
- 2. Staged relief fans with a minimum of four stages.

6.5.3.3 Multiple-Zone VAV System Ventilation Optimization Control

Multiple-zone VAV systems with DDC of individual zone boxes reporting to a central *control* panel shall include means to automatically reduce *outdoor air* intake flow below design rates in response to changes

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in system ventilation efficiency as defined by Appendix A of ASHRAE Standard 62.1.

Exceptions to 6.5.3.3

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

6.5.3.4 Parallel-Flow Fan-Powered VAV Air Terminal Control

Parallel-flow fan-powered VAV air terminals shall have automatic controls configured to

- a. turn off the *terminal* fan except when *space* heating is required or if required for *ventilation*;
- b. turn on the terminal fan as the first stage of heating before the heating coil is activated; and
- c. during heating for warmup or setback temperature control, either
 - 1. operate the *terminal* fan and heating coil without primary air or
 - 2. reverse the *terminal* damper logic and provide heating from the central air handler through primary air.

6.5.3.5 Supply Air Temperature Reset Controls

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

Exceptions to 6.5.3.5

- 1. Climate Zones 0A, 1A, 2A, and 3A.
- 2. Systems that prevent reheating, recooling, or mixing of heated and cooled supply air.
- 3. *Systems* in which at least 75% of the *energy* for *reheating* (on an annual basis) is from *site recovered energy* or *site-solar energy*.

6.5.3.6 Fractional Horsepower Fan Motors

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

Exceptions to 6.5.3.6

- 1. Motors in the airstream within fan-coils and *terminal* units that operate only when providing heating to the *space* served.
- 2. Motors installed in *space*-conditioning *equipment* certified under Section 6.4.1.
- 3. Motors covered by Table 10.8-4 or Table 10.8-5.

6.5.3.7 Ventilation Design

The required minimum *outdoor air* rate is the larger of the minimum *outdoor air* rate or the minimum exhaust air rate required by Standard 62.1, Standard 170, or applicable codes or accreditation standards. *Outdoor air ventilation systems* shall comply with one of the following:

- a. Design minimum *system outdoor air* provided shall not exceed 135% of the required minimum *outdoor air* rate.
- b. Dampers, *ductwork*, and *controls* shall be provided that allow the *system* to supply no more than the required minimum *outdoor air* rate with a single *set-point* adjustment.

1. The system includes exhaust air energy recovery complying with Section 6.5.6.1.

6.5.4 Hydronic System Design and Control

6.5.4.1 Boiler Turndown

Boiler systems with design input of at least 1,000,000 Btu/h shall comply with the turndown ratio specified in Table 6.5.4.1.

The *system* turndown requirement shall be met through the use of multiple single-input *boilers*, one or more modulating *boilers*, or a combination of single-input and modulating *boilers*.

All boilers shall meet the minimum efficiency requirements in Table 6.8.1-6.

Boiler System Design Input, Btu/h	Minimum Turndown Ratio
≥1,000,000 and ≤5,000,000	3 to 1
>5,000,000 and ≤10,000,000	4 to 1
>10,000,000	5 to 1

Table 6.5.4.1Boiler Turndown

6.5.4.2 Hydronic Variable Flow Systems

Chilled- and hot-water *distribution systems* that include three or more *control* valves designed to modulate or step open and close as a function of load shall be designed for variable fluid flow and shall be capable of and configured to reduce pump flow rates to no more than the larger of 25% of the design flow rate or the minimum flow required by the heating/cooling *equipment manufacturer* for the proper operation of *equipment*. Individual or parallel pumps serving variable-flow heating-water or chilled-water *systems*, where the *nameplate horsepower* of the motor or combined parallel motors is at least the power shown in Table 6.5.4.2, shall have *controls* or devices that will result in pump motor *demand* of no more than 30% of design wattage at 50% of design water flow. The *controls* or devices shall be controlled as a function of desired flow or to maintain a minimum required differential pressure. Differential pressure shall be measured at or near the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure. The differential pressure *set point* shall be no more than 110% of that required to achieve design flow through the heat exchanger. Where differential pressure *control* is used to comply with this section and *DDC systems* are used, the *set point* shall be *reset* downward based on valve positions until one valve is nearly wide open.

Exceptions to 6.5.4.2

- 1. Differential pressure *set-point reset* is not required where valve position is used to comply with Section 6.5.4.4.
- 2. Variable-pump flow *control* is not required on heating-water pumps where more than 50% of annual heat is generated by an electric *boiler*.
- 3. Variable flow is not required for primary pumps in a primary/secondary system.
- 4. Variable flow is not required for a coil pump provided for freeze protection.
- 5. Variable flow is not required for heat recovery coil runaround loops.

Chilled-Water Pumps in These Climate Zones	Heating Water Pumps in These Climate Zones	Motor Nameplate Horsepower
0A, 0B, 1A, 1B, 2B	NR	≥2 hp
2A, 3B	NR	≥3 hp
3A, 3C, 4A, 4B	7, 8	≥5 hp
4C, 5A, 5B, 5C, 6A, 6B	3C, 5A, 5C, 6A, 6B	≥7.5 hp
	4A, 4C, 5B	≥10 hp
7, 8	4B	≥15 hp
	2A, 2B, 3A, 3B	≥25 hp
	1B	≥100 hp
	0A, 0B, 1A	≥200 hp

Table 6.5.4.2 Pump Flow Control Requirements

6.5.4.3 Chiller and Boiler Isolation

6.5.4.3.1

When a chilled-water plant includes more than one chiller, provisions shall be made so that all fluid flow through the chiller is automatically shut off when the chiller is shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller. Where constant-speed chilled-water or condenser water pumps are used to serve multiple chillers, the number of pumps shall be no less than the number of chillers and staged on and off with the chillers.

6.5.4.3.2

When a *boiler* plant includes more than one *boiler*, provisions shall be made so that the flow through the *boiler* is automatically shut off when the *boiler* is shut down. Where constant-speed hot-water pumps are used to serve multiple *boilers*, the number of pumps shall be no less than the number of *boilers* and staged on and off with the *boilers*.

6.5.4.4 Chilled- and Hot-Water Temperature Reset Controls

Chilled- and hot-water *systems* with a *design capacity* exceeding 300,000 Btu/h supplying chilled or heated water to comfort conditioning *systems* shall include controls that automatically *reset* supply water temperatures by representative *building* loads (including return water temperature) or by *outdoor air* temperature. Where *DDC* is used to *control* valves, the *set point* shall be *reset* based on valve positions until one valve is nearly wide open or *set-point* limits of the *system equipment* or application have been reached.

Exceptions to 6.5.4.4

- 1. Where chilled-water supply is already cold, such as chilled water supplied from a district cooling or thermal *energy* storage *system*, such that blending would be required to achieve the *reset* chilled-water supply temperature.
- 2. Where a specific temperature is required for a *process*.
- 3. Water temperature *reset* is not required where valve position is used to comply with Section 6.5.4.1.

6.5.4.5 Hydronic (Water Loop) Heat Pumps and Water-Cooled Unitary Air Conditioners

6.5.4.5.1

Each hydronic heat pump and water-cooled unitary air conditioner shall have a two-position *automatic* valve interlocked to shut off water flow when the compressor is off.

Exception to 6.5.4.5.1

Units employing a *fluid economizer*.

6.5.4.5.2

Hydronic heat pumps and water-cooled unitary air conditioners having a total pump system power

exceeding 5 hp shall have *controls* and/or devices (such as variable-speed *control*) that will result in pump motor *demand* of no more than 30% of design wattage at 50% of design water flow.

6.5.4.6 Pipe Sizing

All chilled-water and condenser-water *piping* shall be designed such that the design flow rate in each *piping* segment shall not exceed the values listed in Table 6.5.4.6 for the appropriate total annual hours of operation. *Piping* size selections for *systems* that operate under variable flow conditions (e.g., modulating two-way *control* valves at coils) and that contain variable-speed pump motors are allowed to be made from the "Variable Flow/Variable Speed" columns. All others shall be made from the "Other" columns.

Exceptions to 6.5.4.6

- 1. Design flow rates exceeding the values in Table 6.5.4.6 are allowed in specific sections of *piping* if the *piping* in question is not in the *critical circuit* at *design conditions* and is not predicted to be in the *critical circuit* during more than 30% of operating hours.
- 2. *Piping systems* that have equivalent or lower total pressure drop than the same *system* constructed with standard weight steel pipe with *piping* and fittings sized per Table 6.5.4.6

Operating Hours/Year	≤2000 Hours/Year		>2000 and ≤4400 Hours/Year		>4400 Hours/Year	
Nominal Pipe Size, in.	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed
2 1/2	120	180	85	130	68	110
3	180	270	140	210	110	170
4	350	530	260	400	210	320
5	410	620	310	470	250	370
6	740	1100	570	860	440	680
8	1200	1800	900	1400	700	1100
10	1800	2700	1300	2000	1000	1600
12	2500	3800	1900	2900	1500	2300
Maximum velocity for pipes over 14 to 24 in. in size	8.5 ft/s	13.0 ft/s	6.5 ft/s	9.5 ft/s	5.0 ft/s	7.5 ft/s

 Table 6.5.4.6 Piping System Design Maximum Flow Rate in GPM

6.5.4.7 Chilled-Water Coil Selection

Chilled-water cooling coils shall be selected to provide a 15°F or higher temperature difference between leaving and entering water temperatures and a minimum of 57°F leaving water temperature at *design conditions*.

Exceptions to 6.5.4.7

- 1. Chilled-water cooling coils that have an air-side pressure drop exceeding 0.70 in. of water when rated at 500 fpm face velocity and dry conditions (no condensation).
- 2. Individual fan-cooling units with a design supply airflow rate 5000 cfm and less.
- 3. Constant-air-volume systems.
- 4. Coils selected at the maximum temperature difference allowed by the chiller.
- 5. Passive coils (no mechanically supplied airflow).
- 6. Coils with design entering chilled-water temperatures of 50°F and higher.
- 7. Coils with design entering air dry-bulb temperatures of 65°F and lower.

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.

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

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

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systems that operate 8000 or more hours per year.

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

Exceptions to 6.5.6.1

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

Systems expected to operate less than 20 hours per week at the outdoor air percentage covered by Table 6.5.6.1-1.

Table 6.5.6.1-1 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, 4C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 5C	NR	NR	NR	NR	≥26,000	≥12,000	≥5,000	≥4,000
6B	≥28,000	≥26,500	≥11,000	≥5,500	≥4,500	≥3,500	≥2,500	≥1,500
0A, 1A, 2A, 3A, 4A,	≥26,000	≥16,000	≥5,500	≥4,500	≥3,500	≥2,000	≥1,000	≥120
5A, 6A								
7, 8	≥4,500	≥4,000	≥2,500	≥1,000	≥140	≥120	≥100	≥80

NR-Not required

Table 6.5.6.1-2 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	≥9,000	≥5,000	≥4,000	≥3,000	≥1,500	≥120
0A, 1A, 2A, 3A, 4B, 5B	≥2,500	≥2,000	≥1,000	≥500	≥140	≥120	≥100	≥80

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

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.

6.5.7 Exhaust Systems

6.5.7.1 Transfer Air

Conditioned supply air delivered to any space with mechanical exhaust shall not exceed the greater of

- a. the supply flow required to meet the *space* heating or cooling load;
- b. the *ventilation* rate required by the *authority having jurisdiction*, the facility Environmental Health and Safety department, or ASHRAE Standard 62.1; or
- c. the mechanical exhaust flow minus the available *transfer air* from *conditioned spaces* or return air plenums on the same *floor*, not in different smoke or fire compartments, and that at their closest point are within 15 ft of each other. Available *transfer air* is that portion of outdoor *ventilation* air that
 - 1. is not required to satisfy other exhaust needs,
 - 2. is not required to maintain pressurization of other spaces, and
 - 3. is transferable according to applicable codes and standards and to the class of air recirculation limitations in ASHRAE Standard 62.1.

Exceptions to 6.5.7.1

- 1. Biosafety level classified laboratories 3 or higher.
- 2. Vivarium spaces.
- 3. *Spaces* that are required by applicable codes and standards to be maintained at positive pressure relative to adjacent *spaces*. For *spaces* taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more *energy*.
- 4. *Spaces* where the *demand* for *transfer air* may exceed the available transfer airflow rate and where the *spaces* have a required negative pressure relationship. For *spaces* taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more *energy*.

6.5.7.2 Kitchen Exhaust Systems

6.5.7.2.1

Replacement air introduced directly into the hood cavity of kitchen exhaust hoods shall not exceed 10% of the hood exhaust airflow rate.

6.5.7.2.2

If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5000 cfm then each hood shall have an exhaust rate that complies with Table 6.5.7.2.2. If a single hood or hood section is installed over appliances with different duty ratings then the maximum allowable flow rate for the hood or hood section shall not exceed the Table 6.5.7.2.2 values for the highest appliance duty rating under the hood or hood section. Refer to ASHRAE Standard 154 for definitions of hood type, appliance duty, and net exhaust flow rate.

Exception to 6.5.7.2.2

At least 75% of all the replacement air is transfer air that would otherwise be exhausted.

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

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

NA = Not allowed

6.5.7.2.3

If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5000 cfm then it shall have one of the following:

- a. At least 50% of all *replacement air* is *transfer air* that would otherwise be exhausted.
- b. *Demand ventilation systems* on at least 75% of the exhaust air. Such *systems* shall be capable of and configured to provide at least 50% reduction in exhaust and *replacement air system* airflow rates, including *controls* necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent, and combustion products during cooking and idle.
- c. Listed *energy* recovery devices that result in a sensible *energy* recovery ratio of not less than 40% on at least 50% of the total exhaust airflow. A 40% sensible *energy* recovery ratio shall mean a change in the dry-bulb temperature of the *outdoor air* supply equal to 40% of the difference between the *outdoor air* and entering exhaust air dry-bulb temperatures at *design conditions*.

6.5.7.2.4 Performance Testing

An approved field test method shall be used to evaluate design airflow rates and demonstrate proper capture and containment performance of installed commercial kitchen exhaust *systems*. Where *demand ventilation systems* are utilized to meet Section 6.5.7.2.3, additional performance testing shall be required to demonstrate proper capture and containment at minimum airflow.

6.5.7.3 Laboratory Exhaust Systems

Buildings with laboratory exhaust *systems* having a total exhaust rate greater than 5000 cfm shall include at least one of the following features:

a. *VAV* laboratory exhaust and room supply *system* capable of and configured to reduce exhaust and makeup airflow rates and/or incorporate a heat recovery *system* to precondition *makeup air* from laboratory exhaust that shall meet the following:

$$A + B \times (E/M) \square \square 50\%$$

where

- A = percentage that the exhaust and makeup airflow rates can be reduced from *design conditions*
- B = sensible *energy* recovery ratio
- E = exhaust airflow rate through the heat recovery device at *design conditions*
- *M* = makeup airflow rate of the system at design conditions.
- b. *VAV* laboratory exhaust and room supply *systems* that are required to have minimum circulation rates to comply with code or accreditation standards shall be capable of and configured to reduce zone exhaust and makeup airflow rates to the regulated minimum circulation values or the minimum required to maintain pressurization relationship requirements. *Systems* serving nonregulated zones shall be capable of and configured to reduce exhaust and makeup airflow rates to 50% of the zone design values or the minimum required to maintain pressurization relationship requirements.
- c. Direct makeup (auxiliary) air supply equal to at least 75% of the exhaust airflow rate, heated no warmer than 2°F below room *set point*, cooled to no cooler than 3°F above room *set point*, no humidification added, and no simultaneous heating and cooling used for dehumidification *control*.

6.5.8 Radiant Heating Systems

6.5.8.1 Heating Unenclosed Spaces

Radiant heating shall be used when heating is required for *unenclosed spaces*.

Exception to 6.5.8.1

Loading docks equipped with air curtains.

6.5.8.2 Heating Enclosed Spaces

Radiant heating systems that are used as primary or supplemental *heating for enclosed spaces* must be in conformance with the governing provisions of the standard, including but not limited to the following:

- a. Radiant hydronic ceiling or *floor* panels (used for heating or cooling).
- b. Combination or hybrid systems incorporating radiant heating (or cooling) panels.
- c. Radiant heating (or cooling) panels used in conjunction with other *systems* such as *VAV* or thermal storage *systems*.

6.5.9 Hot-Gas Bypass Limitation

Cooling *systems* shall not use hot-gas bypass or other evaporator pressure *control systems* unless the *system* is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot-gas bypass shall be limited as indicated in Table 6.5.9 for *VAV* units and single-zone *VAV* units. Hot-gas bypass shall not be used on constant-volume units.

Rated Capacity	Maximum Hot-Gas Bypass, % of Total Capacity
≤240,000 Btu/h	15%
≥240,000 Btu/h	10%

Table 6.5.9 Hot-Gas Bypass Limitation

6.5.10 Door Switches

Any conditioned space with a door, including doors with more than one-half glass, opening to the outdoors

shall be provided with controls that, when any such door is open,

- a. disable mechanical heating or *reset* the heating *set point* to 55°F or lower within five minutes of the *door* opening and
- b. disable *mechanical cooling* or *reset* the cooling *set point* to 90°F or greater within five minutes of the *door* opening. *Mechanical cooling* may remain enabled if *outdoor air* temperature is below *space* temperature.

Exceptions to 6.5.10

- 1. Building entries with automatic closing devices.
- 2. Any space without a thermostat.
- 3. *Alterations* to *existing buildings*.
- 4. Loading docks.

6.5.11 Refrigeration Systems

Refrigeration *systems* that comprise refrigerated display cases, *walk-in coolers*, or *walk-in freezers* connected to remote compressors, remote condensers, or remote *condensing units* shall meet the requirements of Sections 6.5.11.1 and 6.5.11.2.

Exception to 6.5.11

Systems utilizing transcritical refrigeration cycle or ammonia refrigerant.

6.5.11.1 Condensers Serving Refrigeration Systems

Fan-powered condensers shall conform to the following requirements:

- a. Design *saturated condensing temperatures* for air-cooled condensers shall be less than or equal to the design dry-bulb temperature plus 10°F for *low-temperature refrigeration systems* and less than or equal to the design dry-bulb temperature plus 15°F for *medium-temperature refrigeration systems*.
 - 1. *Saturated condensing temperature* for blend refrigerants shall be determined using the average of liquid and vapor temperatures as converted from the condenser drain pressure.
- b. Condenser fan motors that are less than 1 hp shall use electronically commutated motors, permanent split-capacitor-type motors, or three-phase motors.
- c. All condenser fans for air-cooled condensers, evaporatively cooled condensers, and air- or watercooled fluid coolers or cooling towers shall incorporate one of the following continuous variablespeed fan *control* approaches and shall reduce fan motor *demand* to no more than 30% of design wattage at 50% of design air volume:
 - 1. Refrigeration *system* condenser *control* for air-cooled condensers shall use variable *set-point control* logic to *reset* the condensing temperature *set point* in response to ambient dry-bulb temperature.
 - 2. Refrigeration *system* condenser *control* for evaporatively cooled condensers shall use variable *set-point control* logic to *reset* the condensing temperature *set point* in response to ambient wetbulb temperature.
- d. Multiple fan condensers shall be controlled in unison.
- e. The minimum condensing temperature *set point* shall be no greater than 70°F.

6.5.11.2 Compressor Systems

Refrigeration compressor systems shall conform to the following requirements:

a. Compressors and multiple-compressor *systems* suction groups shall include *control systems* that use floating suction pressure *control* logic to *reset* the target suction pressure temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.

Exceptions to 6.5.11.2(a)

1. Single-compressor *systems* that do not have variable-capacity capability.

- 2. Suction groups that have a design saturated suction temperature equal to or greater than 30°F, suction groups that comprise the high stage of a two-stage or cascade *system*, or suction groups that primarily serve chillers for secondary cooling fluids.
- b. Liquid subcooling shall be provided for all low-temperature compressor *systems* with a design cooling capacity equal to or greater than 100,000 Btu/h with a design saturated suction temperature equal to or less than -10° F. The subcooled liquid temperature shall be controlled at a maximum temperature *set point* of 50°F at the exit of the subcooler using either compressor economizer (interstage) ports or a separate compressor suction group operating at a saturated suction temperature equal to or greater than 18°F.
 - 1. Subcooled liquid lines are subject to the insulation requirements of Table 6.8.3-2.
- c. All compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

6.6 Alternative Compliance Path

6.6.1 Computer Rooms Systems[bv4]

6.6.2 Computer Room Systems

HVAC systems serving the heating, cooling, or ventilating needs of a *computer room* shall comply with Sections 6.1, 6.4, 6.6.1.1 or 6.6.1.2, 6.6.1.3, 6.7, and 6.8.

HVAC systems only serving the heating, cooling, or ventilating needs of a *computer room* with IT *equipment* load greater than 10 kW shall comply with ASHRAE Standard 90.4, *Energy Standard for Data Centers*.

<u>6.6.1.1</u>6.6.2.1

The *computer room PUE1* shall be less than or equal to the values listed in Table 6.6.1. Hourly simulation of the *proposed design*, for purposes of calculating *PUE1*, shall be based on the ASHRAE Standard 90.1 Appendix G simulation methodology.

Exception to 6.6.1.1

This compliance path is not allowed for a *computer room proposed design* utilizing a combined heat and power *system*.

Climate Zone	PUE ^a
0A	1.64
0B	1.62
1A	1.61
1B	1.53
2A	1.49
2B	1.45
3A	1.41
3B	1.42
3C	1.39
4A	1.36
4B	1.38
4C	1.38
5A	1.36
5B	1.33
5C	1.36
6A	1.34
6B	1.33
7	1.32
8	1.30

Table 6.6.1 Power Usage Effectiveness (PUE) Maximum

a. *PUE0* and *PUE1* shall not include *energy* for battery charging.

<u>6.6.1.2</u>6.6.2.2

The *computer room PUE0* is less than or equal to the values listed in Table 6.6.1, shall be the highest value determined at outdoor *cooling design temperatures*, and shall be limited to *systems* only using electricity for an *energy* source. *PUE0* shall be calculated for two conditions: 100% design *IT equipment energy* and 50% design *IT equipment energy*.

<u>6.6.1.3</u>6.6.2.3

Documentation shall be provided, including a breakdown of *energy* consumption or *demand* by at least the following components: IT *equipment*, power distribution losses external to the IT *equipment*, *HVAC* systems, and lighting.

6.7 Submittals

6.7.1 General

The *authority having jurisdiction* may require submittal of compliance documentation and supplemental information in accordance with Section 4.2.2 of this standard.

6.7.2 Completion Requirements

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

6.7.2.1 Drawings

Construction documents shall require that, within 90 days after the date of *system* acceptance, *record* drawings of the actual installation be provided to the *building* owner or the designated representative of the *building* owner. *Record drawings* shall include, as a minimum, the location and performance data on each piece of *equipment*; general configuration of the duct and pipe *distribution system*, including sizes; and the *terminal* air or water design flow rates.

6.7.2.2 Manuals

Construction documents shall require that an operating manual and a maintenance manual be provided to the *building* owner or the designated representative of the *building* owner within 90 days after the date

of *system* acceptance. These manuals shall be in accordance with industry-accepted standards (see Informative Appendix E) and shall include, at a minimum, the following:

- a. Submittal data stating *equipment* size and selected options for each piece of *equipment* requiring maintenance.
- b. Operation manuals and maintenance manuals for each piece of *equipment* and *system* requiring maintenance, except *equipment* not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
- c. Names and addresses of at least one *service agency*.
- d. HVAC *controls system* maintenance and calibration information, including wiring diagrams, schematics, and *control* sequence descriptions. Desired or field-determined *set points* shall be permanently recorded on *control* drawings at *control devices* or, for digital *control systems*, in programming comments.
- e. A complete narrative of how each system is intended to operate, including suggested set points.

6.7.2.3 System Balancing

6.7.2.3.1 General

Construction documents shall require that all *HVAC systems* be balanced in accordance with *generally accepted engineering standards* (see Informative Appendix E). *Construction documents* shall require that a written balance report be provided to the *building* owner or the designated representative of the *building* owner for *HVAC systems* serving zones with a total conditioned area exceeding 5000 ft².

6.7.2.3.2 Air System Balancing

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

6.7.2.3.3 Hydronic System Balancing

Hydronic *systems* shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions.

Exceptions to 6.7.2.3.3

Impellers need not be trimmed nor pump speed adjusted

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

6.7.2.4 System Commissioning

HVAC *control systems* shall be tested to ensure that *control* elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft² conditioned area, except warehouses and *semiheated spaces*, detailed instructions for commissioning *HVAC systems* (see Informative Appendix E) shall be provided by the designer in plans and specifications.

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 [I-P]

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure ^a
Air conditioners, air	<65,000 Btu/h ^b	All	Split system, three phase	13.0 SEER	AHRI 210/240
cooled			Single package, three	14 SEER	
			phase		

		Heating	Subcategory or	Minimum	
Equipment Type	Size Category	Section Type	Rating Condition	Efficiency	Test Procedure ^a
Through the <i>wall</i> , air	≤30,000 Btu/h ^b	All	Split system, three phase	12.0 SEER	AHRI 210/240
cooled			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 conditioners, air cooled	≥65,000 Btu/h and <135,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)	Split system and single package	11.2 EER 12.9 IEER	AHRI 340/360
		All other		11.0 EER 12.7 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		11.0 EER 12.4 IEER	
		All other		10.8 EER 12.2 IEER	
	≥240,000 Btu/h and <760,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		10.0 EER 11.6 IEER	
		All other		9.8 EER 11.4 IEER	
	≥760,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		9.7 EER 11.2 IEER	
		All other		9.5 EER 11.0 IEER	
Air conditioners, water cooled	<65,000 Btu/h	All	Split <i>system</i> and single package	12.1 EER 12.3 IEER	AHRI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	<i>Electric</i> <i>resistance</i> (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	<i>Electric</i> <i>resistance</i> (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	<i>Electric</i> <i>resistance</i> (or none)		12.4 EER 13.6 IEER	
		All other		12.2 EER 13.4 IEER	
	≥760,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		12.2 EER 13.5 IEER	
		All other		12.1 EER 13.3 IEER	
Air conditioners, evaporatively cooled	<65,000 Btu/h ^b	All	Split <i>system</i> and single package	12.1 EER 12.3 IEER	AHRI 210/240

Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements [I-P]

<i>Equipment</i> Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum <i>Efficiency</i>	Test Procedure ^a
	≥65,000 Btu/h and <135,000 Btu/h	<i>Electric</i> <i>resistance</i> (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	<i>Electric</i> <i>resistance</i> (or none)		12.0 EER 12.2 IEER	
		All other		11.8 EER 12.0 IEER	
	≥240,000 Btu/h and <760,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		11.9 EER 12.1 IEER	
		All other		11.7 EER 11.9 IEER	
	≥760,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		11.7 EER 11.9 IEER	
		All other		11.5 EER 11.7 IEER	
<i>Condensing units</i> , 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

Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements [I-P]

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.

<i>Equipment</i> Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum <i>Efficiency</i>	Test Procedure ^a
Air cooled (cooling mode)	<65,000 Btu/h ^b	All	Split system, three phase and applications outside US single phase ^b	14 <u>.0</u> SEER before 1/1/2023 14.3 SEER2 after 1/1/2023	AHRI 210/240 <u>-</u> 2017 before <u>1/1/2023</u> AHRI 210/240-
			Single package, three phase_and applications outside US single phase ^b	14 <u>.0</u> SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	<u>2023 after</u> <u>1/1/2023</u>
Through the wall,Space constrained, air cooled (cooling	\leq 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 <u>-</u> 2017 before <u>1/1/2023</u> AHRI 210/240-
mode)			Single package, three phase <u>and applications</u> <u>outside US single</u> <u>phase^b</u>	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	<u>2023 after</u> <u>1/1/2023</u>
Small duct, high velocity, air cooled (cooling mode)	<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 <u>-</u> 2017 before 1/1/2023 AHRI 210/240- 2023 after 1/1/2023
Air cooled (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)	Split system and single package	11.0 EER 12.2 IEER before 1/1/2023 14.1 IEER after 1/1/2023	AHRI 340/360
		All other		10.8 EER 12.0 IEER before 1/1/2023 13.9 IEER after 1/1/2023	
	≥135,000 Btu/h and <240,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		10.6 EER 11.6 IEER before 1/1/2023 13.5 IEER after 1/1/2023	
		All other		10.4 EER 11.4 IEER before 1/1/2023 13.3 IEER after 1/1/2023	
	≥240,000 Btu/h	<i>Electric</i> <i>resistance</i> (or none)		9.5 EER 10.6 IEER before 1/1/2023 12.5 IEER after 1/1/2023	

Table 6.8.1-2 Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements [I-P]

<i>Equipment</i> Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum <i>Efficiency</i>	Test Procedure ^a
		All other		9.3 EER 10.4 IEER before 1/1/2023 12.3 IEER after 1/1/2023	
Water to air, water loop (cooling mode)	<17,000 Btu/h ≥17,000 Btu/h and <65,000 Btu/h ≥65,000 Btu/h and <135,000 Btu/h	All	86°F entering water	12.2-EER 13.0-EER 13.0-EER	ISO 13256-1
Water to air, groundwater (cooling mode)	<135,000 Btu/h	All	59°F entering water	18 EER	ISO 13256-1
Brine to air, ground loop (cooling mode)	<135,000 Btu/h	All	77°F entering water	14.1 <i>EER</i>	ISO 13256-1
Water to water, water loop (cooling mode)	<135,000 Btu/h	All	86°F entering water	10.6 <i>EER</i>	ISO 13256-2
Water to water, groundwater (cooling mode)	<135,000 Btu/h	All	59°F entering water	16.3 <i>EER</i>	ISO 13256-2
Brine to water, ground loop (cooling mode)	<135,000 Btu/h	All	77°F entering water	12.1 <i>EER</i>	ISO 13256-2
Air cooled (heating mode)	<65,000 Btu/h ^b		Split system, three phase and applications outside US single phase ^b	8.2 <i>HSPF</i> <u>before</u> <u>1/1/2023</u> <u>7.5 <i>HSPF2</i> after</u> <u>1/1/2023</u>	AHRI 210/240 <u>-</u> 2017 before <u>1/1/2023</u> AHRI 210/240-
			Single package, three phase_and applications outside US single phase ^b	8.0 <i>HSPF</i> before <u>1/1/2023</u> <u>6.7 <i>HSPF2</i> after</u> <u>1/1/2023</u>	2023 after 1/1/2023
Through the <i>wall</i> , Space constrained, air cooled (heating mode)	≤30,000 Btu/h ^b (cooling capacity)		Split system, three phase and applications outside US single phase ^b	7.4 <i>HSPF</i> before <u>1/1/2023</u> <u>6.3 <i>HSPF2</i> after</u> <u>1/1/2023</u>	AHRI 210/240 <u>-</u> 2017 before <u>1/1/2023</u> AHRI 210/240-
			Single package, three phase <u>and applications</u> <u>outside US single</u> <u>phase^b</u>	7.4 <i>HSPF</i> before <u>1/1/2023</u> <u>6.3 <i>HSPF2</i> after</u> <u>1/1/2023</u>	<u>2023 after</u> <u>1/1/2023</u>
Small duct high velocity, air cooled (heating mode)	<65,000 Btu/h ^b		Split system, three phase and applications outside US single phase ^b	6.8-7.2 HSPF before 1/1/2023 6.1 HSPF2 after 1/1/2023	AHRI 210/240 <u>-</u> 2017 before 1/1/2023 AHRI 210/240- 2023 after 1/1/2023

Table 6.8.1-2 Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements [I-P]

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum <i>Efficiency</i>	Test Procedure ^a
Air cooled (heating mode)	≥65,000 Btu/h ^c and <135,000 Btu/h (cooling capacity)		47°F db/43°F wb outdoor air	3.3 <u>0</u> COP _H before 1/1/2023 <u>3.40 COP_H</u> before 1/1/2023	AHRI 340/360
			17°F db/15°F wb outdoor air	2.25 <i>COP_H</i>	
	≥135,000 Btu/h ^c (cooling capacity) <u>and <240,000</u> <u>Btu/h^c</u>		47°F db/43°F wb outdoor air	3.2 <u>0</u> COP _H before 1/1/2023 <u>3.30 COP_H</u> before 1/1/2023	
			17°F db/15°F wb outdoor air	2.05 <i>COP_H</i>	
Water to air, water loop (heating mode)	<135,000 Btu/h (cooling capacity)		68°F entering water	4 .3 <i>COP</i> <i></i>	ISO 13256-1
Water to air, groundwater (heating mode)	< 135,000 Btu/h (cooling capacity)		50°F entering water	3.7 <i>СОР</i>Н	ISO 13256-1
Brine to air, ground loop (heating mode)	<135,000 Btu/h (cooling capacity)		32°F entering fluid	3.2 <i>COP</i>⊬	ISO 13256-1
Water to water, water loop (heating mode)	<135,000 Btu/h (cooling capacity)		68°F entering water	3.7 СОР н	ISO 13256-2
Water to water, groundwater (heating mode)	< 135,000 Btu/h (cooling capacity)		50°F entering water	3.1 <i>COPH</i>	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

Table 6.8.1-2 Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements [I-P]

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 as consumer products by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430. SEER, SEER2, and HSPF2 and HSPF2 values for single-phase products are set by the U.S. Department of Energy.</p>

Informative Note: See Informative Appendix F for the U.S. Department of Energy minimum for US applications.

Equipment Type	Size Category	Units	Path A	Path B	Test Procedure ^c
Air-cooled chillers	<150 tons	EER	≥10.100 FL	≥9.700 FL	AHRI 550/590
		(Btu/Wh)	≥13.700 <i>IPLV</i> .IP	≥15.800 <i>IPLV</i> .IP	
	≥ 150 tons		≥10.100 FL	≥9.700 FL	
			≥14.000 <i>IPLV</i> .IP	≥16.100 <i>IPLV</i> .IP	
Air-cooled without condenser, electrically operated	All capacities	EER (Btu/Wh)	Air-cooled chillers wit rated with matching co with air-cooled chiller	AHRI 550/590	
Water-cooled,	<75 tons	kW/ton	≤0.750 FL	≤0.780 FL	AHRI 550/590
electrically operated			≤0.600 <i>IPLV</i> .IP	≤0.500 <i>IPLV</i> .IP	
positive displacement	\geq 75 tons and		≤0.720 FL	≤0.750 FL	
	<150 tons		≤0.560 <i>IPLV</i> .IP	≤0.490 <i>IPLV</i> .IP	
	≥ 150 tons and		≤0.660 FL	≤0.680 FL	
	<300 tons		≤0.540 <i>IPLV</i> .IP	≤0.440 <i>IPLV</i> .IP	
	\geq 300 tons and		≤0.610 FL	≤0.625 FL	
	<600 tons		≤0.520 <i>IPLV</i> .IP	≤0.410 <i>IPLV</i> .IP	
	≥600 tons		≤0.560 FL	≤0.585 FL	-
			≤0.500 <i>IPLV</i> .IP	≤0.380 <i>IPLV</i> .IP	
Water-cooled, electrically operated	<150 tons	kW/ton	≤0.610 FL	≤0.695 FL	AHRI 550/590
			≤0.550 <i>IPLV</i> .IP	≤0.440 <i>IPLV</i> .IP	
centrifugal	≥ 150 tons and		≤0.610 FL	≤0.635 FL	
	<300 tons		≤0.550 <i>IPLV</i> .IP	≤0.400 <i>IPLV</i> .IP	
	\geq 300 tons and		≤0.560 FL	≤0.595 FL	
	<400 tons		≤0.520 <i>IPLV</i> .IP	≤0.390 <i>IPLV</i> .IP	-
	≥400 tons and <600 tons ≥600 tons		≤0.560 FL	≤0.585 FL	
			≤0.500 <i>IPLV</i> .IP	≤0.380 <i>IPLV</i> .IP	
			≤0.560 FL	≤0.585 FL	
			≤0.500 <i>IPLV</i> .IP	≤0.380 <i>IPLV</i> .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	All capacities	COP (W/W)	≥1.000 FL	NA ^d	AHRI 560
effect, indirect fired			≥1.050 <i>IPLV</i> .IP	<u>] </u>	
Absorption double	All capacities	COP	≥1.000 FL	NA ^d	AHRI 560
effect, direct fired		(W/W)	≥1.000 <i>IPLV</i> .IP		

Table 6.8.1-3	Water-Chilling Packages_	–Minimum <i>Efficienc</i> y	Requirements ^{a,b,e}	[I- P]
1 able 0.0.1-5	Water-Chinning Lackages-	-winning Ejjiciency	Requirements	[1-1]

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 Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps — Minimum Efficiency Requirements [I-P]

<i>Equipment</i> Type	Size Category (Input)	Subcategory or Rating Condition	Minimum <i>Efficiency</i>	Test Procedure ^a
PTAC (cooling mode) standard size	All capacities	9 5°F db <i>outdoor air</i>	$\frac{13.8 - (0.300 \times \text{Cap}/1000)^{\text{e}}}{(\text{before } 1/1/2015)}$ $\frac{14.0 - (0.300 \times \text{Cap}/1000)^{\text{e}}}{(\text{as of } 1/1/2015)}$	AHRI 310/380
PTAC (cooling mode) nonstandard size ^a	All capacities	95°F db <i>outdoor air</i>	$\frac{10.9 (0.213 \times Cap/1000)^{e}}{EER}$	AHRI 310/380
PTHP (cooling mode) standard size	All capacities	95°F db <i>outdoor air</i>	14.0 (0.300 × Cap/1000) ^e	AHRI 310/380
PTHP (cooling mode) nonstandard size ^b	All capacities	95°F db <i>outdoor air</i>	$\frac{10.8 - (0.213 \times \text{Cap}/1000)^{\text{e}}}{\text{EER}}$	AHRI 310/380
PTHP (heating mode) standard size	All capacities		3.7 (0.052 × Сар/1000) е СОР н	AHRI 310/380
PTHP (heating mode) nonstandard size ^b	All capacities		$\frac{2.9 - (0.026 \times \text{Cap}/1000)^{e}}{COP_{\mu}}$	AHRI 310/380
SPVAC (cooling mode)	<65.000 Btu/h	95°F db/75°F wb	10.0 EER	AHRI 390
	≥65,000 Btu/h and <135,000 Btu/h	outdoor air	10.0 <i>EER</i>	
	≥135,000 Btu/h and <240,000 Btu/h		10.0 <i>EER</i>	
SPVHP (cooling mode)	<65,000 Btu/h	95°F db/75°F wb <i>outdoor air</i>	10.0 <i>EER</i>	AHRI 390
	≥65,000 Btu/h and <135,000 Btu/h		10.0 <i>EER</i>	
	≥135,000 Btu/h and <240,000 Btu/h		10.0 <i>EER</i>	
SPVHP (heating mode)	<65,000 Btu/h	47°F db/43°F wb	3.0 COP _H	AHRI 390
	≥ 65,000 Btu/h and <135,000 Btu/h	outdoor air	3.0 <i>COP</i> _H	
	≥ 135,000 Btu/h and <240,000 Btu/h		3.0 <i>CO</i>₽ ₩	
Room air conditioners with	<6000 Btu/h		9.7 SEER	ANSI/AHAM
louvered sides	<u>≥6000 Btu/h and</u> <8000 Btu/h		9.7 SEER	RAC-1
	<u>≥8000 Btu/h and</u> <14,000 Btu/h		9.8 SEER	
	≥14,000 Btu/h and <20,000 Btu/h	-	9.7 SEER	
	<u>≥20,000 Btu/h</u>	7	8.5 SEER	
SPVAC (cooling mode),	<u>≤30,000 Btu/h</u>	95°F db/75°F wb	9.2 EER	AHRI 390
nonweatherized space constrained	>30,000 Btu/h and ≤36,000 Btu/h	outdoor air	9.0 <i>EER</i>	
SPVHP (cooling mode),	<u>≤30,000 Btu/h</u>	95°F db/75°F wb	9.2 EER	AHRI 390
nonweatherized space constrained	>30,000 Btu/h and ≤36,000 Btu/h	outdoor air	9.0 <i>EER</i>	

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 [I-P]

<i>Equipment</i> Type	Size Category (Input)	Subcategory or Rating Condition	Minimum <i>Efficiency</i>	Test Procedure ^a	
SPVHP (heating mode),	≤30,000 Btu/h	47°F db/43°F wb	3.0 COP _H	AHRI 390	
nonweatherized space constrained	>30,000 Btu/h and ≤36,000 Btu/h	outdoor air	3.0 <i>COP</i> _H		
Room air conditioners	<8000 Btu/h		9.0 <i>EER</i>	ANSI/AHAM	
without louvered sides	<u>≥8000 Btu/h and</u> <20,000 Btu/h		8.5 <i>EER</i>	RAC-1	
	<u>≥20,000 Btu/h</u>		8.5 EER		
Room air conditioner heat	<20,000 Btu/h		9.0 <i>EER</i>	ANSI/AHAM	
pumps with louvered sides	<u>≥20,000 Btu/h</u>		8.5 <i>EER</i>	RAC-1	
Room air conditioner heat	<14,000 Btu/h		8.5 <i>EER</i>	ANSI/AHAM	
pumps without louvered sides	<u>≥14,000 Btu/h</u>		8.0 <i>EER</i>	KAC-I	
<i>Room air conditioner</i> , casement only	All capacities		8.7 <i>EER</i>	ANSI/AHAM RAC-1	
<i>Room air conditioner</i> , 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.

e. "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 6.8.1-4 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 [I-P]

<u>Equipment Type</u>	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency ^d	Test Procedure ^a
PTAC (cooling mode)	<7,000 Btu/h	95°F db/75°F wb	<u>11.9 EER</u>	AHRI 310/380
standard size	<u>≥7,000 Btu/h and</u> ≤15,000 Btu/h	outdoor air ^c	$14.0 - (0.300 \times \text{Cap}/1000) \text{ EER}$	
	>15,000 Btu/h		<u>9.50 EER</u>	
PTAC (cooling mode)	<7,000 Btu/h	95°F db/75°F wb	<u>9.40 EER</u>	AHRI 310/380
nonstandard size ^a	≥7,000 Btu/h and ≤15,000 Btu/h	outdoor air ^c	$10.9 - (0.213 \times \text{Cap}/1000) \text{ EER}$	
	>15,000 Btu/h		<u>7.70 EER</u>	
PTHP (cooling mode)	<7,000 Btu/h	95°F db/75°F wb	11.9 EER	AHRI 310/380
standard size	<u>≥7,000 Btu/h and</u> ≤15,000 Btu/h	<u>outdoor air^c</u>	$14.0 - (0.300 \times Cap/1000) EER$	
	>15,000 Btu/h		9.50 EER	
PTHP (cooling mode)	<7,000 Btu/h	95°F db/75°F wb	9.30 EER	AHRI 310/380
nonstandard size ^b	<u>≥7,000 Btu/h and</u> ≤15,000 Btu/h	outdoor air ^c	$10.8 - (0.213 \times Cap/1000) EER$	
	>15,000 Btu/h		7.60 EER	
PTHP (heating mode)	<7,000 Btu/h	47°F db/43°F wb	3.30 <i>COP</i> _H	AHRI 310/380
standard size	<u>≥7,000 Btu/h and</u> ≤15,000 Btu/h	outdoor air ^c	$\frac{3.7 - (0.052 \times \text{Cap}/1000)^{\text{c}} COP_{H}}{2}$	
	>15,000 Btu/h		2.90 СОРн	
<i>PTHP</i> (heating mode)	<7,000 Btu/h	47°F db/43°F wb	2.70 <i>COP</i> _H	AHRI 310/380
nonstandard size ^b	≥7,000 Btu/h and <15,000 Btu/h	outdoor air ^c	$2.9 - (0.026 \times \text{Cap}/1000)^{\circ} COP_{H}$	-
	>15.000 Btu/h		2.50 COP _H	
SPVAC (cooling mode)	<65.000 Btu/h	95°F db/75°F wb	11.0 EER	AHRI 390
single and 3 phase	<u>>65,000 Btu/h and</u> <135,000 Btu/h	outdoor air ^c	<u>10.0 EER</u>	
	≥135,000 Btu/h and <240,000 Btu/h	•	<u>10.0 EER</u>	-
SPVHP (cooling mode)	<65.000 Btu/h	95°F db/75°F wb	11.0 <i>EER</i>	AHRI 390
<u></u>	≥65,000 Btu/h and <135,000 Btu/h	outdoor air ^c	<u>10.0 EER</u>	
	>135,000 Btu/h and		10.0 <i>EER</i>	
	<240,000 Btu/h			
SPVHP (heating mode)	<u><65,000 Btu/h</u>	$47^{\circ}F db/43^{\circ}F wb$	<u>3.30 COP_H</u>	<u>AHRI 390</u>
	<u>≥65,000 Btu/h and</u> <135,000 Btu/h	outdoor air ^c	<u>3.00 COP_H</u>	
	≥135,000 Btu/h and <240,000 Btu/h		<u>3.00 COP_H</u>	
Room air conditioners	<6000 Btu/h		11.0 CEER	ANSI/AHAM
without reverse cycle with louvered sides for	≥6000 Btu/h and <8000 Btu/h		<u>11.0 CEER</u>	<u>RAC-1</u>
sale outside US ^d	≥8000 Btu/h and <14,000 Btu/h		<u>10.9 CEER</u>	

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 [I-P]

<i>Equipment</i> Type	Size Category (Input)	Subcategory or Rating Condition	Minimum <i>Efficiency</i> ^d	Test Procedure ^a
	≥14,000 Btu/h and <20,000 Btu/h		<u>10.7 CEER</u>	
	<u>>20,000 Btu/h and</u> <28,000 Btu/h		<u>9.4 CEER</u>	-
	≥28,000 Btu/h		<u>9.0 CEER</u>	
Room air conditioners	<u><6000 Btu/h</u>		<u>10.0 CEER</u>	ANSI/AHAM
without louvered sides	<u>≥6000 Btu/h and</u> <8000 Btu/h		<u>10.0 CEER</u>	<u>RAC-1</u>
	<u>≥8,000 Btu/h and</u> <11,000 Btu/h		<u>9.6 CEER</u>	
	<u>≥11,000 Btu/h and</u> <14,000 Btu/h		<u>9.5 CEER</u>	
	≥14,000 Btu/h and <20,000 Btu/h		<u>9.3 CEER</u>	
	≥20,000 Btu/h		<u>9.4 CEER</u>	
Room air conditioners	<20,000 Btu/h		<u>9.8 CEER</u>	ANSI/AHAM
with reverse cycle, with	<u>≥20,000 Btu/h</u>		<u>9.3 CEER</u>	<u>RAC-1</u>
louvered sides for sale outside US ^d				
<u>Room air conditioners</u>	<u><14,000 Btu/h</u>		<u>9.3 CEER</u>	ANSI/AHAM
with reverse cycle without louvered sides for sale outside US ^d	<u>≥14,000 Btu/h</u>		<u>8.7 CEER</u>	<u>RAC-1</u>
Room air conditioners, casement only for sale outside US ^d	All		<u>9.5 CEER</u>	ANSI/AHAM RAC-1
<u>Room air conditioners,</u> casement slider for sale outside US ^d	All		<u>10.4 CEER</u>	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 <u>670 in.²</u>.

c. The cooling-mode wet bulb temperature requirement only applies for units that reject condensate to the condenser coil.

d. Room air conditioners are regulated as consumer products by the US Department of Energy at 10 CFR 430. For US sales of room air conditioners, refer to Informative Appendix F, Table F-3, for the U.S. Department of Energy minimum efficiency requirements.

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 [I-P]

<i>Equipment</i> Type	Size Category (Input)	Subcategory or Rating Condition	Minimum <i>Efficiency</i>	Test Procedure ^a
Warm-air furnace, gas fired <u>for application</u> <u>outside the US^g</u>	<225,000 Btu/h	Maximum capacity ^c	$\frac{7880\% AFUE (non-weatherized) or 81\%}{AFUE (weatherized) or80\% Etb,d}$	DOE-10 CFR Part 430 Appendix N or Section 2.39, Thermal <i>Efficiency</i> , ANSI Z21.47
Warm-air furnace, gas fired	≥225,000 Btu/h	Maximum capacity ^c	$\frac{80\% E_{t}^{b.d} \text{ before}}{\frac{1/1/2023}{81\% E_{t}^{d}} \text{ after } 1/1/2023}$	DOE 10 CFR Part 430 or Section 2.39, Thermal <i>Efficiency</i> , ANSI Z21.47
Warm-air furnace, oil fired for application outside the US ^g	<225,000 Btu/h	Maximum capacity ^c	$\frac{7883\% AFUE (non-weatherized) or 78\%}{AFUE (weatherized) or 78\%}$ $\frac{AFUE (weatherized) or}{80\% E_t^{b,d}}$	DOE-10 CFR Part 430 Appendix N or Section 42, Combustion, UL 727
Warm-air furnace, oil fired	≥225,000 Btu/h	Maximum capacity ^c	$\frac{80\% E_t^{d} \underline{before}}{\frac{1/1/2023}{82\% E_t^{d}} after \frac{1}{1/2023}}$	Section 42, Combustion, UL 727
Electric Furnaces for applications outside the US ^g	<u><225,000 Btu/h</u>	All	$\frac{96\% \ AFUE}{P_{W,SB} \le 10 \ W}$ $\frac{P_{W,OFF} \le 10 \ W}{P_{W,OFF} \le 10 \ W}$	10 CFR 430 Appendix N
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity ^c	80% E_c^{e}	Section 2.10, <i>Efficiency</i> , ANSI Z83.3
Warm-air unit heaters, gas fired	All capacities	Maximum capacity ^c	$80\% E_c^{e,f}$	Section 2.10, <i>Efficiency</i> , ANSI Z83.3
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.Combination units (i.e., furnaces contained within the same cabinet as an air conditioner) not covered by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430 (i.e. three-phase power or with cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating. All other units <225 kBtu/h sold in the US must meet the AFUE standards for consumer products and test using DOE's AFUE test procedure at 10 CFR 430, Subpart B, Appendix N.</p>

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, uUnits must also include an interrupted or intermittent ignition device (IID) and have either power venting or an *automatic flue damper*.

g. For US applications of federal covered <225,000 Btu/h products see Informative Appendix F, Table F-4.

<i>Equipment</i> Type ^a	Subcategory or Rating Condition	Size Category (Input)	Minimum <i>Efficiencyⁱ</i>	<i>Efficiency</i> as of 3/2/ 2020 2022	Test Procedure
<i>Boilers</i> , hot water	Gas fired	<300,000 Btu/h ^{f,g} for applications outside <u>USⁱ</u>	82% AFUE	82% AFUE	10 CFR Part 430 Appendix N
		≥300,000 Btu/h and ≤2,500,000 Btu/h ^d	$80\% E_{t}^{c}$	$80\% E_t^{\odot}$	10 CFR Part 431 <u>.86</u>
		>2,500,000 Btu/h ^a	82% $E_c^{\underline{b}}$	82% $E_c^{\underline{b}}$	
	Oil fired ^e	<300,000 Btu/h ^{f.g} for applications outside <u>USⁱ</u>	84% <i>AFUE</i>	84% AFUE	10 CFR Part 4 30 <u>Appendix N</u>
		≥300,000 Btu/h and ≤2,500,000 Btu/h ^d	82% E ^c	82% E ^c	10 CFR Part 431 <u>.86</u>
		>2,500,000 Btu/h ^a	84% $E_c^{\underline{b}}$	84% $E_c^{\underline{b}}$	
Boilers, steam	Gas fired	<300,000 Btu/h ^f for applications outside <u>USⁱ</u>	80% AFUE	80% AFUE	10 CFR Part 4 30 <u>Appendix N</u>
	Gas fired—all, except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h ^d	79% E ^c	79% E ^c	10 CFR Part 431 <u>.86</u>
		>2,500,000 Btu/h ^a	79% E_t^{c}	79% E_t^{c}	
	Gas fired—natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h ^d	77% E_t^{c}	79% E_t^{c}	
		>2,500,000 Btu/h ^a	77% E_t^{c}	79% E_t^{c}	
	Oil fired ^e	<300,000 Btu/h ^f for applications outside <u>USⁱ</u>	82% AFUE	82% AFUE	10 CFR Part 4 30 <u>Appendix N</u>
		≥300,000 Btu/h and ≤2,500,000 Btu/h ^d	$81\% E_t^{c}$	$81\% E_t^{c}$	10 CFR Part 431 <u>.86</u>
		>2,500,000 Btu/h ^a	81% E_t^{c}	81% E_t^{c}	

Table 6.8.1-6 Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements [I-P]

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.

h. For new construction, refer to Section 6.4.1.1.1 for additional system compliance requirements. [bp5]

i. See Informative Appendix F, Table F-4 for US minimum efficiencies for residential products covered by DOE requirements for US applications.

	Total System Heat- Rejection Canacity	Subcategory or	Performance	
Equipment Type	at Rated Conditions	Rating Condition ^h	Required ^{a,b,c,f,g}	Test Procedure ^{d,e}
Propeller or axial fan	All	95°F entering water	≥40.2 gpm/hp	CTI ATC-105 and
open-circuit cooling		85°F leaving water		CTI STD-201 RS
towers		75°F entering wb		
Centrifugal fan open-	All	95°F entering water	≥20.0 gpm/hp	CTI ATC-105 and
circuit cooling towers		85°F leaving water		CTI STD-201 RS
Ũ		75°F entering wb		
Propeller or axial fan	All	102°F entering water	≥16.1 gpm/hp	CTI ATC-105S and
closed-circuit cooling		90°F leaving water		CTI STD-201 RS
towers		75°F entering wb		
Centrifugal fan	All	102°F entering water	≥7.0 gpm/hp	CTI ATC-105S and
closed-circuit cooling		90°F leaving water		CTI STD-201 RS
towers		75°F entering wb		
Propeller or axial fan	All	R-507A test fluid	>157.000 Btu/h·hp	CTI ATC-106
evaporative		165°F entering gas temperature	,	
condensers		105°F condensing temperature		
		75°F entering wb		
Propeller or axial fan	All	Ammonia test fluid	≥134,000 Btu/h·hp	CTI ATC-106
evaporative		140°F entering gas temperature	· · ·	
condensers		96.3°F condensing temperature		
		75°F entering wb		
Centrifugal fan	All	R-507A test fluid	≥135,000 Btu/h·hp	CTI ATC-106
evaporative		165°F entering gas temperature		
condensers		105°F condensing temperature		
		75°F entering wb		
Centrifugal fan	All	Ammonia test fluid	≥110,000 Btu/h·hp	CTI ATC-106
evaporative		140°F entering gas temperature	-	
condensers		96.3°F condensing temperature		
		75°F entering wb		
Air cooled condensers	All	125°F condensing temperature	≥176,000 Btu/h·hp	AHRI 460
		190°F entering gas temperature	· ·	
		15°F subcooling		
		95°F entering db		

Table 6.8.1-7 Performance Requirements for Heat Rejection Equipment—Minimum Efficiency Requirements [I-P]

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, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan motor nameplate power.

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-507A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-507A must meet the minimum *efficiency* requirements listed above with R-507A as the test fluid.

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 [I-P]

<i>Equipment</i> Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
<i>VRF</i> 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	<i>Electric resistance</i> (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	<i>Electric resistance</i> (or none)	VRF multisplit system	(as of 1/1/2017) 11.0 EER 12.9 IEER (before 1/1/2017) 14.9 IEER (as of 1/1/2017)	
	≥240,000 Btu/h	<i>Electric resistance</i> (or none)	VRF multisplit system	10.0 EER 11.6 IEER (before 1/1/2017) 13.9 IEER (as of 1/1/2017)	

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
<i>VRF</i> air cooled (cooling mode)	<65,000 Btu/h ≥65,000 Btu/h and <135,000 Btu/h	All Electric resistance (or none)	VRF multisplit system	13.0 SEER 11.0 EER 12.9 IEER (before 1/1/2017) 14.6 IEER (as of 1/1/2017)	AHRI 1230
			<i>VRF</i> multisplit <i>system</i> 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)	

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
			<i>VRF</i> 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)	
			<i>VRF</i> multisplit system with heat recovery	9.3 <i>EER</i> 10.8 <i>IEER</i> (before 1/1/2017) 12.5 <i>IEER</i> (as of 1/1/2017)	
<i>VRF</i> water source (cooling mode)	<65,000 Btu/h	All	VRF multisplit system 86°F entering water	12.0 EER 16.0 IEER (as of 1/1/2018)	AHRI 1230
			VRF multisplit system 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 <i>EER</i> 16.0 <i>IEER</i> (as of 1/1/2018)	
			<i>VRF</i> 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 <i>EER</i> 14.0 <i>IEER</i> (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 <i>EER</i> (before 1/1/2018) 12.0 <i>IEER</i> (as of 1/1/2018)	

			Subcategory or		
<i>Equipment</i> Type	Size Category	Heating Section	Rating Condition	Minimum Efficiency	Test Procedure
<u>Iquipmeni Type</u>		- ipe	VRF multisplitsystem with heatrecovery86°F entering	9.8 <i>EER</i> (before 1/1/2018) 11.8 <i>IEER</i> (as of 1/1/2018)	Troccuare
<i>VRF</i> groundwater source (cooling mode)	<135,000 Btu/h	All	waterVRF multisplitsystem with heatrecovery59°F enteringwaterVRF multisplit	16.2 EER 16.0 EER	AHRI 1230
			system with heat recovery 59°F entering water		
	≥135,000 Btu/h		VRF multisplit system with heat recovery 59°F entering water	13.8 EER	
			<i>VRF</i> multisplit system with heat recovery 59°F entering water	13.6 EER	
<i>VRF</i> ground source (cooling mode)	<135,000 Btu/h	All	VRF multisplit system 77°F entering water	13.4 EER	AHRI 1230
			<i>VRF</i> 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	
			<i>VRF</i> multisplit system with heat recovery 59°F entering water	10.8 <i>EER</i>	
<i>VRF</i> 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)		<i>VRF</i> multisplit system 47°F db/43°F wb outdoor air	3.3 <i>COP</i> _H	

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
			<i>VRF</i> multisplit system 17°F db/15°F wb outdoor air	3.25 COP _H	
	≥135,000 Btu/h (cooling capacity)		VRF multisplit system 47°F db/43°F wb	3.2 <i>COP_H</i>	
			VRF multisplit system 17°F db/15°F wb outdoor air	2.05 COP _H	
<i>VRF</i> water source (heating mode)	<65,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	4.2 <i>COP_H</i> (before 1/1/2018) 4.3 <i>COP_H</i> (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 <i>COP_H</i> (before 1/1/2018) 4.3 <i>COP_H</i> (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 <i>COP_H</i> (before 1/1/2018) 4.0 <i>COP_H</i> (as of 1/1/2018)	
	≥240,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	3.9 <i>COP_H</i>	
<i>VRF</i> groundwater source (heating mode)	<135,000 Btu/h (cooling capacity)		VRF multisplit system 50°F entering water	3.6 <i>COP_H</i>	AHRI 1230
	≥135,000 Btu/h (cooling capacity)		VRF multisplit system 50°F entering water	3.3 <i>COP_H</i>	
<i>VRF</i> ground source (heating mode)	<135,000 Btu/h (cooling capacity)		VRF multisplit system 32°F entering water	3.1 <i>COP</i> _H	AHRI 1230
	≥135,000 Btu/h (cooling capacity)		VRF multisplit system 32°F entering water	2.8 <i>COP_H</i>	

			Minimum Net Sensible <i>COP</i> _C			
			Return Air I Dew-Point T	Dry-Bulb Tem Temperature	perature/	
			Class 1 Class 2		Class 3	
<i>Equipment</i> 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 Btu/h and	Downflow unit		2.20		
	<240,000 Btu/h	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	<65,000 Btu/h	Downflow unit		2.50		AHRI 1360
cooled	,	Upflow unit—ducted		2.40		
		Upflow unit—nonducted	2.25			
		Horizontal-flow unit			2.70	
	≥65,000 Btu/h 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	<65,000 Btu/h	Downflow unit		2.45		AHRI 1360
cooled with	,	Upflow unit—ducted		2.25		
fluid		Upflow unit—nonducted	2.20			
economizer		Horizontal-flow unit			2.60	
	≥65,000 Btu/h and	Downflow unit		2.35		
	<240,000 Btu/h	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	2.05		-
		Horizontal-flow unit			2.40	1
Glycol	<65.000 Btu/h	Downflow unit		2.30		AHRI 1360
cooled	35,000 D tu/II	Upflow unit_ducted		2.10		
		Upflow unit—nonducted	2.00			1
		Horizontal-flow unit			2.40	1

Table 6.8.1-11 Air Conditioners and Condensing Units Serving Computer Rooms—Minimum Efficiency Requirements [I-P]

			Minimum Net Sensible COPcReturn Air Dry-Bulb Temperature/Dew-Point Temperature			
			Class 1	Class 2	Class 3	
Equipment	Net Sensible					
Туре	Cooling Capacity	Standard Model	75°F/52°F	85°F/52°F	95°F/52°F	Test Procedure
	\geq 65,000 Btu/h and	Downflow unit		2.05		
	<240,000 Btu/h	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	<65,000 Btu/h	Downflow unit		2.25		AHRI 1360
cooled with		Upflow unit-ducted		2.10		
fluid		Upflow unit-nonducted	2.00			
economizer		Horizontal-flow unit			2.35	
	≥65,000 Btu/h and	Downflow unit		1.95		
	<240,000 Btu/h	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 6.8.1-11 Air Conditioners and Condensing Units Serving Computer Rooms—Minimum Efficiency Requirements [I-P]

Table 6.8.1-11 Floor Mounted Air Conditioners and Condensing Units Serving Computer Rooms— Minimum Efficiency Requirements [I-P]

<i>Equipment</i> Type	Standard Model	Net Sensible Cooling Capacity	Minimum Net Sensible <i>COP</i>	Rating Conditions Return air (dry bulb/dew point)	Test Procedure
Air cooled	Downflow	<80,000 Btu/h	2.70	85°F/52°F (Class 2)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.58		
		≥295,000 Btu/h	2.36		
	Upflow -	<80,000 Btu/h	2.67		
	Ducted	≥80,000 Btu/h and <295,000 Btu/h	2.55		
		≥295,000 Btu/h	2.33		
	Upflow –	<65,000 Btu/h	2.16	75°F/52°F (Class 1)	
	Nonducted	≥65,000 Btu/h and <240,000 Btu/h	2.04		
		≥240,000 Btu/h	1.89		
	Horizontal	<65,000 Btu/h	2.65	95°F/52°F (Class 3)	

<i>Fauinment</i> Type	Standard Model	Net Sensible Cooling	Minimum Net Sensible COP	Rating Conditions Return air (dry bulb/dew point)	Test Procedure
	mouch	≥65,000 Btu/h and <240,000 Btu/h	2.55		
		≥240,000 Btu/h	2.47		
Air Cooled with Fluid	Downflow	<80,000 Btu/h	2.70	85°F/52°F (Class 1)	AHRI 1360
Economizer		≥80,000 Btu/h and <295,000 Btu/h	2.58		
		≥295,000 Btu/h	2.36		
	Upflow –	<80,000 Btu/h	2.67		
	Ducted	≥80,000 Btu/h and <295,000 Btu/h	2.55		
		≥295,000 Btu/h	2.33		
	Upflow -	<65,000 Btu/h	2.09	75°F/52°F (Class 1)	
	Nonducted	≥65,000 Btu/h and <240,000 Btu/h	1.99		
		≥240,000 Btu/h	1.81		
	Horizontal	<65,000 Btu/h	2.65	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.55		
		≥240,000 Btu/h	2.47		
Air Cooled with Fluid	Downflow	<80,000 Btu/h	2.82	85°F/52°F (Class 1)	AHRI 1360
Economizer		≥80,000 Btu/h and <295,000 Btu/h	2.73		
		≥295,000 Btu/h	2.67		
	Upflow –	<80,000 Btu/h	2.79		
	Ducted	≥80,000 Btu/h and <295,000 Btu/h	2.70		
		≥295,000 Btu/h	2.64		
	Upflow -	<65,000 Btu/h	2.43	75°F/52°F (Class 1)	
	Nonducted	≥65,000 Btu/h and <240,000 Btu/h	2.32		
		≥240,000 Btu/h	2.20		
	Horizontal	<65,000 Btu/h	2.79	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.68		
		≥240,000 Btu/h	2.60		
Water Cooled with Fluid	Downflow	<80,000 Btu/h	2.77	85°F/52°F (Class 1)	AHRI 1360
Economizer		≥80,000 Btu/h and <295,000 Btu/h	2.68		
		≥295,000 Btu/h	2.61		
	Upflow –	<80,000 Btu/h	2.74		
	Ducted	≥80,000 Btu/h and <295,000 Btu/h	2.65		
		≥295,000 Btu/h	2.58		
	Upflow -	<65,000 Btu/h	2.35	75°F/52°F (Class 1)	

Table 6.8.1-11 Floor Mounted Air Conditioners and Condensing Units Serving Computer Rooms— Minimum Efficiency Requirements [I-P]

<i>Equipment</i> Type	Standard Model	Net Sensible Cooling Capacity	Minimum Net Sensible <i>COP</i>	Rating Conditions Return air (dry bulb/dew point)	Test Procedure
	Nonducted	≥65,000 Btu/h and <240,000 Btu/h	2.24		
		≥240,000 Btu/h	2.12		
	Horizontal	<65,000 Btu/h	2.71	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.60		
		≥240,000 Btu/h	2.54		
Glycol cooled	Downflow	<80,000 Btu/h	2.56	85°F/52°F (Class 1)	AHRI 1360
		≥80,000 Btu/h and <295,000 Btu/h	2.24		
		≥295,000 Btu/h	2.21		
	Upflow –	<80,000 Btu/h	2.53		
	Ducted	≥80,000 Btu/h and <295,000 Btu/h	2.21		
		≥295,000 Btu/h	2.18		
	Upflow -	<65,000 Btu/h	2.08	75°F/52°F (Class 1)	
	Nonducted	≥65,000 Btu/h and <240,000 Btu/h	1.90		
		≥240,000 Btu/h	1.81		
	Horizontal	<65,000 Btu/h	2.48	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.18		
		≥240,000 Btu/h	2.18		
Glycol Cooled with Fluid	Downflow	<80,000 Btu/h	2.51	85°F/52°F (Class 1)	AHRI 1360
Economizer		≥80,000 Btu/h and <295,000 Btu/h	2.19		
		≥295,000 Btu/h	2.15		
	Upflow –	<80,000 Btu/h	2.48		
	Ducted	≥80,000 Btu/h and <295,000 Btu/h	2.16		
		≥295,000 Btu/h	2.12		
	Upflow -	<65,000 Btu/h	2.00	75°F/52°F (Class 1)	
	Nonducted	≥65,000 Btu/h and <240,000 Btu/h	1.82		
		≥240,000 Btu/h	1.73		
	Horizontal	<65,000 Btu/h	2.44	95°F/52°F (Class 3)	
		≥65,000 Btu/h and <240,000 Btu/h	2.10		
		≥240,000 Btu/h	2.10		

Table 6.8.1-11 Floor Mounted Air Conditioners and Condensing Units Serving Computer Rooms— Minimum Efficiency Requirements [I-P]

Table 6.8.1-12 Commercial Refrigerators and Freezers Minimum Efficiency Requirements [I-P]

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

V = the chiller or frozen compartment volume (ft³) as defined in Association of Home Appliance Manufacturers Standard HRF-1.

Table 6.8.1-13 Commercial Refrigeration Minimum Efficiency Requirements [I-P]

Equipment Type					
Equipment			Rating	Energy Use	Test
Class ^a	Family Code	Operating Mode	Temperature	Limits ^{b,e} , kWh/day	Procedure
VOP.RC.M	Vertical open	Remote condensing	Medium temperature	$0.82 \times TDA + 4.07$	AHRI 1200
SVO.RC.M	Semivertical open	Remote condensing	Medium temperature	$0.83 \times TDA + 3.18$	AHRI 1200
HZO.RC.M	Horizontal open	Remote condensing	Medium temperature	$0.35 \times TDA + 2.88$	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	$0.22 \times TDA + 1.95$	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	$1.74 \times TDA + 4.71$	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	$0.38 \times V + 0.88$	AHRI 1200
HCT.SC.I	Horizontal transparent door	Self contained	Ice cream	0.56 × TDA + 0.43	AHRI 1200
SVO.RC.L	Semivertical open	Remote condensing	Low temperature	$2.27 \times TDA + 6.85$	AHRI 1200
VOP.RC.I	Vertical open	Remote condensing	Ice-cream	$2.89 \times TDA + 8.7$	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	$0.72 \times TDA + 8.74$	AHRI 1200
VCT.RC.I	Vertical transparent door	Remote condensing	Ice cream	$0.66 \times TDA + 3.05$	AHRI 1200
HCT.RC.M	Horizontal transparent door	Remote condensing	Medium temperature	$\frac{0.16 \times \text{TDA} + 0.13}{0.16 \times \text{TDA} + 0.13}$	AHRI 1200
HCT.RC.L	Horizontal transparent door	Remote condensing	Low temperature	$0.34 \times TDA + 0.26$	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	$0.11 \times V + 0.26$	AHRI 1200
VCS.RC.L	Vertical solid door	Remote condensing	Low temperature	$0.23 \times V + 0.54$	AHRI 1200
VCS.RC.I	Vertical solid door	Remote condensing	Ice cream	$0.27 \times V + 0.63$	AHRI 1200
HCS.RC.M	Horizontal solid door	Remote condensing	Medium temperature	$0.11 \times V + 0.26$	AHRI 1200
HCS.RC.L	Horizontal solid door	Remote condensing	Low temperature	$0.23 \times V + 0.54$	AHRI 1200
HCS.RC.I	Horizontal solid door	Remote condensing	Ice cream	$0.27 \times V + 0.63$	AHRI 1200

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

<i>Equipment</i> T	ype				
Equipment Class^a	Family Code	Operating Mode	Rating Temperature	Energy Use Limits ^{b,c} , kWh/day	Test Procedure
SOC.RC.L	Service over counter	Remote condensing	Low temperature	$1.08 \times TDA + 0.22$	AHRI 1200
SOC.RC.I	Service over counter	Remote condensing	Ice-cream	$1.26 \times TDA + 0.26$	AHRI 1200
VOP.SC.L	Vertical open	Self contained	Low temperature	$4.37 \times TDA + 11.82$	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	$4.34 \times TDA + 11.51$	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	$2.44 \times TDA + 9.0$	AHRI 1200
SOC.SC.I	Service over counter	Self contained	Ice cream	$1.76 \times TDA + 0.36$	AHRI 1200
HCS.SC.I	Horizontal solid door	Self contained	Ice cream	$0.38 \times V + 0.88$	AHRI 1200

Table 6.8.1-13 Commercial Refrigeration Minimum Efficiency Requirements [I-P]

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.

						Maximum Daily	
	Condensing					Energy	
<u>Equipment</u>	Unit	Equipment	Rating	Operating	<u>Equipment</u>	Consumption,	Test
<u>Category</u>	Configuration	Family	Temp (°F)	Temp (°F)	Classification ^c	<u>kWh/day^{d,e}</u>	Standard
	Remote (RC)	Vertical Open	<u>38 (M)</u>	<u>>32</u>	<u>VOP.RC.M</u>	$\underline{0.64 \times TDA + 4.07}$	
		<u>(VOP)</u>	<u>0 (L)</u>	<u><32</u>	VOP.RC.L	$\underline{2.20 \times TDA + 6.85}$	
		Semivertical	<u>38 (M)</u>	<u>>32</u>	<u>SVO.RC.M</u>	$\underline{0.66 \times TDA + 3.18}$	
		Open (SVO)	<u>0 (L)</u>	<u><32</u>	SVO.RC.L	$\underline{2.20 \times TDA + 6.85}$	
		Horizontal	<u>38 (M)</u>	<u>>32</u>	HZO.RC.M	$\underline{0.35 \times TDA + 2.88}$	
		Open (HZO)	<u>0 (L)</u>	<u><32</u>	HZO.RC.L	$\underline{0.55 \times TDA + 6.88}$	
Domoto		Vertical Closed	<u>38 (M)</u>	<u>>32</u>	VCT.RC.M	$0.15 \times TDA + 1.95$	
<u>Remote</u> <u>Condensing</u>		Transparent (VCT)	<u>0 (L)</u>	<u><32</u>	<u>VCT.RC.L</u>	$\underline{0.49 \times TDA + 2.61}$	
Refrigerators		Horizontal	<u>38 (M)</u>	<u>≥32</u>	HCT.RC.M	$\underline{0.16 \times TDA + 0.13}$	AHRI 1200
and		Closed	<u>0 (L)</u>	<u><32</u>	HCT.RC.L	$\underline{0.34 \times TDA + 0.26}$	
Commercial Freezers		<u>Transparent</u> (HCT)					
		Vertical Closed	<u>38 (M)</u>	<u>>32</u>	VCS.RC.M	$\underline{0.10 \times V + 0.26}$	
		Solid (VCS)	<u>0 (L)</u>	<u><32</u>	VCS.RC.L	$\underline{0.21 \times V + 0.54}$	
		<u>Horizontal</u>	<u>38 (M)</u>	<u>>32</u>	HCS.RC.M	$\underline{0.10 \times V + 0.26}$	
		Closed Solid (HCS)	<u>0 (L)</u>	<u><32</u>	HCS.RC.L	$\underline{0.21 \times V + 0.54}$	
		Service Over	<u>38 (M)</u>	<u>>32</u>	SOC.RC.M	$\underline{0.44 \times TDA + 0.11}$	
		Counter (SOC)	<u>0 (L)</u>	<u><32</u>	SOC.RC.L	$0.93 \times TDA + 0.22$	
Self-	Self-Contained	Vertical Open	<u>38 (M)</u>	<u>>32</u>	VOP.SC.M	$1.69 \times TDA + 4.71$	A LIDI 1000
Contained	<u>(SC)</u>	(VOP)	<u>0 (L)</u>	<u><32</u>	VOP.SC.L	4.25 × TDA +	<u>AHKI 1200</u>

Table 6.8.1-13 Commercial Refrigerators, Freezers, and Refrigeration—Minimum Efficiency Requirements [I-P]

Table 6.8.1-13	Commercial Refrigerators, Freezers, and Refrigeration—Minimum Efficiency
	Requirements [I-P]

<u>Equipment</u> <u>Category</u>	<u>Condensing</u> <u>Unit</u> Configuration	<u>Equipment</u> <u>Family</u>	<u>Rating</u> Temp (°F)	<u>Operating</u> Temp (°F)	Equipment Classification ^c	<u>Maximum Daily</u> <u>Energy</u> <u>Consumption,</u> <u>kWh/day^{d,e}</u>	<u>Test</u> <u>Standard</u>
Commercial						11.82	
<u>Refrigerators</u>		G · · · 1	<u>38 (M)</u>	<u>>32</u>	SVO.SC.M	$\underline{1.70 \times TDA + 4.59}$	
and Commercial		<u>Open (SVO)</u>	<u>0 (L)</u>	<u><32</u>	<u>SVO.SC.L</u>	<u>4.26 × TDA +</u> 11.51	
Freezers With		Horizontal	38 (M)	>32	HZO.SC.M	$0.72 \times TDA + 5.55$	
Doors		Open (HZO)	0 (L)	<32	HZO.RC.L	$1.90 \times TDA + 7.08$	
<u></u>		Vertical Closed	38 (M)	>32	VCT.SC.M	$0.10 \times V + 0.86$	
		Transparent (VCT)	<u>0 (L)</u>	<32	VCT.SC.L	$0.29 \times V + 2.95$	
		Vertical Closed	38 (M)	<u>≥32</u>	VCS.SC.M	$0.05 \times V + 1.36$	
		Solid (VCS)	0 (L)	<32	VCS.SC.L	$0.22 \times V + 1.38$	
		Horizontal	38 (M)	>32	HCT.SC.M	$0.06 \times V + 0.37$	
		Closed	0 (L)	<32	HCT.SC.L	$0.08 \times V + 1.23$	
		<u>Transparent</u> (HCT)					
		Horizontal	<u>38 (M)</u>	<u>≥32</u>	HCS.SC.M	$\underline{0.05 \times V + 0.91}$	
		Closed Solid (HCS)	<u>0 (L)</u>	<u><32</u>	HCS.SC.L	$\underline{0.06 \times V + 1.12}$	
		Service Over	<u>38 (M)</u>	<u>>32</u>	SOC.SC.M	$\underline{0.52 \times TDA + 1.00}$	
		Counter (SOC)	<u>0 (L)</u>	<u><32</u>	SOC.SC.L	$\underline{1.10 \times TDA + 2.10}$	
Self- Contained Commercial Refrigerators with Transparent Doors for Pull-Down Temperature Applications	<u>Self-Contained</u> (SC)	<u>Pull-Down</u> (PD)	<u>38 (M)</u>	<u>>32</u>	<u>PD.SC.M</u>	$0.11 \times V + 0.81$	<u>AHRI 1200</u>
		Vertical Open			VOP.RC.I	$\underline{2.79 \times TDA + 8.70}$	
		(VOP) Semivertical Open (SVO)			<u>SVO.RC.I</u>	<u>2.79 × TDA + 8.70</u>	
		Horizontal Open (HZO)			HZO.RC.I	$\underline{0.70 \times TDA + 8.74}$	1
<u>Commercial</u> <u>Ice-Cream</u> <u>Freezers</u>	Remote (RC)	Vertical Closed <u>Transparent</u> (VCT)	<u>– 15 (I)</u>	<u><-5^b</u>	<u>VCT.RC.I</u>	$\underline{0.58 \times TDA + 3.05}$	<u>AHRI 1200</u>
		Horizontal Closed Transparent			<u>HCT.RC.I</u>	$\underline{0.40 \times TDA + 0.31}$	
		Vertical Closed Solid (VCS)			<u>VCS.RC.I</u>	$\underline{0.25 \times V + 0.63}$	

<u>Equipment</u> <u>Category</u>	<u>Condensing</u> <u>Unit</u> <u>Configuration</u>	<u>Equipment</u> <u>Family</u>	<u>Rating</u> <u>Temp (°F)</u>	<u>Operating</u> <u>Temp (°F)</u>	Equipment Classification ^c	<u>Maximum Daily</u> <u>Energy</u> <u>Consumption,</u> <u>kWh/day^{d,e}</u>	<u>Test</u> <u>Standard</u>
		Horizontal Closed Solid (HCS)			HCS.RC.I	$\underline{0.25 \times V + 0.63}$	
		Service Over Counter (SOC)			SOC.RC.I	$\underline{1.09 \times TDA + 0.26}$	
		<u>Vertical Open</u> (VOP)			<u>VOP.SC.I</u>	$\frac{5.40\times \text{TDA}}{15.02}$	
		Semivertical Open (SVO)			<u>SVO.SC.I</u>	<u>5.41 × TDA +</u> <u>14.63</u>	
		<u>Horizontal</u> Open (HZO)			HZO.SC.I	$\underline{2.42 \times \text{TDA} + 9.00}$	
		<u>Vertical Closed</u> <u>Transparent</u> <u>(VCT)</u>			<u>VCT.SC.I</u>	<u>0.62 × TDA + 3.29</u>	
	Self-Contained (SC)	<u>Horizontal</u> <u>Closed</u> <u>Transparent</u> (HCT)			HCT.SC.I	$\underline{0.56 \times \text{TDA} + 0.43}$	<u>AHRI 1200</u>
		Vertical Closed Solid (VCS)			VCS.SC.I	$\underline{0.34 \times V + 0.88}$	
		Horizontal Closed Solid (HCS)			HCS.SC.I	$\underline{0.34 \times V + 0.88}$	
		Service Over Counter (SOC)			<u>SOC.SC.I</u>	<u>1.53 × TDA + 0.36</u>	

Table 6.8.1-13 Commercial Refrigerators, Freezers, and Refrigeration—Minimum Efficiency Requirements [I-P]

a. The meaning of the letters in this column is indicated in the columns to the left.

d. V is the volume of the case (ft³) as measured in AHRI Standard 1200, Appendix C.

e. TDA is the total display area of the case (ft²) as measured in AHRI Standard 1200, Appendix D.

b. Ice-cream freezer is defined in 10 CFR 431.62 as a commercial freezer that is designed to operate at or below -5°F and that the manufacturer designs, markets, or intends for the storing, displaying, or dispensing of ice cream.

c. Equipment class designations consist of a combination (in sequential order separated by periods (AAA).(BB).(C)) of the following: (AAA)—An equipment family code (VOP = vertical open, SVO = semivertical open, HZO = horizontal open, VCT = vertical closed transparent doors, VCS = vertical closed solid doors, HCT = horizontal closed transparent doors, HCS = horizontal closed 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.

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)	Rating Conditions: A, B, or C	3.5 MRE	
Single package indoor air-cooled (with or without economizer)	Rating Conditions: A, B, or C	3.5 <i>MRE</i>	
Split <i>system</i> indoor air-cooled (with or without economizer)	Rating Conditions: A, B, or C	3.5 MRE	

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

 [I-P]

a. Units without air-cooled condenser.

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

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

Table 6.8.1-16	Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without
	Energy Recovery—Minimum Efficiency Requirements [I-P]

Equipment Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
Air cooled (dehumidification mode)		5.2 ISMRE	AHRI 920
Air source heat pumps (dehumidification mode)		5.2 ISMRE	AHRI 920
Water cooled	Cooling tower condenser water	5.3 ISMRE	AHRI 920
(dehumidification mode)	Chilled water	6.6 ISMRE	
Air source heat pump (heating mode)		3.3 ISMRE	AHRI 920
Water source heat pump	Ground source, closed loop	5.2 ISMRE	AHRI 920
(dehumidification mode)	Ground-water source	5.8 ISMRE	
	Water source	4.8 ISMRE	
Water source heat pump	Ground source, closed loop	3.8 ISMRE	AHRI 920
(heating mode)	Ground-water source	4.0 ISMRE	
	Water source	4.8 ISMRE	

Table 6.8.1-17 Electrically Operated Water Source Heat Pumps—Minimum Efficiency Requirements [I-P]

<u>Equipment Type</u>	Size Category	<u>Heating</u> <u>Section</u> <u>Type</u>	Subcategory or Rating Condition	<u>Minimum</u> <u>Efficiency</u>	<u>Test</u> <u>Procedure^a</u>
Water to air, water loop (cooling mode)	<u><17,000 Btu/h</u>	All	86°F entering water	<u>12.2 EER</u>	<u>ISO 13256-1</u>
	\geq 17,000 Btu/h and			<u>13.0 EER</u>	
	<u>≥65,000 Btu/h</u> <u>≥65,000 Btu/h and</u> <u><135,000 Btu/h</u>			<u>13.0 EER</u>	
Water to air, groundwater (cooling mode)	<u><135,000 Btu/h</u>	All	59°F entering water	<u>18.0 EER</u>	<u>ISO 13256-1</u>
Brine to air, ground loop (cooling mode)	<135,000 Btu/h	All	77°F entering water	<u>14.1 EER</u>	<u>ISO 13256-1</u>
Water to water, water loop (cooling mode)	<135,000 Btu/h	All	86°F entering water	<u>10.6 EER</u>	<u>ISO 13256-2</u>

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Water to water, groundwater (cooling mode)	<135,000 Btu/h	All	59°F entering water	<u>16.3 EER</u>	<u>ISO 13256-2</u>
Brine to water, ground loop (cooling mode)	<u><135,000 Btu/h</u>	All	77°F entering water	<u>12.1 EER</u>	<u>ISO 13256-2</u>
Water to air, water loop (heating mode)	<135,000 Btu/h (cooling capacity)		68°F entering water	<u>4.3 COP_H</u>	<u>ISO 13256-1</u>
Water to air, groundwater (heating mode)	<135,000 Btu/h (cooling capacity)		50°F entering water	<u>3.7 COP_H</u>	<u>ISO 13256-1</u>
Brine to air, ground loop (heating mode)	<135,000 Btu/h (cooling capacity)		32°F entering water	<u>3.2 COP_H</u>	<u>ISO 13256-1</u>
Water to water, water loop (heating mode)	<135,000 Btu/h (cooling capacity)		68°F entering water	<u>3.7 COP_H</u>	<u>ISO 13256-1</u>
Water to water, groundwater (heating mode)	<135,000 Btu/h (cooling capacity)		50°F entering water	<u>3.1 COP_H</u>	<u>ISO 13256-2</u>
Brine to water, ground loop (heating mode)	<135,000 Btu/h (cooling capacity)		32°F entering water	<u>2.5 COP_H</u>	<u>ISO 13256-2</u>

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. Single-phase, U.S. air-cooled heat pumps <19 kW are regulated as consumer products by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430. SCOP_C, SCOP_L, SCOP_H and SCOP_H 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. © ASHRAE. Per international copyright law, additional reproduction, distribution, or transmission in either print or digital form is not permitted without ASHRAE's prior written permission.

				Rating Conditions	
E	Standard	Net Sensible Cooling	Minimum Net	Return air (dry	Test
Ain Cooled with Ence Ain	Durated	Capacity	2 05	Duid/dew point)	AUDI 1200
Discharge Condenser	Ducted	<29,000 Btu/n	2.05	$75^{\circ}F/52^{\circ}F$ (Class 1)	AHKI 1300
		<65,000 Btu/h	2.02		
		≥65,000 Btu/h	1.92		
	Nonducted	<29,000 Btu/h	2.08		
		≥29,000 Btu/h and <65,000 Btu/h	2.05		
		≥65,000 Btu/h	1.94		
Air Cooled with Free Air	Ducted	<29,000 Btu/h	2.01	75°F/52°F (Class 1)	AHRI 1360
Discharge Condenser with fluid economizer		≥29,000 Btu/h and <65,000 Btu/h	1.97		
		≥65,000 Btu/h	1.87		
	Nonducted	<29,000 Btu/h	2.04		
		≥29,000 Btu/h and <65,000 Btu/h	2.00		
		≥65,000 Btu/h	1.89		
Air Cooled with Ducted	Ducted	<29,000 Btu/h	1.86	75°F/52°F (Class 1)	AHRI 1360
Condenser		≥29,000 Btu/h and <65,000 Btu/h	1.83		
		≥65,000 Btu/h	1.73		
	Nonducted	<29,000 Btu/h	1.89		
		≥29,000 Btu/h and <65,000 Btu/h	1.86		
		≥65,000 Btu/h	1.75		
Air Cooled with Fluid	Ducted	<29,000 Btu/h	1.82	75°F/52°F (Class 1)	AHRI 1360
Economizer and Ducted Condenser		≥29,000 Btu/h and <65,000 Btu/h	1.78		
		≥65,000 Btu/h	1.68		
	Nonducted	<29,000 Btu/h	1.85		
		≥29,000 Btu/h and <65,000 Btu/h	1.81		
		≥65,000 Btu/h	1.70		
Water Cooled	Ducted	<29,000 Btu/h	2.38	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	2.28		
		≥65,000 Btu/h	2.18		
	Nonducted	<29,000 Btu/h	2.41		
		≥29,000 Btu/h and <65,000 Btu/h	2.31		
		≥65,000 Btu/h	2.20		
Water Cooled with Fluid	Ducted	<29,000 Btu/h	2.33	75°F/52°F (Class 1)	AHRI 1360
Economizer		≥29,000 Btu/h and <65,000 Btu/h	2.23		
		≥65,000 Btu/h	2.13		
	Nonducted	<29,000 Btu/h	2.36		

Table 6.8.1-19 Ceiling Mounted Computer Room Air Conditioners—Minimum Efficiency Requirements [I-P]

Equipment Type	Standard Model	Net Sensible Cooling Capacity	Minimum Net Sensible COP	Rating Conditions Return air (dry bulb/dew point)	Test Procedure
		≥29,000 Btu/h and <65,000 Btu/h	2.26		
		≥65,000 Btu/h	2.16		
Glycol Cooled	Ducted	<29,000 Btu/h	1.97	75°F/52°F (Class 1)	AHRI 1360
		≥29,000 Btu/h and <65,000 Btu/h	1.93		
		≥65,000 Btu/h	1.78		
	Nonducted	<29,000 Btu/h	2.00		
		≥29,000 Btu/h and <65,000 Btu/h	1.98		
		≥65,000 Btu/h	1.81		
Glycol Cooled with Fluid	Ducted	<29,000 Btu/h	1.92	75°F/52°F (Class 1)	AHRI 1360
Economizer		≥29,000 Btu/h and <65,000 Btu/h	1.88		
		≥65,000 Btu/h	1.73		
	Nonducted	<29,000 Btu/h	1.95		
		≥29,000 Btu/h and <65,000 Btu/h	1.93		
		≥65,000 Btu/h	1.76		

Table 6.8.1-19 Ceiling Mounted Computer Room Air Conditioners—Minimum Efficiency Requirements [I-P]

6.8.2 Duct Insulation Tables

	Duct Location				
Climate Zone	Exterior ^b	Unconditioned Space and Buried Ducts	Indirectly Conditioned Space ^{c,d}		
Supply and Return Ducts for Heating and Cooling					
0 to 4	R-8	R-6	R-1.9		
5 to 8	R-12	R-6	R-1.9		
Supply and Retu	rn Ducts for Heatin	ng Only			
0 to 1	None	None	None		
2 to 4	R-6	R-6	R-1.9		
5 to 8	R-12	R-6	R-1.9		
Supply and Return Ducts for Cooling Only					
0 to 6	R-8	R-6	R-1.9		
7 to 8	R-1.9	R-1.9	R-1.9		

Table 6.8.2 Minimum Duct Insulation R-Value^a

a. Insulation *R-values*, measured in $h \cdot ft^{2} \cdot \circ F/Btu$, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where portions of the *building envelope* are used as a *plenum* enclosure, *building envelope* insulation shall be as required by the most restrictive condition of Section 6.4.4.1 or Section 5, depending on whether the *plenum* is located in the *roof, wall*, or *floor*. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a *mean temperature* of 75°F at the installed thickness.

b. Includes attics above insulated ceilings, parking garages and crawl spaces.

c. Includes return air plenums with or without exposed roofs above.

d. Return ducts in this duct location do not require insulation.

6.8.3 Piping Insulation Tables

Table 6.8.3-1	Minimum <i>Piping</i> Insulation Thickness Heating and Hot Water <i>Systems</i> ^{a,b,c,d,e}
(Stean	, Steam Condensate, Hot-Water Heating and Domestic Water Systems)

Fluid Operating	Insulation Conductivity		≥Nominal Pipe or Tube Size, in.				
Temperature Range	Conductivity,	Mean Rating	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
(°F) and Usage	Btu•in/h•ft ² •°F	Temperature, °F	Insulation	Thickness, in	1.		
>350	0.32 to 0.34	250	4.5	5.0	5.0	5.0	5.0
251 to 350	0.29 to 0.32	200	3.0	4.0	4.5	4.5	4.5
201 to 250	0.27 to 0.30	150	2.5	2.5	2.5	3.0	3.0
141 to 200	0.25 to 0.29	125	1.5	1.5	2.0	2.0	2.0
105 to 140	0.22 to 0.28	100	1.0	1.0	1.5	1.5	1.5

a. For insulation outside the stated conductivity range, the minimum thickness (*T*) shall be determined as follows: $T = r\{(1+t/r)^{K/k} - 1\}$, where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft²·°F], and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b. These thicknesses are based on *energy efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

c. For *piping* smaller than 1.5 in. and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1 in. shall be permitted (before thicknesses adjustment required in footnote [a]) but not to thicknesses below 1 in.

d. For direct-buried heating and hot-water *system piping*, reduction of these thicknesses by 1.5 in. shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses below 1 in.

e. The table is based on steel pipe. Nonmetallic pipes schedule 80 thickness or less shall use the table values. For other nonmetallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per metrethan a steel pipe of the same size with the insulation thickness shown in the table.

Fluid Operating Temperature Range	Insulation Conductivity		≥Nominal Pipe or Tube Size, in.				
	Conductivity,	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
(°F) and Usage	Btu•in/h•ft ² •°F		Insulation Thickness, in.				
40 to 60	0.21 to 0.27	75	0.5	0.5	1.0	1.0	1.0
<40	0.20 to 0.26	50	0.5	1.0	1.0	1.0	1.5

 Table 6.8.3-2
 Minimum Piping Insulation Thickness Cooling Systems (Chilled Water, Brine, and Refrigerant) ^{a,b,c,d}

a. For insulation outside the stated conductivity range, the minimum thickness (*T*) shall be determined as follows: $T = r\{(1+t/r)^{K/k} - 1\}$, where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft²·°F], and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b. These thicknesses are based on *energy efficiency* considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

c. For direct-buried cooling system piping, insulation is not required.

d. The table is based on steel pipe. Nonmetallic pipes schedule 80 thickness or less shall use the table values. For other nonmetallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

HVAC *control systems* shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft² conditioned area, except warehouses and *semiheated spaces*, detailed instructions for *commissioning HVAC systems* (see Informative Appendix E) shall be provided by the designer in plan and specifications.

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7 SERVICE WATER HEATING

7.1 General

7.1.1 Service Water-Heating Scope

7.1.1.1 New Buildings

Service water-heating systems and equipment shall comply with the requirements of this section as described in Section 7.2.

7.1.1.2 Additions to Existing Buildings

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

Exception to 7.1.1.2

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

7.1.1.3 Alterations to Existing Buildings

Building service water-heating equipment installed as a direct replacement for *existing building service water-heating equipment* shall comply with the requirements of Section 7 applicable to the *equipment* being replaced. New and replacement *piping* shall comply with Section 7.4.3.

Exception to 7.1.1.3

Compliance shall not be required where there is insufficient *space* or access to meet these requirements.

7.2 Compliance Paths

7.2.1 Compliance

Compliance shall be achieved by meeting the requirements of Section 7.1, "General"; Section 7.4, "Mandatory Provisions"; Section 7.5, "Prescriptive Path"; Section 7.7, "Submittals"; and Section 7.8, "Product Information."

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

7.3 Simplified/Small Building Option (Not Used)

7.4 Mandatory Provisions

7.4.1 Load Calculations

Service water-heating system design loads for the purpose of sizing systems and equipment shall be determined in accordance with manufacturers' published sizing guidelines or generally accepted engineering standards and handbooks acceptable to the adopting authority (e.g., ASHRAE Handbook—HVAC Applications).

7.4.2 Equipment Efficiency

All water-heating *equipment*, *hot-water supply boilers* used solely for heating potable water, *pool* heaters, and hot-water storage tanks shall meet the criteria listed in Table 7.8. Where multiple criteria are listed, all criteria shall be met. Omission of minimum performance requirements for certain classes of *equipment* does not preclude use of such *equipment* where appropriate. *Equipment* not listed in Table 7.8 has no minimum performance requirements.

Exceptions to 7.4.2

All *water heaters* and *hot-water supply boilers* having more than 140 gal of storage capacity are not required to meet the standby loss (SL) requirements of Table 7.8 when

- 1. the tank surface is thermally insulated to R-12.5,
- 2. a standing pilot light is not installed, and
- 3. gas- or oil-fired storage water heaters have a flue damper or fan-assisted combustion.

7.4.3 Service Hot-Water Piping Insulation

The following *piping* shall be insulated to levels shown in Section 6, Table 6.8.3-1:

- a. *Recirculating system piping*, including the supply and return *piping* of a circulating tank type *water heater*.
- b. The first 8 ft of outlet *piping* for a constant-temperature nonrecirculating storage system.
- c. The first 8 ft of branch *piping* connecting to recirculated, heat-traced, or impedance heated *piping*.
- d. The inlet *piping* between the storage tank and a heat trap in a nonrecirculating storage system.
- e. *Piping* that is externally heated (such as *heat trace* or impedance heating).
- f.

7.4.4 Service Water-Heating System Controls

7.4.4.1 Temperature Controls

Temperature *controls* shall be provided that allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use.

Exception to 7.4.4.1

When the *manufacturers*' installation instructions specify a higher minimum *thermostat* setting to minimize condensation and resulting corrosion.

7.4.4.2 Temperature Maintenance Controls

Systems designed to maintain usage temperatures in hot-water pipes, such as recirculating hot-water systems or heat trace, shall be equipped with *automatic* time switches or other *controls* that can be set to switch off the usage temperature maintenance system during extended periods when hot water is not required.

7.4.4.3 Outlet Temperature Controls

Temperature controlling means shall be provided to limit the maximum temperature of water delivered from lavatory faucets in *public facility restrooms* to 110°F.

7.4.4.4 Circulating Pump Controls

When used to maintain storage tank water temperature, recirculating pumps shall be equipped with *controls* limiting operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle.

7.4.5 Pools

7.4.5.1 Pool Heaters

Pool heaters shall be equipped with a *readily accessible* on/off switch to allow shutting off the heater without adjusting the *thermostat* setting. *Pool* heaters fired by natural gas shall not have continuously burning pilot lights.

7.4.5.2 Pool Covers

Heated *pools* shall be equipped with a vapor retardant *pool* cover on or at the water surface. *Pools* heated to more than 90°F shall have a *pool* cover with a minimum insulation value of R-12.

Exception to 7.4.5.2 *Pools* deriving over 60% of the *energy* for heating from *site-recovered energy* or *site-solar energy*.

7.4.5.3 Time Switches

Time switches shall be installed on swimming *pool* heaters and pumps.

Exceptions to 7.4.5.3

- 1. Where public health standards require 24-hour pump operation.
- 2. Where pumps are required to operate solar and waste heat recovery pool heating systems.

7.4.6 Heat Traps

Vertical pipe risers serving storage *water heaters* and storage tanks not having integral heat traps and serving a *nonrecirculating system* shall have heat traps on both the inlet and outlet *piping* as close as practical to the storage tank. A heat trap is a means to counteract the natural convection of heated water in a vertical pipe run. The means is either (a) a device specifically designed for the purpose or an arrangement of tubing that forms a loop of 360 degrees, or (b) *piping* that from the point of connection to the *water heater* (inlet or outlet) includes a length of *piping* directed downward before connection to the vertical *piping* of the supply water or hot-water *distribution system*, as applicable.

7.5 Prescriptive Path

7.5.1 Space Heating and Service Water Heating

The use of a gas-fired or oil-fired *space*-heating *boiler system* otherwise complying with Section 6 to provide the total *space* heating and *service water heating* for a *building* is allowed when one of the following conditions is met:

a. The single *space*-heating *boiler*, or the component of a modular or multiple *boiler system* that is heating the *service* water, has a standby loss in Btu/h not exceeding

$(13.3 \square \square \text{pmd} + 400)/n$

where pmd is the probable maximum *demand* in gal/h determined in accordance with the procedures described in *generally accepted engineering standards* and handbooks, and *n* is the fraction of the year when the outdoor daily *mean temperature* is greater than 64.9° F.

The standby loss is to be determined for a test period of 24 hours duration while maintaining a *boiler* water temperature of at least 90°F above ambient, with an ambient temperature between 60°F and 90°F. For a *boiler* with a modulating burner, this test shall be conducted at the lowest input.

- b. It is demonstrated to the satisfaction of the *authority having jurisdiction* that the use of a single heat source will consume less *energy* than separate units.
- c. The energy input of the combined boiler and water heater system is less than 150,000 Btu/h.

7.5.2 Service Water-Heating Equipment

Service water-heating equipment used to provide the additional function of *space* heating as part of a combination (integrated) *system* shall satisfy all stated requirements for the *service water-heating* equipment.

7.5.3 Buildings with High-Capacity Service Water-Heating Systems

New buildings with gas service water-heating systems with a total installed gas water-heating input capacity

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

Exception to 7.5.3

- 1. Where 25% of the annual service water-heating requirement is provided by *site-solar energy* or *site-recovered energy*.
- 2. Water heaters installed in individual dwelling units.
- 3. Individual gas water heaters with input capacity not greater than 100,000 Btu/h.

7.6 Alternative Compliance Path (Not Used)

7.7 Submittals

7.7.1 General

a. The *authority having jurisdiction* may require submittal of compliance documentation and supplemental information in accord with Section 4.2.2 of this standard.

7.8 **Product Information**

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required ^a	Test Procedure ^{b,c}
Electric table-top water heaters	≤12 kW	$\frac{\text{Resistance} ≥20}{\frac{\text{gal} < 4000 (Btu/h)/gal}}$ ≥20 gal and ≤120 gal	For applications outside US, see footnote (h). SFor US applications, see footnote (g).	<u>10 CFR 430</u> Appendix E
Electric <u>storage</u> water heaters	≤12 kW ^e		For applications outside US, see footnote (h). SFor US applications, see footnote (g).	<u>10 CFR 430</u> Appendix E
		<4000 (Btu/h)/gal >55 gal and ≤120 gal	For applications outside US, see footnote (h). For US applications, see footnote (g).	<u>10 CFR 430</u> Appendix E
	>12 kW ^e	Resistance ≥20 gal≤4000 (Btu/h)/gal	$\leq 0.3 + 27/V_m \%/h$	Section G.2 of ANSI Z21.10.3 <u>10 CFR</u> 431.106
	<u>≤24 Amps and ≤250</u> Volts	Heat pump	See footnote (g).	
Electric instantaneous water heaters	<u>≤12 kW</u>	<u>≥4000 (Btu/h)/gal</u> <2 gal	For applications outside US, see footnote (h). For US applications, see footnote (g).	<u>10 CFR 430</u> Appendix E
	$\frac{>12 \text{ kW and } \leq 58.6}{\text{kW}^{c}}$	<u>≥4000 (Btu/h)/gal</u> <u><2 gal</u> ≤180°F	$\frac{\text{Very Small DP: UEF} =}{0.80}$ $\underline{\text{Low DP: UEF} = 0.80}$ $\underline{\text{Medium DP: UEF} = 0.80}$ $\underline{\text{High DP: UEF} = 0.80}$	<u>10 CFR 430</u> Appendix E
	<u>6 kW^c</u>	<u>≥4000 (Btu/h)/gal</u> <10 gal	No requirement	

Table 7.8 Performance Requirements for Water-Heating Equipment—Minimum Efficiency Requirements (I-P)

<i>Equipment</i> Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required ^a	Test Procedure ^{b,c}	
		<u>≥4000 (Btu/h)/gal</u> ≥10 gal	No requirement		
Gas storage water heaters	≤75,000 Btu/h	<u>≥20 gal<4000</u> (<u>Btu/h)/gal</u> ≥20 gal and ≤55 gal	For applications outside US, see footnote (h). SFor US applications, see footnote (g).	<u>10 CFR 430</u> Appendix E	
		<4000 (Btu/h)/gal >55 gal and ≤100 gal	For applications outside US, see footnote (h). For US applications, see footnote (g).	<u>10 CFR 430</u> <u>Appendix E</u>	
	<u>>75,000 Btu/h and</u> ≤105,000 Btu/h ^d	<u><4000 (Btu/h)/gal</u> <u>≤120 gal</u> <u>≤180°F</u>	$\frac{\text{Very Small DP: UEF} =}{0.2674 - (0.0009 \times V_r)}$ $\underline{\text{Low DP: UEF} = 0.5362 -}{(0.0012 \times V_r)}$ $\underline{\text{Medium DP: UEF} =}{0.6002 - (0.0011 \times V_r)}$ $\underline{\text{High DP: UEF} = 0.6597 -}{(0.0009 \times V_r)}$	<u>10 CFR 430</u> <u>Appendix E</u>	
	> 75<u>105</u>,000 Btu/h^{d_f}	<4000 (Btu/h)/gal	$80\% E_t$ $SL \le (Q/800 + 110\sqrt{V})$ $SL, Btu/h$	Sections G.1 and G.2 of ANSI Z21.10.310 CFR 431.106	
Gas instantaneous water heaters	>50,000 Btu/h and 200,000 Btu/h	≥4000 (Btu/h)/gal and <2 gal	For applications outside US, see footnote (h). SFor US applications, see footnote (g).	<u>10 CFR 431.106</u>	
	≥≥200,000 Btu/h ^{d,f}	≥4000 (Btu/h)/gal and-<10 gal	80% E _t	Sections G.1 and G.2 of ANSI Z21.10.310 CFR 431.106	
	≥200,000 Btu/h ^{.f}	≥4000 (Btu/h)/gal -and-≥10 gal	<u>SL \leq 80% E_t(Q/800 + 110\sqrt{V})-SL, Btu/h</u>	<u>10 CFR 431.106</u>	
Oil storage water heaters	≤105,000 Btu/h	$\frac{\geq 20 \leq 4000}{(Btu/h)/gal} \leq 50 \text{ gal}$	For applications outside US, see footnote (h). SFor US applications, see footnote (g).	<u>10 CFR 430</u> Appendix E	
	≥105,000 Btu/h and ≤140,000 Btu/h ^e		$\frac{\text{Very Small DP: UEF} =}{0.2932 - (0.0015 \times V_r)}$ $\frac{\text{Low DP: UEF} = 0.5596 -}{(0.0018 \times V_r)}$ $\frac{\text{Medium DP: UEF} =}{0.6194 - (0.0016 \times V_r)}$ $\frac{\text{High DP: UEF} = 0.6740 -}{(0.0013 \times V_r)}$	<u>10 CFR 430</u> Appendix E	
	> <u>140,000</u> 105,000 Btu/h	<4000 (Btu/h)/gal	$80\% E_t$ $SL \leq (Q/800 + 110\sqrt{V})$ $SL, Btu/h$	Sections G.1 and G.2 of ANSI Z21.10.310 CFR 430.106	

Table 7.8 Performance Requirements for Water-Heating Equipment—Minimum Efficiency Requirements (I-P)

<i>Equipment</i> Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required ^a	Test Procedure ^{b,c}
Oil instantaneous water heaters	≤210,000 Btu/h	≥4000 (Btu/h)/gal and <2 gal	For applications outside US, see footnote (h). SFor US applications, see footnote (g).	<u>10 CFR 430</u> <u>Appendix E as it</u> <u>appeared as of</u> <u>1/1/2014</u>
	>210,000 Btu/h	≥4000 (Btu/h)/gal - and -<10 gal	80% E _t	Sections G.1 and G.2 of ANSI Z21.10.310 CFR 431.106
	>210,000 Btu/h	≥4000 (Btu/h)/gal -and-≥10 gal	78% E_t <u>SL $\leq (Q/800 + 110\sqrt{V})$</u> <u>SL</u> , Btu/h	<u>10 CFR 431.106</u>
Hot-water supply <i>boilers</i> , gas and oil ^f	≥300,000 Btu/h and <12,500,000 Btu/h	≥4000 (Btu/h)/gal - and -<10 gal	80% E _t	Sections G.1 and G.2 of ANSI Z21.10.310 CFR 431.106
Hot-water supply <i>boilers</i> , gas ^f	<u>≥300,000 Btu/h and</u> <u><12,500,000 Btu/h</u>	≥4000 (Btu/h)/gal -and-≥10 gal	80% E_t <u>SL < (Q</u> /800 + 110 \sqrt{V}) SL , Btu/h	Sections G.1 and G.2 of ANSI Z21.10.310 CFR 431.106
Hot-water supply <i>boilers</i> , oil		≥4000 (Btu/h)/gal -and-≥10 gal	78% E_t <u>SL < (Q/800 + 110</u> \sqrt{V}) <u>SL</u> , Btu/h	Sections G.1 and G.2 of ANSI Z21.10.310 CFR 431.106
<i>Pool</i> heaters, oil and gas	All		$\frac{82\% E_t, \text{ for commercial}}{\text{pool heaters and for}}$ $\frac{\text{applications outside US.}}{\text{SFor US applications, see}}$ footnote (g).	ASHRAE 146 <u>10</u> CFR 430 Appendix P
Heat pump <i>pool</i> heaters	All	50°F db 44.2°F wb Outdoor air 80.0°F entering water	4.0 <i>COP</i>	AHRI 116010 CFR 430 Appendix P
Unfired storage tanks	All		R-12.5	(none)

Table 7.8 Performance Requirements for Water-Heating Equipment—Minimum Efficiency Requirements (I-P)

a. Thermal *efficiency* (*E*_t) is a minimum requirement, while standby loss (SL) is <u>a maximum Btu/h based on a 70°F temperature difference</u> between stored water and ambient requirements. In the <u>SL standby loss</u> equation, *V* is the rated volume in gallons and *Q* is the nameplate input rate in Btu/h. *V_m* is the measured volume in the tank in gallons. <u>Standby loss for electric water heaters is in terms of %/h and denoted</u> by the term "S", and standby loss for gas and oil water heaters is in terms of Btu/h and denoted by the term "SL". Draw pattern (DP) refers to the water draw profile in the Uniform Energy Factor (UEF) test. UEF Energy Factor (EF) are minimum requirements. In the UEF standard equations, V_r refers to the rated volume in gallons.

- b. Section 12 contains a complete specification, including the year version, of the referenced test procedure.
- c. Electric instantaneous water heaters with input capacity >12 kW and ≤58.6 kW must comply with the requirements for > 58.6 kW if the water heater either (1) has a storage volume >2 gallons; (2) is designed to provide outlet hot water at temperatures greater than 180°F; or (3) uses 3-phase power.Section G.1 is titled "Test Method for Measuring Thermal Efficiency" and Section G.2 is titled "Test Method for Measuring Standby Loss."
- d. Gas storage water heaters with input capacity >75,000 Btu/h and ≤105,000 Btu/h must comply with the requirements for the >105,000 Btu/h if the water heater either (1) has a storage volume >120 gallons; (2) is designed to provide outlet hot water at temperatures greater than 180°F; or (3) uses 3-phase power. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures of 180°F or higher.
- e. Oil storage water heaters with input capacity >105,000 Btu/h and \leq 140,000 Btu/h must comply with the requirements for the >140,000 Btu/h if the water heater either (1) has a storage volume >120 gallons; (2) is designed to provide outlet hot water at temperatures greater than 180°F; or (3) uses 3-phase power. Electric *water heaters* with input rates below 12 kW must comply with these requirements if the *water heater* is designed to heat water to temperatures of 180°F or higher.
- f. Refer to Section 7.5.3 for additional requirements for gas storage and instantaneous water heaters and gas hot-water supply boilers.
- g. In the U.S., the *efficiency* requirements for *water Water heaters* or gas *pool* heaters in this category or subcategory are regulated as consumer products by the US Department of Energy defined in 10 CFR 430.specified by the U.S. Department of Energy. Those requirements and applicable test procedures are found in the Code of Federal Regulations 10 CFR Part 430.

Table 7.8 Performance Requirements for Water-Heating Equipment—Minimum Efficiency Requirements (I-P)

<i>Equipment</i> Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required ^a	Test Procedure ^{b,c}
h. Where this standard is being applied to a building outside the United States and Canada and water heaters in this subcategory are being				
installed in that building, those water heaters shall meet the local efficiency requirements. If there are no local efficiency standards for				
residential water heaters, consideration should be given to using the U.S. DOE efficiency requirements shown in Table F-2 of Appendix F.				

Informative Note: See Informative Appendix F for the U.S. Department of Energy efficiency requirements applicable to these water heaters and pool heaters.

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8 POWER

8.1 General

8.1.1 Scope

This section applies to all building power distribution systems and only to equipment described below.

8.1.2 New Buildings

Equipment installed in new buildings shall comply with the requirements of this section.

8.1.3 Addition to Existing Buildings

Equipment installed in addition to existing buildings shall comply with the requirements of this section.

8.1.4 Alterations to Existing Buildings

Exception to 8.1.4

Compliance shall not be required for the relocation or reuse of existing equipment at the same site.

8.1.4.1

Alterations to building service equipment or systems shall comply with the requirements of this section

applicable to those specific portions of the *building* and its systems that are being altered.

8.1.4.2

Any new *equipment* subject to the requirements of this section that is installed in conjunction with the *alterations* as a direct replacement of *existing equipment* shall comply with the specific requirements applicable to that *equipment*.

8.2 Compliance Paths

8.2.1 Compliance

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

Exception to 8.2.1

8.3 Power *distribution systems* and *equipment* serving a *computer room* with IT *equipment* load greater than 10 kW shall be permitted to comply with Section 8.6, "Alternative Compliance Path" Simplified/Small Building Option (Not Used)

8.4 Mandatory Provisions

8.4.1 Voltage Drop

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

8.4.1.1 Automatic Receptacle ControlAutomatic Receptacle Control

The following shall be automatically controlled:

- a. At least 50% of all 125 V, 15 and 20 amp receptacles in all private offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, classrooms, and individual workstations.
- b. At least 25% of *branch circuit* feeders installed for modular furniture not shown on the *construction documents*.

This *control* shall function on

- a. a scheduled basis using a time-of-day operated *control device* that turns receptacles off at specific programmed times—an independent program schedule shall be provided for controlled areas of no more than 5000 ft² and not more than one *floor* (the occupant shall be able to manually override the *control device* for up to two hours);
- b. an *occupant sensor* that shall turn receptacles off within 20 minutes of all occupants leaving a *space*; or
- c. an automated signal from another *control* or alarm *system* that shall turn receptacles off within 20 minutes after determining that the area is unoccupied.

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

Exceptions to Section 8.4.2

Receptacles for the following shall not require an *automatic control device*:

- 1. Receptacles specifically designated for *equipment* requiring continuous operation (24/day, 365 days/year).
- 2. *Spaces* where an *automatic control* would endanger the safety or security of the room or *building* occupants.

8.4.2 Electrical Energy Monitoring

8.4.2.1 Monitoring

Measurement devices shall be installed in new buildings to monitor the electrical energy use for each of
the following separately:

- a. Total electrical energy
- b. HVAC systems
- c. Interior lighting
- d. Exterior lighting
- e. Receptacle circuits

For *buildings* with tenants, these *systems* shall be separately monitored for the total *building* and (excluding shared *systems*) for each individual tenant.

Exception to 8.4.3.1

Up to 10% of the load for each of the categories (b) through (e) shall be allowed to be from other electrical loads.

8.4.2.2 Recording and Reporting

The electrical *energy* use for all loads specified in Section 8.4.3.1 shall be recorded a minimum of every 15 minutes and reported at least hourly, daily, monthly, and annually. The data for each tenant *space* shall be made available to that tenant. In *buildings* with a digital *control system* installed to comply with Section 6.4.3.10, the *energy* use data shall be transmitted to the digital *control system* and graphically displayed. The *system* shall be capable of maintaining all data collected for a minimum of 36 months.

Exceptions to Sections 8.4.3.1 and 8.4.3.2

- 1. Building less than $25,000 \text{ ft}^2$.
- 2. Individual tenant *spaces* less than $10,000 \text{ ft}^2$.
- 3. Dwelling units.
- 4. *Residential buildings* with less than $10,000 \text{ ft}^2$ of common area.
- 5. Critical and *Equipment* branches of NEC Article 517.

8.4.3 Low-Voltage Dry-Type Distribution Transformers

Low-voltage *dry-type transformers* shall comply with the provisions of the Energy Policy Act of 2005, where applicable, as shown in Table 8.4.4. *Transformers* that are not included in the scope of the Energy Policy Act of 2005 have no performance requirements in this section and are listed for ease of reference as exceptions.

Exception to 8.4.4

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

- 1. Special purpose applications.
- 2. Not likely to be used in general purpose applications.
- 3. *Transformers* with multiple voltage taps, where the highest tap is at least 20% more than the lowest tap.
- 4. Drive transformer.
- 5. Rectifier transformer.
- 6. Auto-transformer.
- 7. Uninterruptible power system transformer.
- 8. Impedance transformer.
- 9. Regulating *transformer*.
- 10. Sealed and nonventilating transformer.
- 11. Machine tool transformer.
- 12. Welding transformer.

13. Grounding transformer.

14. Testing *transformer*.

Table 8.4.4 Minimum Nominal Efficiency Levels for Low-Voltage Dry-Type Distribution Transformers^a

Single-Pha	ase Transformers	Three-Pha	se Transformers		
kVA ^b	Efficiency,% ^c	kVA ^b	Efficiency,% ^c		
15	97.70	15	97.89		
25	98.00	30	98.23		
37.5	98.20	45	98.40		
50	98.30	75	98.60		
75	98.50	112.5	98.74		
100	98.60	150	98.83		
167	98.70	225	98.94		
250	98.80	300	99.02		
333	98.90	500	99.14		
		750	99.23		
		1000	99.28		

a. A low-voltage distribution *transformer* is a *transformer* that is air-cooled, does not use oil as a coolant, has an input voltage ≤ 600 V, and is rated for operation at a frequency of 60 Hz.

b. Kilovolt-ampere rating

c. Nominal efficiencies shall be established in accordance with the 10 CFR 431 test procedure for low-voltage dry-type transformers.

8.5 Prescriptive Path (Not Used)

8.6 Alternative Compliance Path (Not Used)

8.6.1 Computer Room Systems

Power *distribution systems* and *equipment* only serving a *computer room* with IT *equipment* load greater than 10 kW shall comply with ASHRAE Standard 90.4, *Energy Standard for Data Centers*.

8.7 Submittals

Drawings

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

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

8.7.2 Manuals

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

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

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

8.8 **Product Information** (Not Used)



9 LIGHTING

9.1 General

9.1.1 Scope

This section shall apply to the following:

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

Exception to 9.1.1

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

9.1.2 Lighting Alterations

For the *alteration* of any *lighting system* in an interior *space*, that *space* shall comply with the *lighting power density* (*LPD*) allowances of Section 9.5.1 or 9.6.1 and the *control* requirements of Section 9.4.1.1(a), (b), (c), (d), (g), (h), and (i), as applicable to that *space*.

For the *alteration* of any *lighting system* for the exterior of a *building* application, that *lighting system* shall comply with the *lighting power density* (*LPD*) allowances of Section 9.4.2 applicable to the area illuminated by that *lighting system* and the applicable *control* requirements of Sections 9.4.1.4 and 9.4.2.

Exception to 9.1.2

- 1. *Alterations* that involve 20% or less of the connected lighting load in a *space* or area need not comply with these requirements, provided that such *alterations* do not increase the installed lighting power.
- 2. Lighting *alterations* that only involve replacement of *lamps* plus *ballasts/drivers* or only involve one-for-one *luminaire* replacement need only comply with *LPD* requirement and Section 9.4.1.1 (h) or 9.4.1.1(i).
- 3. Routine maintenance or *repair* situations.

9.1.3 Installed Lighting Power

The *luminaire* wattage for all interior and exterior applications shall include all power used by the *luminaires*, including *lamps*, *ballasts/drivers*, *transformers*, and *control devices*, except as specifically

exempted in Section 9.1.1, 9.2.2.3, or 9.4.2.

Exception to 9.1.3

If two or more independently operating *lighting systems* in a *space* are capable of being controlled to prevent simultaneous user operation, the *installed interior lighting power* or the *installed exterior lighting power* shall be based solely on the *lighting system* with the highest wattage.

9.1.4 Interior and Exterior Luminaire Wattage

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

- a. The wattage of line-voltage *luminaires* not containing *permanently installed ballasts, transformers*, or similar devices shall be the *manufacturers' labeled* maximum wattage of the *luminaire*.
- b. The wattage of *luminaires* with *permanently installed* or remote *ballasts/drivers*, *transformers*, or similar devices shall be the operating input wattage of the maximum *lamp/*auxiliary combination based on values from the auxiliary *manufacturers*' literature or recognized testing laboratories or shall be the maximum *labeled* wattage of the *luminaire*.

Exception to 9.1.4(b)

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

- c. For line-voltage lighting track and plug-in busway designed to allow the addition and/or relocation of *luminaires* without altering the wiring of the *system*, the wattage shall be
 - 1. the specified wattage of the luminaires included in the system with a minimum of 30 W/lin ft,
 - 2. the wattage limit of the system's circuit breaker, or
 - 3. the wattage limit of other permanent current-limiting devices on the system.
- d. The wattage of low-voltage lighting track, cable conductor, rail conductor, and other flexible *lighting systems* that allow the addition and/or relocation of *luminaires* without altering the wiring of the *system* shall be the specified wattage of the *transformer* supplying the *system*.
- e. The wattage of all other miscellaneous lighting *equipment* shall be the specified wattage of the lighting *equipment*.

9.1.5 Climate

Climate zones shall be determined in accordance with Section 5.1.4.

9.2 Compliance

9.2.1 Compliance Paths

Lighting systems and *equipment* shall comply with Section 9.1, "General"; Section 9.4, "Mandatory Provisions"; Section 9.7, "Submittals"; and the prescriptive requirements of either

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

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

9.2.2 Prescriptive Requirements

9.2.2.1 Building Area Method

This method for determining the *interior lighting power allowance*, described in Section 9.5, is a simplified approach for demonstrating compliance.

9.2.2.2 Space-by-Space Method

This method, described in Section 9.6, is an alternative approach that allows greater flexibility.

9.2.2.3 Interior Lighting Power

The *interior lighting power allowance* for a *building* or a separately metered or permitted portion of a *building* shall be determined by either the *Building* Area Method, described in Section 9.5, or the Spaceby-Space Method, described in Section 9.6. Trade-offs of *interior lighting power allowance* among portions of the *building* for which a different method of calculation has been used are not permitted. The *installed interior lighting power* identified in accordance with Section 9.1.3 shall not exceed the *interior lighting power allowance* developed in accordance with Section 9.5 or 9.6.

Exception to 9.2.2.3

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

- 1. Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments.
- 2. Lighting that is integral to *equipment* or instrumentation and is installed by its *manufacturer*.
- 3. Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical *equipment*.
- 4. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.
- 5. Lighting integral to food warming and food preparation *equipment*.
- 6. Lighting specifically designed for the life support of nonhuman life forms.
- 7. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
- 8. Lighting in interior *spaces* that have been specifically designated as a registered interior *historic* landmark.
- 9. Lighting that is an integral part of advertising or direction signage.
- 10. Exit signs.
- 11. Lighting that is for sale or lighting educational demonstration systems.
- 12. Lighting for theatrical purposes, including performance, stage, and film and video production.
- 13. Lighting for television broadcasting in sporting activity areas.
- 14. Casino gaming areas.
- 15. Furniture-mounted supplemental *task lighting* that is controlled by *automatic* shutoff and complies with Section 9.4.1.3(c).
- 16. Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas.
- 17. Parking garage transition lighting—lighting for covered vehicle entrances and exits from *buildings* and parking structures—that complies with Section 9.4.1.2(a) and 9.4.1.2(c); each transition zone shall not exceed a depth of 66 ft inside the structure and a width of 50 ft.

9.3 (Not Used)

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 ft² if the *space* is $\leq 10,000$ ft² and (2) no larger than 10,000 ft² 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*. Calibration shall not require the physical presence of a person at the sensor while it is processing.
- 2. The photocontrol shall reduce electric lighting <u>power</u> in response to available daylight using continuous dimming to 20% or less and off.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. When an automatic partial OFF control has reduced the lighting power to the unoccupied setpoint in accordance with Section 9.4.1(g), the daylight responsive control shall adjust the electric light in response to available daylight, but it shall not allow the lighting power to be above the unoccupied setpoint. 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 or natural object is

at least twice as high above the windows as its horizontal distance away from the windows.

- 2. Sidelighted areas where the total glazing area is less than 20 ft^2 .
- 3. Retail spaces.
- 4.
- 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 calibration adjustment *control* shall be located no higher than 11 ft (3.4 m) above the finished *floor*. Calibration shall not require the physical presence of a person at the sensor while it is processing.
 - 2. The photocontrol shall reduce electric lighting in response to available daylight using continuous dimming to 20% or less and off.-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.
 - **1.3.** When an *automatic* partial OFF control has reduced the lighting power to the unoccupied setpoint in accordance with Section 9.4.1(g), the daylight responsive control shall adjust the electric light in response to available daylight, but it shall not allow the lighting power to be above the unoccupied setpoint.
 - 2. The calibration shall not require the physical presence of a person at the sensor while the calibration is processing.
 - 3.4. 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.

Exception to 9.4.1.1(f)

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

- 1. *Daylight area under skylights* where it is documented that existing adjacent structures or natural objects block direct sunlight for more than 1500 daytime hours per year between 8 a.m. and 4 p.m.
- 2. Daylight area under skylights where the overall skylight effective aperture for the enclosed space is less than 0.006.
- 3. In each *space* within *buildings* in Climate Zone 8 where the input power of the *general lighting* within *daylight areas* is less than 200 W.
- g. Automatic partial OFF (full OFF complies): The general lighting power in the space shall be automatically reduced by at least 50% within 20 minutes of all occupants leaving the space.

Exception to 9.4.1.1(g)

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

- 1. The *space* has an installed *LPD* of no more than 0.80 W/ft^2 .
- 2. The *space* is lighted by *HID lamp*.
- 3. The *general lighting* power in the *space* is automatically reduced by at least 30% within 20 minutes of all occupants leaving the *space*.
- 4. Lighting load does not exceed 0.02 W/ft² multiplied by the *gross lighted area* of the *building*.
- h. *Automatic full OFF:* All lighting, including lighting connected to emergency circuits, shall be automatically shut off within 20 minutes of all occupants leaving the *space*. A *control device* meeting this requirement shall *control* no more than 5000 ft².

Exception to 9.4.1.1(h)

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

- 1. General lighting and task lighting in shop and laboratory classrooms.
- 2. *General lighting* and *task lighting* in *spaces* where *automatic* shutoff would endanger the safety or security of room or *building* occupants.
- 3. Lighting required for 24/7 operation.
- i. *Scheduled shutoff:* All lighting in the *space*, including lighting connected to emergency circuits, shall be automatically shut off during periods when the *space* is scheduled to be unoccupied using either (1) a time-of-day operated *control device* that automatically turns the lighting off at specific programmed times or (2) a signal from another *automatic control device* or alarm/security *system*. The *control device* or *system* shall provide independent *control sequences* that (1) *control* the lighting for an area of no more than 25,000 ft², (2) include no more than one *floor*, and (3) shall be programmed to account for weekends and holidays. Any *manual control* installed to provide override of the scheduled shutoff *control* shall not turn the lighting on for more than two hours per activation during scheduled off periods and shall not *control* more than 5000 ft².

Exception to 9.4.1.1(i)

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

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

j.

9.4.1.2 Parking Garage Lighting Control

Lighting for parking garages shall comply with the following requirements:

- a. Parking garage lighting shall have *automatic* lighting shutoff per Section 9.4.1.1(i).
- b. Lighting power of each *luminaire* shall be automatically reduced by a minimum of 3050% when there is no activity detected within a lighting zone for 2010 minutes. Lighting zones for this requirement shall be no larger than 3600 ft² (334 m²).
- c. <u>Parking garage daylight transition Llighting exempt per Section 9.2.2.3</u>, for covered vehicle entrances and exits from *buildings* and parking structures shall be separately controlled to by a device that automatically reduces the lighting to no more than the general light level at night by at least 50%-from sunset to sunrise.
- d. The power to *luminaires* within 20 ft of any perimeter *wall* <u>openings totaling at least 24 ft² (2.2 m²)</u> structure that has a net opening to *wall* ratio of at least 40% and no exterior obstructions within 20 ft, shall be automatically reduced <u>through *continuous dimming*</u> in response to <u>available</u> daylight. by at least 50%.

Exceptions to 9.4.1.2(d)

Lighting in the following areas is exempt:

- <u>1. Lighting in Parking garage</u> daylight transitions zones and ramps without parking lighting exempt per Section 9.2.2.3.
- 2. Where permanent screens or architectural element obstruct more than 50% of the opening.
- **1.3.** Where the top of any existing adjacent structure or natural object is at least twice as high above the openings as its horizontal distance from the opening.

9.4.1.3 Special Applications

- a. The following lighting shall be separately controlled from the *general lighting* in all *spaces*:
 - 1. Display or accent lighting.
 - 2. Lighting in display cases.
 - 3. Nonvisual lighting, such as for plant growth or food warming.
 - 4. Lighting *equipment* that is for sale or used for demonstrations in lighting education.
- b. Guestrooms
 - 1. All lighting and all switched receptacles in guestrooms and suites in hotels, motels, boarding houses, or similar *buildings* shall be automatically controlled such that the power to the lighting and switched receptacles in each *enclosed space* will be turned off within 20 minutes after all occupants leave that *space*.

Exception to 9.4.1.3(b)(1)

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

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

Exception to 9.4.1.3(b)(2)

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

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

9.4.1.4 Exterior Lighting Control

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

- a. Lighting shall be controlled by a device that automatically turns off the lighting when sufficient daylight is available.
- b. All *building* façade and landscape lighting shall be automatically shut off between midnight or business closing, whichever is later, and 6 a.m. or business opening, whichever comes first, or between times established by the *authority having jurisdiction*.
- c. Lighting not specified in Section 9.4.1.4 (b) and lighting for signage shall be controlled by a device that automatically reduces the connected lighting power by at least 50% for at least one of the following conditions:
 - 1. From 12 midnight or within one hour of the end of business operations, whichever is later, until 6 a.m. or business opening, whichever is earlier.
 - 2. During any period when no activity has been detected for a time of no longer than 15 minutes.
- d. *Luminaires* serving outdoor parking areas and having a rated input wattage of greater than 78 W and a mounting height of 24 ft or less above the ground shall be controlled to automatically reduce the power of each *luminaire* by a minimum of 50% when no activity has been detected in the area illuminated by the controlled *luminaires* for a time of no longer than 15 minutes. No more than 1500 W of lighting power shall be controlled together.

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

Exceptions to 9.4.1.4

- 1. Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.
- 2. Lighting that is integral to signage and installed in the signage by the manufacturer.

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. 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
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Lighting Zone	Description
0	Undeveloped areas within national parks, state parks, forest land, rural areas, and other undeveloped areas as defined by the <i>authority having jurisdiction</i>
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of <i>residential</i> zoning, neighborhood business districts, light industrial with limited nighttime use and <i>residential</i> 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 tradab	le or nontradable	surfaces.)								
	No allowance	350 W	400 W	500 W	900 W						
Tradable Surfaces											
(<i>LPD</i> allowances for uncovered parking areas, <i>building</i> grounds, <i>building entrances</i> , exits and loading docks, canopies and overhangs, and outdoor sales areas may be traded.)											
Uncovered Parking Areas			1		1						
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	0.60 W/ft ²	0.70 W/ft ²	0.70 W/ft^2	0.70 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 D	ocks										
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	0.20 W/ft^2	0.20 W/ft^2	0.20 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											

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Open areas (including vehicle sales lots)	No allowance	0.2 W/ft^2	0.2 W/ft^2	0.2 W/ft^2	0.2 W/ft^2
Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	No allowance	7 W/lin ft	7 W/lin ft	21 W/lin ft

Table 9.4.2-2 Individual Lighting Power Allowances for Building Exteriors

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.)

<i>Building</i> facades (The allowance for each illuminated façade <i>orientation</i> shall be calculated by multiplying the allowance value by the entire façade area or façade length for that <i>orientation</i> .)	No allowance	No allowance	0.1 W/ft ² of <i>façade area</i> or 2.5 W/linear foot of façade length	0.15 W/ft ² of <i>façade area</i> or 3.75 W/linear foot of façade length	0.2 W/ft ² of <i>façade area</i> or 5.0 W/linear foot of façade length
Automated teller machines and night depositories	No allowance	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location
Uncovered entrances and gatehouse inspection stations at guarded facilities	No allowance	0.5 W/ft^2	0.5 W/ft ²	0.5 W/ft ²	0.5 W/ft ²
Uncovered loading areas for law enforcement, fire, ambulance, and other emergency service 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 <i>authority having jurisdiction</i>	A single <i>luminaire</i> of 25 W or less	No additional allowance	No additional allowance	No additional allowance	No additional allowance

Exceptions 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.

9.4.3 Functional Testing

Lighting *control devices* and *control systems* shall be tested to ensure that *control* hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the *construction documents* and *manufacturer*'s installation instructions. When *occupant sensors*, time switches, programmable schedule *controls*, or *photosensors* are installed, at a minimum, the following procedures shall be performed:

- a. Occupant Sensors
 - 1. Certify that the sensor has been located and aimed in accordance with *manufacturer* recommendations.
 - 2. For projects with up to seven (7) occupancy sensors, all occupancy sensors shall be tested.
 - 3. For projects with more than seven (7) occupancy sensors, testing shall be done for each unique combination of sensor type and *space* geometry.
 - (a) For each sensor to be tested, verify the following:
 - (1) Status indicator (as applicable) operates correctly.
 - (2) Controlled lights turn off or down to the permitted level within the required time.
 - (3) For auto-ON *occupant sensors*, the lights turn on to the permitted level when someone enters the *space*.
 - (4) For manual-ON sensors, the lights turn on only when manually activated.
 - (5) The lights are not incorrectly turned on by movement in nearby areas or by HVAC operation.
- b. Automatic Time Switches
 - 1. Confirm that the *automatic* time-switch *control* is programmed with appropriate weekday, weekend, and holiday (as applicable) schedules.
 - 2. Document for the owner *automatic* time-switch programming, including weekday, weekend, and holiday schedules, as well as all setup and preference program settings.
 - 3. Verify that correct time and date are properly set in the time switch.
 - 4. Verify that any battery backup (as applicable) is installed and energized.
 - 5. Verify that the override time limit is set to no more than two (2) hours.
 - 6. Simulate occupied condition. Verify and document the following:
 - (a) All lights can be turned on and off by their respective area *control* switch.
 - (b) The switch only operates lighting in the *enclosed space* in which the switch is located.
 - 7. Simulate unoccupied condition. Verify and document the following:
 - (a) All nonexempt lighting turns off.
 - (b) *Manual* override switch allows only the lights in the *enclosed space* where the override switch is located to turn on or remain on until the next scheduled shut off occurs.
- c. Daylight Controls
 - 1. All *control devices* (photocontrols) have been properly located, field-calibrated, and set for appropriate *set points* and threshold light levels.
 - 2. Daylight controlled lighting loads adjust to appropriate light levels in response to available daylight.
 - 3. The location where calibration adjustments are made is *readily accessible* only to authorized personnel.

The individuals responsible for the functional testing shall not be directly involved in either the design or *construction* of the project and shall provide documentation certifying that the installed lighting *controls*

meet or exceed all documented performance criteria.

9.4.4 Dwelling Units

Not less than 75% of the *permanently installed* lighting *fixtures* shall use *lamps* with an *efficacy* of at least 55 lm/W or have a total *luminaire efficacy* of at least 45 lm/W.

Exception to 9.4.4:

1. Lighting that is controlled with *dimmers* or *automatic control devices*.

2.

9.5 Building Area Method Compliance Path

9.5.1 Building Area Method of Calculating Interior Lighting Power Allowance

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

- a. Determine the appropriate *building* area type from Table 9.5.1 and the corresponding *LPD* allowance. For *building* area types not listed, selection of a reasonably equivalent type shall be permitted.
- b. Determine the gross lighted floor area in ft^2 of the building area type.
- c. Multiply the gross lighted floor areas of the building area types times the LPD.
- d. The *interior lighting power allowance* for the *building* is the sum of the lighting power allowances of all *building* area types. Trade-offs among *building* area types are permitted, provided that the total *installed interior lighting power* does not exceed the *interior lighting power allowance*.

Building Area Type ^a	LPD, W/ft ²
Automotive facility	0.71
Convention center	0.76
Courthouse	0.90
Dining: Bar lounge/leisure	0.90
Dining: Cafeteria/fast food	0.79
Dining: Family	0.78
Dormitory	0.61
Exercise center	0.65
Fire station	0.53
Gymnasium	0.68
Health-care clinic	0.82
Hospital	1.05
Hotel/motel	0.75
Library	0.78
Manufacturing facility	0.90
Motion picture theater	0.83
Multifamily	0.68
Museum	1.06
Office	0.79
Parking garage	0.15
Penitentiary	0.75
Performing arts theater	1.18
Police station	0.80
Post office	0.67
Religious facility	0.94
Retail	1.06

 Table 9.5.1
 Lighting Power Density Allowances Using the Building Area Method (I-P)

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	print or digital form is not perm	itted without ASHRAE's	prior written	permission.	

School/university	0.81	
Sports arena	0.87	
Town hall	0.80	
Transportation	0.61	
Warehouse	0.48	
Workshop	0.90	
workshop	0.90	

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.

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 ft² 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*.

				The <i>control</i> functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each <i>space</i> 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.								
<i>Informative Note:</i> This table is divided into two sections; this first section covers <i>space</i> types that can be commonly found in multiple <i>building</i> types. The second part of this table covers <i>space</i> types that are typically found in a single <i>building</i> type.		Local <i>Control</i> (See Section 9.4.1.1[a])	Restricted Manual ON (See Section 9.4.1.1[b])	Restricted to Partial <i>Automatic</i> ON (See Section 9.4.1.1[c])	Bilevel Lighting <i>Control</i> (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/ft ²	<i>RCR</i> Threshold	а	b	с	d	e	f	g	h	i	
Atrium												
<20 ft in height	0.03/ft total height	NA	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2	
≥20 ft and ≤40 ft in height	0.03/ft total height	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
>40 ft in height	0.40 + 0.02/ft total height	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
Audience Seating Area												
Auditorium	0.63	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	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
Motion picture theater	1.14	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
Penitentiary	0.28	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2	
Performing arts theater	2.03	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
Religious facility	1.53	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
Sports arena	0.43	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2	
All other audience seating areas	0.43	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2	
Banking Activity Area	0.86	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
Breakroom (See Lounge/Breakroom	m)											
Classroom/Lecture Hall/Training F	Room											
Penitentiary	1.34	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ		
All other classrooms/lecture halls/training rooms	0.92	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ		
Conference/Meeting/ Multipurpose Room	1.07	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ		
Confinement Cells	0.81	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2	
Copy/Print Room	0.56	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ		
Corridor ²												

				functions be within Secti EQs shall be st one ADD1 st one ADD2	low shall be on 9.4.1.1. Fo implemented (when prese (when prese	implemented or each <i>space</i> nt) shall be in nt) shall be in	in accordance type: nplemented. nplemented.	with the descr	riptions found	d in the refer	enced
<i>Informative Note:</i> This table is divided into two sections; this first section covers <i>space</i> types that can be commonly found in multiple <i>building</i> types. The second part of this table covers <i>space</i> types that are typically found in a single <i>building</i> type.			Local <i>Control</i> (See Section 9.4.1.1[a])	Restricted Manual ON (See Section 9.4.1.1[b])	Restricted to Partial <i>Automatic</i> ON (See Section 9.4.1.1[c])	Bilevel Lighting <i>Control</i> (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/ft ²	RCR Threshold	а	b	с	d	е	f	g	h	i
Facility for the visually impaired (and not used primarily by the staff) ³	0.92	width <8 ft	REQ				REQ	REQ	REQ	ADD2	ADD2
Hospital	0.92	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	width <8 ft	REQ				REQ	REQ	REQ	ADD2	ADD2
Courtroom	1.39	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Computer Room	1.33	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Dining Area											
Penitentiary	0.96	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Facility for the visually impaired (and not used primarily by the staff) ³	2.00	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Bar/lounge or leisure dining	0.93	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Cafeteria or fast food dining	0.63	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Family dining	0.71	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
All other dining areas	0.63	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Electrical/Mechanical Room ⁷	0.43	6	REQ				REQ	REQ			
Emergency Vehicle Garage	0.41	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Food Preparation Area	1.06	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Guest Room	0.77	6	See Section	9.4.1.3(b).							
Laboratory											
In or as a classroom	1.20	6	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
All other laboratories	1.45	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Laundry/Washing Area	0.43	4	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.										
<i>Informative Note:</i> This table is divided into two sections; this first section covers <i>space</i> types that can be commonly found in multiple <i>building</i> types. The second part of this table covers <i>space</i> types that are typically found in a single <i>building</i> type.		Local <i>Control</i> (See Section 9.4.1.1[a])	Restricted Manual ON (See Section 9.4.1.1[b])	Restricted to Partial <i>Automatic</i> ON (See Section 9.4.1.1[c])	Bilevel Lighting <i>Control</i> (See Section 9.4.1.1[d])	Automatic Daylight Responsive <i>Controls</i> for Sidelighting (See Section 9.4.1.1[e] ⁶)	Daylight Responsive <i>Controls</i> for <i>Toplighting</i> (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/ft ²	RCR Threshold	а	b	с	d	e	f	g	h	i
Loading Dock, Interior	0.58	6	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Lobby											
Facility for the visually impaired (and not used primarily by the staff) ³	2.03	4	REQ				REQ	REQ	REQ	ADD2	ADD2
Elevator	0.69	6	REQ				REQ	REQ		ADD2	ADD2
Hotel	1.06	5	REQ				REQ	REQ		ADD2	ADD2
Motion picture theater	0.45	5	REQ				REQ	REQ		ADD2	ADD2
Performing arts theater	1.70	6	REQ				REQ	REQ	REQ	ADD2	ADD2
All other lobbies	1.00	4	REQ				REQ	REQ	REQ	ADD2	ADD2
Locker Room	0.48	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Lounge/Breakroom											
Healthcare facility	0.78	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
All other lounges/breakrooms	0.62	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Office											
Enclosed and $\leq 250 \text{ ft}^2$	0.93	8	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Enclosed and >250 ft ²	0.93	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Open plan	0.81	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Parking Area, Interior	0.14	4	See Section	9.4.1.2			<u>.</u>				
Pharmacy Area	1.34	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	8					REQ	REQ		REQ	
All other restrooms	0.85	8					REQ	REQ		REQ	

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

				The <i>control</i> functions below shall be implemented in accordance with the descriptions found in the referenced							
			(1) All REOs shall be implemented.								
		(1) At leas	(2) At least one ADD1 (when present) shall be implemented.								
			(3) At leas	st one ADD2	(when prese	nt) shall be ii	nplemented.				
<i>Informative Note:</i> This table is divided into two sections; this first section covers <i>space</i> types that can be commonly found in multiple <i>building</i> types. The second part of this table covers <i>space</i> types that are typically found in a single <i>building</i> type.		Local <i>Control</i> (See Section 9.4.1.1[a])	Restricted Manual ON (See Section 9.4.1.1[b])	Restricted to Partial <i>Automatic</i> ON (See Section 9.4.1.1[c])	Bilevel Lighting <i>Control</i> (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	IPD Allowances W/ft ²	RCR Threshold	9	h	c	d	0	f	a	h	;
	1.22	6	a REO			u PEO	e	PEO	g		
Sales Area	1.22	0	KEQ	ADDI	ADDI	KĽQ		KEQ		ADD2	ADD2
Seating Area, General	0.42	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Stairway	The space containing the st	tairway shall o	determine the	LPD and con	trol requirem	ents for the st	airway.	1			
Stairwell	0.58	10				REQ	REQ	REQ	REQ	ADD2	ADD2
Storage Room											
<50 ft ²	0.97	6	REQ							ADD2	ADD2
\geq 50 ft ² and \leq 1000 ft ²	0.46	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	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Workshop	1.14	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2

		The <i>control</i> functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each <i>space</i> 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.									
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Building Type Specific/Space Types ¹	<i>LPD</i> Allowances, W/ft ²	RCR Threshold	а	b	с	d	e	f	g	h	i
Facility for the visually impaired ³	,		-		-	-	-	-	8		<u> </u>
Chapel (used primarily by residents)	1.06	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Recreation room/common living room (and not used primarily by staff)	1.80	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Automotive (See "Vehicular Maint	tenance Area")										
Convention Center—Exhibit Space	0.88	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Dormitory—Living Quarters	0.54	8	REQ								
Fire Station—Sleeping Quarters	0.20	6	REQ								
Gymnasium/Fitness Center											
Exercise area	0.50	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Playing area	0.82	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Healthcare Facility											
Exam/treatment room	1.68	8	REQ			REQ	REQ	REQ		ADD2	ADD2
Imaging room	1.06	6	REQ			REQ				ADD2	ADD2
Medical supply room	0.54	6	(See "Storag	e Room" und	er "Common	Space Types'	' for control req	uirements.)			
Nursery	1.00	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Nurse's station	0.81	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Operating room	2.17	6	REQ			REQ				ADD2	ADD2
Patient room	0.62	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Physical therapy room	0.84	6	REQ			REQ	REQ	REQ		ADD2	ADD2
Recovery room	1.03	6	REQ			REQ	REQ	REQ		ADD2	ADD2

		The <i>control</i> functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each <i>space</i> 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.									
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Building Type Specific/Space		RCR									
Types ¹	LPD Allowances, W/ft ²	Threshold	a	b	c	d	e	f	g	h	i
Library											
Reading area	0.82	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Stacks	1.20	4	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
Manufacturing Facility											
Detailed manufacturing area	0.93	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Equipment room	0.65	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Extra high bay area (>50 ft <i>floor</i> -to-ceiling height)	1.05	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
High bay area (>25 to 50 ft <i>floor</i> -to-ceiling height)	0.75	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Low bay area (<25 ft <i>floor</i> -to-ceiling height)	0.96	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Museum											
General exhibition area	1.05	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Restoration room	0.85	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Performing Arts Theater— Dressing Room	0.36	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Post Office—Sorting Area	0.68	4	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
Religious Facility											
Fellowship hall	0.55	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Worship/pulpit/choir area	1.53	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Retail Facilities											
Dressing/fitting room	0.50	8	REQ	ADD1	ADD1	REQ		REQ		REQ	

	The control paragraphs (1) All RI (2) At leas (3) At leas	The <i>control</i> functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each <i>space</i> 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.									
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Building Type Specific/Space	IPD Allowances W/ft^2	RCR Threshold	9	ь	c	d	0	f	a	h	
Mall concourse	0.90	4	REO	ADD1	ADD1	REO	REO	REO	5	ADD2	ADD2
Sports Arena_Playing Area ⁸											
Class I facility	2.47	4	REO	ADD1	ADD1	REO	REO	REO		ADD2	ADD2
Class II facility	1.96	4	REO	ADD1	ADD1	REO	REO	REO		ADD2	ADD2
Class III facility	1.70	4	REO	ADD1	ADD1	REO	REQ	REO		ADD2	ADD2
Class IV facility	1.13	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Transportation Facility	•	•		•							
Baggage/carousel area	0.45	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Airport concourse	0.31	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Terminal ticket counter	0.62	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Warehouse—Storage Area											
Medium to bulky, palletized items	0.35	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/ft² shall be allowed, provided that the additional lighting is controlled separately from the base allowance of 0.43 W/ft². The additional 0.52 W/ft² allowance shall not be used for any other purpose.

8. Class of play as defined by IES RP-6.

9.6.2 Additional Interior Lighting Power

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

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

- a. For *spaces* in which lighting is specified to be installed in addition to the *general lighting* for the purpose of decorative appearance or for highlighting art or exhibits not exempted in Section 9.2.2.3, Exception 1, provided that the additional lighting power shall not exceed 0.75 W/ft² of such *spaces*.
- b. For lighting *equipment* installed in sales areas and specifically designed and directed to highlight merchandise, calculate the additional lighting power as follows:

Additional Interior Lighting Power Allowance = $1000 \text{ W} + (\text{Retail Area } 1 \times 0.45 \text{ W/ft}^2) + (\text{Retail Area } 2 \times 0.45 \text{ W/ft}^2)$ $+ (\text{Retail Area } 3 \times 1.05 \text{ W/ft}^2) + (\text{Retail Area } 4 \times 1.88 \text{ W/ft}^2)$

where

Retail Area 1	=	the <i>floor</i> area for all products not listed in Retail Areas 2, 3, or 4
Retail Area 2	=	the <i>floor</i> area used for the sale of vehicles, sporting goods, and small electronics
Retail Area 3	=	the <i>floor</i> area used for the sale of furniture, clothing, cosmetics, and artwork
Retail Area 4	=	the <i>floor</i> area used for the sale of jewelry, crystal, and china

Exception to 9.6.2

Other merchandise categories may be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the *authority having jurisdiction*.

9.6.3 Additional Interior Lighting Power Using Nonmandatory Controls

An additional lighting power allowance shall be permitted for *space* types with nonmandatory *controls* installed as identified in Table 9.6.3 when all mandatory *controls* are used according to Section 9.4. This allowance is added to the *interior lighting power allowance* and is calculated as follows:

Additional Interior Lighting Power Allowance = Lighting Power Under Control × Control Factor

where

Lighting Power Under Control	=	the total input watts of all <i>lamps</i> being controlled using the <i>control</i> method indicated
Control Factor	=	the value given in Table 9.6.3 for the corresponding <i>space</i> type and <i>control</i> method

	Space Ty	уpe			
Additional <i>Control</i> Method (in Addition to Mandatory Requirements)	Open Office	Private Office	Conference Room, Meeting Room, Classroom (Lecture/ Training)	Retail Sales Area	Lobby, Atrium, Dining Area, Corridors/ Stairways, Gym/ <i>Pool</i> , Mall Concourse, Parking Garage
<i>Manual</i> , continuous dimming <i>control</i> or programmable multilevel dimming <i>control</i>	0.05	0.05	0.10	0.10	0
Programmable multilevel dimming <i>control</i> using programmable time scheduling	0.05	0.05	0.10	0.10	0.10
<i>Occupancy sensors</i> controlling the downlight component of workstation specific <i>luminaires</i> with continuous dimming to off capabilities	0.25 ^a	0	0	0	0
Occupancy sensors controlling the downlight component of workstation specific <i>luminaires</i> with continuous dimming to off operation, in combination with personal continuous dimming <i>control</i> of downlight illumination by workstation occupant	0.30 ^{a,b}	0	0	0	0
Automatic continuous daylight dimming in secondary sidelighted areas	0.10 ^e	0.10 ^e	0.10 e	0.10 e	0.10 e

Table 9.6.3 Control Factors Used in Calculating Additional Interior Lighting Power Allowance

a. *Control* factor is limited to workstation-specific *luminaires* in partitioned single occupant work *spaces* contained within an open office environment (i.e. direct-indirect *luminaires* with separately controlled downlight and uplight components, with the downward component providing illumination to a single occupant in an open plan workstation). Within 30 minutes of the occupant leaving the *space*, the downward component shall continuously dim to off over a minimum of two minutes. Upon the occupant entering the *space*, the downward component shall turn on at the minimum level and continuously raise the illumination to a preset level over a minimum of 30 seconds. The uplight component of workstation specific *luminaire* shall comply with Section 9.4.1.1 (h) (*automatic* full off).

b. In addition to the requirements described in footnote (a), the *control* shall allow the occupant to select their preferred light level via a personal computer, handheld device, or similarly accessible device located within the workstation.

c. Control factors may not be used if controls are used to satisfy exceptions to Section 5.5.4.2.3.

9.6.4 Room Geometry Adjustment

When using the Space-by-Space Method, an adjustment of the *space LPD* allowance is permitted for individual *spaces* where *room cavity ratio* (*RCR*) calculated for the empty room is documented to be greater than the *RCR* threshold for that *space* type shown in Table 9.6.1.

 $RCR = 2.5 \times \text{Room Cavity Height} \times \text{Room Perimeter Length/Room Area}$

where Room Cavity Height = Luminaire Mounting Height – Workplane.

For corridor/transition *spaces*, this adjustment is allowed when the corridor is less than 8 ft wide, regardless of the *RCR*.

The LPD allowance for these spaces may be increased by the following amount:

LPD Increase = Base *Space LPD* \times 0.20

where Base Space LPD = the applicable LPD allowance from Table 9.6.1.

9.7 Submittals

9.7.1 General

9.7.2 Where required by the *authority having jurisdiction*, the submittal of compliance documentation and supplemental information in accordance with Section 4.2.2.**Completion Requirements**

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

9.7.2.1 Drawings

Construction documents shall require that within 90 days after the date of system acceptance, record drawings of the actual installation be provided to the building owner or the designated representative of the building owner. Record drawings shall include, as a minimum, the location, luminaire identifier, control, and circuiting for each piece of lighting equipment.

9.7.2.2 Manuals

Construction documents shall require for all lighting *equipment* and lighting *controls* that an operating *manual* and maintenance *manual* be provided to the *building* owner or the designated representative of the *building* owner within 90 days after the date of *system* acceptance. These manuals shall include, at a minimum, the following:

- a. Submittal data indicating all selected options for each piece of lighting *equipment*, including but not limited to *lamps*, *ballasts*, *drivers*, and lighting *controls*.
- b. Operation and maintenance manuals for each piece of lighting *equipment* and lighting *controls* with routine maintenance clearly identified including, as a minimum, a recommended relamping/cleaning program and a schedule for inspecting and recalibrating all lighting *controls*.
- c. A complete narrative of how each lighting *control system* is intended to operate, including recommended settings.

9.7.2.3 Daylighting Documentation

The design documents shall identify all *luminaires* for *general lighting* that are located within *daylight areas under skylights, daylight areas under roof monitors,* and *primary sidelighted area* and *secondary sidelighted areas.*

9.8 Product Information (Not Used)

9.9 Functional Testing

Lighting *control devices* and control *systems* shall be tested to ensure that *control* hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the *construction documents* and *manufacturer*'s installation instructions. When *occupancy sensors*, time switches, programmable schedule controls, or *photosensors* are installed, at a minimum, the following procedures shall be performed:

- a. Occupancy Sensors
 - 1. Certify that the sensor has been located and aimed in accordance with *manufacturer* recommendations.
 - 2. For projects with up to seven (7) occupancy sensors, all occupancy sensors shall be tested.
 - 3. For projects with more than seven (7) *occupancy sensors*, testing shall be done for each unique combination of sensor type and *space* geometry.
 - (a) For each sensor to be tested, verify the following:
 - (1) Status indicator (as applicable) operates correctly.
 - (2) *Controlled* lights turn off or down to the permitted level within the required time.
 - (3) For auto-ON *occupancy sensors*, the lights turn on to the permitted level when someone enters the *space*.
 - (4) For manual-ON sensors, the lights turn on only when manually activated.
 - (5) The lights are not incorrectly turned on by movement in nearby areas or by HVAC operation.
- b. Automatic Time Switches
 - 1. Confirm that the *automatic* time-switch *control* is programmed with appropriate weekday, weekend, and holiday (as applicable) schedules.
 - 2. Document for the owner *automatic* time-switch programming, including weekday, weekend, and holiday schedules, as well as all setup and preference program settings.
 - 3. Verify that correct time and date are properly set in the time switch.

- 4. Verify that any battery backup (as applicable) is installed and energized.
- 5. Verify that the override time limit is set to no more than two (2) hours.
- 6. Simulate occupied condition. Verify and document the following:
 - (a) All lights can be turned on and off by their respective area *control* switch.
 - (b) The switch only operates lighting in the *enclosed space* in which the switch is located.
- 7. Simulate unoccupied condition. Verify and document the following:
 - (a) All nonexempt lighting turns off.

(b) *Manual* override switch allows only the lights in the *enclosed space* where the override switch is located to turn on or remain on until the next scheduled shut off occurs.

- c. Daylight Controls
- 1. All *control devices* (photocontrols) have been properly located, field-calibrated, and set for appropriate *set points* and threshold light levels.
- 2. Daylight *controlled* lighting loads adjust to appropriate light levels in response to available daylight.
- 3. The location where calibration adjustments are made is *readily accessible* only to authorized personnel.

The individuals responsible for the functional testing shall not be directly involved in either the design or *construction* of the project and shall provide documentation certifying that the installed lighting *controls* meet or exceed all documented performance criteria.



10 OTHER EQUIPMENT

10.1 General

10.1.1 Scope

This section applies only to the *equipment* described below.

10.1.1.1 New Buildings

Other *equipment* installed in new *buildings* shall comply with the requirements of this section.

10.1.1.2 Additions to Existing Buildings

Other *equipment* installed in additions to *existing buildings* shall comply with the requirements of this section.

10.1.1.3 Alterations to Existing Buildings

10.1.1.3.1

Alterations to other building service equipment or systems shall comply with the requirements of this section applicable to those specific portions of the building and its systems that are being altered.

10.1.1.3.2

Any new *equipment* subject to the requirements of this section that is installed in conjunction with the *alterations* as a direct replacement of *existing equipment* or *control devices* shall comply with the specific requirements applicable to that *equipment* or *control devices*.

Exception to 10.1.1.3.2

Compliance shall not be required for the relocation or reuse of existing equipment.

10.2 Compliance Paths

10.2.1 Compliance

Compliance with Section 10 shall be achieved by meeting all requirements of Section 10.1, "General"; Section 10.4, "Mandatory Provisions"; and Section 10.8, "Product Information."

10.2.2

Projects using the *Energy Cost Budget* Method (Section 11 of this standard) must comply with Section 10.4, the mandatory provisions of this section, as a portion of that compliance path.

10.3 Simplified/Small Building Option (Not Used)

10.4 Mandatory Provisions

10.4.1 Electric Motors

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

Electric motors manufactured alone or as a component of another piece of *equipment* with a *rated motor power* of 1 hp or more, and less than or equal to 200 hp, shall comply with the requirements shown in Table 10.8-1 for *NEMA Design A motors*, *NEMA Design B motors*, and *IEC Design N motors*, and Table 10.8-2 for *NEMA Design C motors* and *IEC Design H motors*.

General purpose *small electric motors* with an *rated motor power* of 0.25 hp or more, and less than or equal to 3 hp, shall have a minimum average full-load *efficiency* that is not less than as shown in Table 10.8-3 for polyphase *small electric motors* and Table 10.8-4 for capacitor-start capacitor-run *small electric motors* and capacitor-start induction-run *small electric motors*.

Fire pump electric motors shall have a minimum nominal full-load *efficiency* that is not less than that shown in Table 10.8-5.

Exception to 10.4.1

The standards in this section do not apply to the following exempt electric motors:

- 1. Air-over electric motors.
- 2. Component sets of an electric motor.
- 3. Liquid-cooled electric motors.
- 4. Submersible electric motors.
- 5. Inverter-only electric motors.

10.4.2 Service Water Pressure-Booster Systems

Service water pressure-booster systems shall be designed such that the following apply:

- a. One or more pressure sensors shall be used to vary pump speed and/or start and stop pumps. The sensors shall either be located near the critical *fixtures* that determine the pressure required, or logic shall be employed that adjusts the *set point* to simulate operation of remote sensors.
- b. No devices shall be installed for the purpose of reducing the pressure of all of the water supplied by any booster *system* pump or booster *system*, except for safety devices.
- c. No booster *system* pumps shall operate when there is no *service* water flow.

10.4.3 Elevators

Elevator systems shall comply with the requirements of this section.

10.4.3.1 Lighting

For the *luminaires* in each elevator cab, not including signals and displays, the sum of the lumens divided by the sum of the watts (as described in Section 9.1.4) shall be no less than 35 lm/W.

10.4.3.2 Ventilation Power Limitation

Cab *ventilation* fans for elevators without air conditioning shall not consume over 0.33 W/cfm at maximum speed.

10.4.3.3 Standby Mode

When stopped and unoccupied with *doors* closed for over 15 minutes, cab interior lighting and *ventilation* shall be de-energized until required for operation.

10.4.3.4 Design Documents

Design documents shall list the following for new elevators:

- a. Usage category as defined in ISO 25745-2 between 1 and 6.
- b. *Energy efficiency* classes A through G per ISO 25745-2, Table 7.

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 Whole-Building Energy Monitoring

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

10.4.5.1 Monitoring

Measurement devices shall be installed to monitor the *building* use of the following types of *energy* supplied by a utility, *energy* provider, or plant that is not within the *building*:

- a. Natural gas
- b. Fuel oil
- c. Propane
- d. Steam
- e. Chilled water
- f. Hot water

10.4.5.2 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 10.4.5.1 and 10.4.5.2

- 1. Buildings or additions less than $25,000 \text{ ft}^2$.
- 2. Individual tenant *spaces* less than $10,000 \text{ ft}^2$.
- 3. Dwelling units.
- 4. *Residential buildings* with less than 10,000 ft² of common area.
- 5. Fuel used for on-site emergency equipment.

6.

- 10.5 Prescriptive Compliance Path (Not Used)
- 10.6 Alternative Compliance Path (Not Used)
- 10.7 Submittals (Not Used)
- **10.8 Product Information**

	Nominal Full-Load <i>Efficiency</i> , %								
	2-Pole	2-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					

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}

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.

	Nominal Full-Load <i>Efficiency</i> , %							
	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		

Table 10.8-2	Minimum Nominal Full-Load Efficiency for NEMA Design C and IEC Design H Motors at 60
	Hz ^{a,b}

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 (I-P)

	Full-Load Efficiency, %	Full-Load Efficiency, %							
	Open Motors	Open Motors							
Number of Poles \Rightarrow	2	4	6						
Synchronous Speed (RPM) \Rightarrow	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	81.1						
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 (I-P)

	Full-Load Efficiency, % Open Motors							
Number of Poles \Rightarrow	2	4	6					
Synchronous Speed (RPM) \Rightarrow	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.

Number of Poles \Rightarrow	Full-Load Efficiency, %									
	Open Drip-Proof Motors				Totally Enclosed Fan-Cooled Motors					
	2	4	6	8	2	4	6	8		
Synchronous Speed (RPM) \Rightarrow	3600	1800	1200	900	3600	1800	1200	900		
Motor Horsepower, hp (kW)										
1 (0.75)	NR	82.5	80.0	74.0	75.5	82.5	80.0	74.0		
1.5 (1.1)	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0		
2 (1.5)	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5		
3 (2.2)	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0		
5 (3.7)	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5		
7.5 (5.5)	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5		
10 (7.5)	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5		
15 (11)	89.5	91.0	90.2	89.5	90.2	91.0	90.2	88.5		
20 (15)	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5		
25 (18.5)	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5		
30 (22)	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0		
40 (30)	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0		
50 (37)	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7		
60 (45)	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7		
75 (55)	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0		
100 (75)	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0		
125 (90)	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6		
150 (110)	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6		
200 (150)	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1		
250 (186)	94.5	95.4	95.4	94.5	95.4	95.0	95.0	94.5		
300 (224)	95.0	95.4	95.4	NR	95.4	95.4	95.0	NR		
350 (261)	95.0	95.4	95.4	NR	95.4	95.4	95.0	NR		
400 (298)	95.4	95.4	NR	NR	95.4	95.4	NR	NR		
450 (336)	95.8	95.8	NR	NR	95.4	95.4	NR	NR		
500 (373)	95.8	95.8	NR	NR	95.4	95.8	NR	NR		

Table 10.8-5 Minimum Nominal Full-Load Efficiency for Fire Pump Electric Motors^a

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



11 ENERGY COST BUDGET METHOD

11.1 General

11.1.1 Energy Cost Budget Method Scope

The *building Energy Cost Budget* Method is an alternative to the prescriptive provisions of this standard. It may be employed for evaluating the compliance of all *proposed designs* except designs with no mechanical *system*.

11.1.2 Trade-Offs Limited to Building Permit

When the *building* permit being sought applies to less than the whole *building*, only the calculation parameters related to the *systems* to which the permit applies shall be allowed to vary. Parameters relating to unmodified existing conditions or to future *building* components shall be identical for both the *energy cost budget* and the *design energy cost* calculations. Future *building* components shall meet the prescriptive requirements of Sections 5.5, 6.5, 7.5, and either 9.5 or 9.6.

11.1.3 Envelope Limitation

For new *buildings* or additions, the *building Energy Cost Budget* Method results shall not be submitted for *building* permit approval to the *authority having jurisdiction* prior to submittal for approval of the *building envelope* design.

11.2 Compliance

Compliance with Section 11 will be achieved if

- a. all requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 are met;
- b. the *design energy cost*, as calculated in Section 11.5, does not exceed the *energy cost budget* as calculated by the *simulation program* described in Section 11.4; and
 - 1. the *energy efficiency* level of components specified in the building design meet or exceed the *efficiency* levels used to calculate the *design energy cost*.

c.

d.

Informative Note

The energy cost budget and the design energy cost calculations are applicable only for determining compliance with this standard. They are not predictions of actual energy consumption or costs of the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this standard, changes in energy rates between design of the building and occupancy, and precision of the calculation tool.

11.3 Simplified Option (Not Used)

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. For components that cannot be modeled by the *simulation program*, the exceptional calculation methods requirements in Section 11.4.5 shall be used.

Informative Note

ASHRAE Standing Standard Project Committee 90.1 recommends that <u>the simulation program a</u> <u>compliance shell implementing implements</u> the rules of <u>a compliance supplement Section 11</u> that controls <u>simulation</u> inputs to and <u>reports</u> 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 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-side economizer and fluid economizer with integrated control.
- h. The budget building design characteristics <u>unless otherwise</u> specified in Section <u>11.5</u>-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, and the results shall be furnished by the software provider.

11.4.2 Climatic Data

The *simulation program* shall perform the simulation using hourly values of climatic data, <u>such as including</u> temperature, <u>and humidity, solar radiation, and wind speed and direction</u> from representative climatic data, for the <u>eity site</u> in which the *proposed design* is to be located. For <u>locations eities or urban regions with</u> several climatic data entries, and for locations for which several climatic data sources are available or where weather data <u>are is</u> not available, the designer shall select available weather data that best represent the climate at the *construction* site. <u>Such The</u> 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.

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. When the *simulation* program does not <u>model</u> a design, material, or device, the *authority having jurisdiction* may approve an exceptional calculation method to shall be used as approved by the *authority having jurisdiction* 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.

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. All applications for approval of an exceptional method shall include the following:

- a. Theoretical and empirical information verifying the method's accuracy, and step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.
- b. copies of all spreadsheets used to perform the calculations.
- c. A sensitivity analysis of *energy* consumption when each of the input parameters that are estimated 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 energy cost budget and design energy cost calculated with and without the exceptional calculation <u>methods.</u>

11.5 Calculation of Design Energy Cost and Energy Cost Budget 11.5.1

11.5.2 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.**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, 8, 9, 10, and 11, 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 multiple HVAC zones are combined into a single thermal block in accordance with Table 11.5.1, the efficiencies for budget System Types 6, 8, and 10 taken from Tables 6.8.1-1 through 6.8.1-4, shall be based on 9,000 Btu/hr equipment capacity for residential spaces otherwise it shall be based on the capacity of the thermal block divided by the number of HVAC zones. Budget System Types 3, 4, 9, and 11 efficiencies taken from Table 6.8.1-1 through 6.8.1-4 shall be based on the cooling equipment capacity of a single floor when grouping identical floors in accordance with Table 11.5.1. 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:

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

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

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

(applies to heat pump-Systems 6 and 9 heating efficiency only)

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

 $\underline{COP_{nfcooling}} = 0.3322 \times EER - 0.2145$

(applies to Systems 8 and 10 cooling efficiency only)

<u> $COP_{nfheating} = 1.1329 \times COP - 0.214$ </u>

(applies to System 8 heating efficiency only)

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.

d. **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.

Exceptions to 11.5.2(d)

^{1.} When modeling *demand control ventilation* in the *proposed design* for spaces where *demand control ventilation* is not required per 6.4.3.8.

- 2. Where the minimum outdoor air intake flow in the proposed design is provided in excess of the amount required by Section 6.5.3.7, the baseline building design shall be modeled to reflect the minimum amount required by Section 6.5.3.7.
- 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.
- g. **Supply Airflow Rates.** *System* design supply air rates for the *budget building design* shall be based on a supply-air-to-room-air temperature <u>set-point</u> difference of 20°F or the minimum outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is greater. For *systems* with multiple zone *thermostat set points*, use the design *set point* that will result in the lowest supply air cooling *set point* or highest supply air heating *set point*. 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 fans serving the same functions and 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.

Exceptions to 11.5.2(g)

- 1. For *systems* serving laboratory *spaces*, airflow rate shall be based on a supply-air-to-room temperature *set-point* difference of 17°F or the required *ventilation* air or *makeup air*, whichever is greater.
- 2. If the *proposed design HVAC system* airflow rate based on latent loads is greater than the design airflow rate based on sensible loads, then the same supply-air-to-room-air humidity ratio difference (gr/lb) used to calculate the *proposed design* airflow shall be used to calculate design airflow rates for the *budget building design*.
- h. **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 (of the 8760 hours simulated). 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. The simulation program used, the version of the simulation program.

- b.c. 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.
- e.d. 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.
- e. 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).
- f. Building elevations and floor plans.
- g. A diagram showing the thermal blocks used in the computer simulation.
- h. An explanation of any significant modeling assumptions.
- d.i. 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 11.5.1, "1. Design Model," paragraph [a]).
- j. 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.
- e.k. Purchased energy rates used in the simulations.
- f.l. An explanation of any error messages noted in the simulation program output.
- m. 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.
- g.n. The reduction in design energy cost associated with on-site renewable energy.

Product Information (Not Used)

Table 11.5.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget

Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
1. Design Model	
a. The simulation model of the <i>proposed design</i> shall be consistent with the design documents, including proper accounting of <i>fenestration</i> and <i>opaque</i> envelope types and area; interior lighting power and <i>controls</i> ; <i>HVAC system</i> types, sizes, and <i>controls</i> ; and <i>service water-heating systems</i> and <i>controls</i> .	The <i>budget building design</i> shall be developed by modifying the <i>proposed design</i> as described in this table. Except as specifically instructed in this table, all <i>building systems</i> and <i>equipment</i> shall be modeled identically in the <i>budget building design</i> and <i>proposed</i>
b. All <i>conditioned spaces</i> in the <i>proposed design</i> shall be simulated as being both heated and cooled, even if no cooling or heating system is being installed. Temperature and humidity <i>control set points</i> and schedules, as well as <i>temperature control</i> <i>throttling range</i> , shall be the same for <i>proposed design</i> and <i>baseline building design</i> .	design.
c. When the <i>Energy Cost Budget</i> Method is applied to <i>buildings</i> in which <i>energy</i> -related features have not yet been designed (e.g., a <i>lighting system</i>), those yet-to-be-designed features shall be described in the <i>proposed design</i> so that they minimally	
comply with applicable mandatory and prescriptive requirements from Sections 5 through 10. Where the space classification for a <i>building</i> is not known, the <i>building</i> shall be categorized as an office <i>building</i> .	
2. Additions and Alterations	
It is acceptable to demonstrate compliance using <i>building</i> models that exclude parts of the <i>existing building</i> , provided all of the following conditions are met:	Same as <i>proposed design</i> .
 a. Work to be performed under the current permit application in excluded parts of the <i>building</i> shall meet the requirements of Sections 5 through 10. 	
b. Excluded parts of the <i>building</i> are served by <i>HVAC systems</i> that are entirely separate from those serving parts of the <i>building</i> that are included in the <i>building</i> model.	
c. Design <i>space</i> temperature and <i>HVAC system</i> operating <i>set points</i> and schedules on either side of the boundary between included and excluded parts of the <i>building</i> are identical.	
d. If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the <i>building</i> are on the same utility meter, the rate shall reflect the utility block or rate for the <i>building</i> plus the addition.	
3. Space Use Classification	
The <i>building</i> area type or <i>space</i> type classifications shall be chosen in accordance with Section 9.5.1 or 9.6.1. The user or designer shall specify the <i>space</i> use classifications using either the <i>building</i> area type or <i>space</i> type categories but shall not combine the two types of categories within a single permit application. More than one <i>building</i> area type category may be used for a <i>building</i> if it is a mixed-use facility.	Same as <i>proposed design</i> .
Exception: Where <i>space</i> types neither exist nor are designated in design documents, use type shall be specified in accordance with Section 9.5.1.	

Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
4. Schedules	
The schedule types listed in Section 11.4.1.1(b) shall be required input. The schedules shall be typical of the <i>proposed design</i> as determined by the designer and approved by the <i>authority having</i> <i>jurisdiction</i> . Required schedules shall be identical for the <i>proposed design</i> and <i>budget building design</i> . Temperature and Humidity Schedules. Temperature and humidity <i>control set points</i> and schedules as well as <i>temperature</i>	Same as proposed design.
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:	
 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. HVAC fans shall remain on during occupied and 	
unoccupied hours in <i>spaces</i> that have health- and safety- mandated minimum <i>ventilation</i> requirements during unoccupied hours.	
3. Dedicated outdoor air supply fans shall stay off during unoccupied hours.	
HVAC fans shall remain on during occupied and unoccupied hours in systems primarily serving computer rooms.	

Fable 11.5.1	Modeling Requirements for	Calculating Design Energy	Cost and Energy Cost Budget
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5. Building Envelope

All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as <u>installed-built</u> for *existing building envelopes*.**Exceptions:** The following *building* elements are permitted to differ from architectural drawings.

- 1. Any *building envelope* assembly that covers less than 5% of the total area of that assembly type (e.g., *exterior walls*) need not be separately described. If not separately described, the area of a *building envelope* assembly must be added to the area of the adjacent assembly of that same type.
- Exterior surfaces whose azimuth *orientation* and tilt differ by no more less than 45 degrees and are otherwise the same may shall be described as either a single surface or by using multipliers.
- 3. The exterior *roof* surface shall be modeled using the aged solar *reflectance* and thermal *emittance* determined in accordance with Section 5.5.3.1.1(a). Where aged test data are unavailable, the *roof* surface shall be modeled with a solar *reflectance* of 0.30 and a thermal *emittance* of 0.90

The *budget building design* shall have identical *conditioned floor area* and identical exterior dimensions and orientations as the *proposed design*, except as follows:

- a. *Opaque* assemblies, such as *roof*, *floors*, *doors*, and *walls*, shall be modeled as having the same *heat capacity* as the *proposed design* but with the minimum *U-factor* required in Section 5.5 for new *buildings* or additions and Section 5.1.3 for *alterations*.
- b. The exterior *roof* surfaces shall be modeled with a solar *reflectance* and thermal *emittance* as required in Section 5.5.3.1.1(a). All other *roofs*, including *roofs* exempted from the requirements in Section 5.5.3.1.1, shall be modeled the same as the *proposed design*.

Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
4. Manually operated <i>fenestration</i> shading devices, such as blinds or shades, shall not be modeled. Permanent shading devices, such as fins, overhang, and lightshelves, shall be modeled.	 C. No shading projections are to be modeled; <i>fenestration</i> shall be assumed to be flush with the <i>wall</i> or <i>roof</i>. If the <i>fenestration area</i> for new <i>buildings</i> 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 <i>vertical fenestration</i> <i>area</i> facing west or east of the <i>proposed design</i> exceeds the area limit set in Section 5.5.4.5 then the <i>energy cost budget</i> shall be generated by simulating the <i>budget building design</i> with its actual <i>orientation</i> and again after rotating the entire <i>budget building</i> <i>design</i> 90, 180, 270 degrees and then averaging the results. <i>Fenestration U-factor</i> shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate, and the <i>SHGC</i> shall be equal to the criteria from Tables 5.5-0 through 5.5-8 for the appropriate climate. For portions of those tables where there are no <i>SHGC</i> requirements, the <i>SHGC</i> shall be equal to that determined in accordance with Section C3.6(c). The <i>VT</i> shall be equal to that determined in accordance with Section C3.6(c). The <i>fenestration</i> model for <i>building envelope alterations</i> shall reflect the limitations on area, <i>U-factor</i>, and <i>SHGC</i> as described in Section 5.1.3. d. <i>Skylights</i> shall be included in each thermal block when required by Section 5.5.4.2.3. Exceptions: When trade-offs are made between an addition and an <i>existing building</i>, as described in the exception to Section 4.2.1.2, the <i>building envelope</i> assumptions for the <i>existing building</i> in the <i>budget</i> <i>building design</i> shall reflect existing conditions prior to <i>on</i> w avaijoiner, that or neart of this accervit.
6. Lighting	
 Lighting power in the <i>proposed design</i> shall be determined as follows: a. Where a complete <i>lighting system</i> exists, the actual lighting power for each <i>thermal block</i> shall be used in this model. b. Where a <i>lighting system</i> has been designed, lighting power shall be determined in accordance with Sections 9.1.3 and 9.1.4. c. Where no lighting exists or is specified, lighting power shall be determined in accordance with the <i>Building</i> Area Method for the appropriate <i>building area type</i>. d. <i>Lighting system</i> power shall include all <i>lighting system</i> components shown or provided for on plans (including <i>lamps</i>, <i>ballasts</i>, task <i>fixtures</i>, and furniture-mounted <i>fixtures</i>). e. The lighting schedules in the <i>proposed design</i> shall reflect the mandatory <i>automatic</i> lighting <i>control</i> requirements in Section 9.4.1 (e.g., programmable <i>controls</i> or occupancy sensors). 	 a. Lighting power in the <i>budget building design</i> shall be determined using the same categorization procedure (<i>Building</i> Area Method or Space-by-Space Method) and categories as the <i>proposed design</i> with lighting power set equal to the maximum allowed for the corresponding method and category in Section 9.2. Additional interior lighting power for nonmandatory <i>controls</i> allowed under Section 9.6.3 shall not be included in the <i>budget building design</i>. b. Power for <i>fixtures</i> not included in the lighting power calculation shall be modeled identically in the <i>proposed design</i> and <i>budget building design</i>. c. Mandatory <i>automatic</i> lighting <i>controls</i> required by Section 9.4.1 shall be modeled the same as the <i>proposed design</i>.

Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
 Exception: Automatic daylighting controls required by Section 9.4.1 shall be modeled directly in the proposed design or through schedule adjustments determined by a daylighting analysis approved by the building official. 1. Automatic lighting controls included in the proposed design but not required by Section 9.4.1 may be modeled directly in the building simulation or be modeled in the building simulation through schedule adjustments determined by a separate analysis approved by the authority having jurisdiction. As an alternative to modeling such lighting controls, the proposed design lighting power may be reduced for each luminaire under control by dividing the rated lighting power of the luminaire by the factor (1 + ΣCF), where ΣCF indicates the sum of all applicable controls factors (CF) per Section 9.6.3 and Table 9.6.3. 	
7. Thermal Blocks—HVAC Zones Designed	
Where <i>HVAC zones</i> are defined on HVAC design drawings, each <i>HVAC zone</i> shall be modeled as a separate <i>thermal block</i> .	Same as proposed design.
Exceptions: Different <i>HVAC zones</i> may be combined to create a single <i>thermal block</i> or identical <i>thermal blocks</i> to which multipliers are applied, provided <u>that</u> all of the following conditions are met:	
 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·ft² (31 W/m²) from the average. 	
2. All <i>HVAC zones</i> in the <i>thermal block</i> that are adjacent to glazed <i>exterior walls</i> and glazed <i>semiexterior walls</i> face the same <i>orientation</i> or their orientations-are within 45 degrees of each other vary by less than 45 degrees.	
3. All of the zones are served by the same <i>HVAC system</i> or	
3.4. All of the zones have schedules that differ by 40 or less equivalent full-load hours per week.	
9 Thomas Blocks HVAC Zones Not Designed	

Table 11.5.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget

0. Therman Divers—ITTAC Zones Not Designed	
Where the <i>HVAC zones</i> and <i>systems</i> have not yet been designed, <i>thermal blocks</i> shall be defined based on similar internal load densities, occupancy, lighting, thermal and <i>space</i> temperature schedules, and in combination with the following:	Same as <i>proposed design</i> .
a. Separate <i>thermal blocks</i> shall be assumed for interior and perimeter <i>spaces</i> . Interior <i>spaces</i> shall be those located more than 15 ft from an <i>exterior wall</i> or <i>semiexterior wall</i> . Perimeter <i>spaces</i> shall be those located closer than 15 ft from an <i>exterior wall</i> or <i>semiexterior wall</i> . A separate thermal zone does not need to be modeled for areas adjacent to <i>semiexterior walls</i> that separate <i>semiheated space</i> from <i>conditioned space</i> .	

Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
b. Separate <i>thermal blocks</i> shall be assumed for <i>spaces</i> adjacent to glazed <i>exterior walls</i> or glazed <i>semiexterior walls</i> ; a separate zone shall be provided for each <i>orientation</i> , except that orientations that differ by <u>no more less</u> than 45 degrees may be considered to be the same <i>orientation</i> . Each zone shall include all <i>floor</i> area within 15 ft of glazed perimeter <i>walls</i> having more than one <i>orientation</i> shall be divided proportionally between zones.	
c. Separate <i>thermal blocks</i> shall be assumed for <i>spaces</i> having <i>floors</i> that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.	
d. Separate <i>thermal blocks</i> shall be assumed for <i>spaces</i> having <u>exterior ceiling or <i>roof</i> assemblies from zones that do not share these features.</u>	
9. Thermal Blocks—Multifamily Residential Buildings	
<i>Residential spaces</i> shall be modeled using <u>at least</u> one <i>thermal</i> <i>block-<u>HVAC zone</u> per <i>spacedwelling unit</i> except that for those <u>units with facing</u> the same orientations <u>which</u> may be combined into one <i>thermal block</i>. Corner units and units with <i>roof</i> or <i>floor</i> loads shall only be combined with units sharing these features.</i>	Same as proposed design.
10. HVAC Systems	
 The <i>HVAC system</i> type and all related performance parameters, such as <i>equipment</i> capacities and efficiencies, in the <i>proposed design</i> shall be determined as follows: a. Where a complete <i>HVAC system</i> exists, the model shall reflect the actual <i>system</i> type using actual component capacities and efficiencies. b. Where an <i>HVAC system</i> has been designed, the HVAC model shall be consistent with design documents. Mechanical <i>equipment</i> efficiencies shall be adjusted from actual <i>design conditions</i> to the standard rating conditions specified in Section 6.4.1 if required by the simulation model. Where <i>efficiency</i> ratings include supply fan <i>energy</i>, the <i>efficiency</i> rating shall be adjusted to remove the supply fan <i>energy</i> from the <i>efficiency</i> rating in the <i>budget building design</i>. The equations in Section 11.5.2 shall not be used in the <i>proposed design HVAC system</i> shall be modeled using <i>manufacturers'</i> full- and part-load data for the <i>HVAC system</i> without fan power. c. Where no heating <i>system</i> exists or no heating <i>system</i> has been specified, the heating <i>system</i> shall be identical to the <i>system</i> modeled in the <i>budget building design</i>. d. Where no cooling <i>system</i> exists or no cooling <i>system</i> has been specified, the cooling <i>system</i> shall be modeled as an air-cooled <i>single-zone system</i>, one unit per <i>thermal block</i>. The <i>system</i> shall be identical to the <i>system</i> shall be identical to the <i>system</i> shall be identical to the system 	The <i>HVAC system</i> type and related performance parameters for the <i>budget building design</i> shall be determined from Figure 11.5.2, the <i>system</i> descriptions in Table 11.5.2-1 and accompanying notes, and in accord with rules specified in Section 11.5.2(a) through 11.5.2(k).

Table 11.5.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget

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Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
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 model 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 is specified has been submitted with the design documents, no service water heating shall be modeled. Piping losses shall not be modeled. 	 The service water-heating system type in the budget building design shall be identical to the proposed design. The service water-heating system performance of the budget building design shall meet the requirements of Table 7.8 Sections 7.4 and 7.5. Exceptions: If the service water-heating system type is not listed in Table 7.8, it shall be identical to the proposed design determined based on Table G3.1.1-2. Where Section 7.5 applies, the boiler shall be split into a separate space-heating boiler and hot-water heater with efficiency requirements set to the least efficiency allowed. For 24-hour facilities that meet the prescriptive criteria for use of condenser heat recovery systems described in Section 6.5.6.2. If a condenser heat recovery 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 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 budget building design.

Table 11.5.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget

12. Miscellaneous Loads

Table 11.5.1	Modeling Requirements fo	r Calculating Design	Energy Cost and	Energy Cost Budget
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Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
 Receptacle, motor, and <i>process loads</i> shall be modeled and estimated based on the <i>building area type</i> or <i>space</i> type category and shall be assumed to be identical in the proposed and <i>budget building designs</i>. These loads shall be included in simulations of the <i>building</i> and shall be included when calculating the <i>energy cost budget</i> and <i>design energy cost</i>. All end-use load components within and associated with the <i>building</i> shall be modeled, unless specifically excluded by Sections 13 and 14-of Table 11.5.1, including but not limited to exhaust fans, parking garage <i>ventilation</i> fans, exterior <i>building</i> lighting, swimming <i>pool</i> heaters and pumps, elevators and escalators, refrigeration <i>equipment</i>, and cooking <i>equipment</i>. a. Where power and other systems covered by Sections 8 and 10 have been designed and submitted with design documents, those systems shall be determined in accordance with Sections 8 and 10. b. Where power and other systems covered by Sections 8 and 10 have not been submitted with design documents, those systems shall comply with but not exceed the requirements of those sections. 	Same as proposed design.Receptacle, motor, and process loads shall be modeled and estimated based on the building area type or space type category and shall be assumed to be identical in the proposed and budget building designs. These loads shall be included in simulations of the building and shall be included when calculating the energy cost budget and design energy cost. All end use load components within and associated with the building shall be modeled, unless specifically excluded by Sections 13 and 14 of Table 11.5.1, including but not limited to exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.
13. Refrigeration	
Where refrigeration equipment in the proposed design is rated in accordance with AHRI 1200, the rated energy use shall be modeled. Otherwise, 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 Table 6.8.1-13, the budget building design shall be modeled as specified in Table 6.8.1-13 using the actual equipment capacities.If the refrigeration equipment is not listed in Table 6.8.1-13, the budget building design shall be modeled the same as the proposed design.
14.13. Modeling Exceptions	·
All elements of the <i>proposed design building envelope</i> , HVAC, <i>service water heating</i> , lighting, and electrical <i>systems</i> shall be modeled in the <i>proposed design</i> in accordance with the requirements of Section 1 through 12 of Table 11.5.1.	None.
Exceptions: Components and <i>systems</i> in the <i>proposed design</i> may be excluded from the simulation model provided that	
1. component <i>energy</i> use does not affect the <i>energy</i> use of <i>systems</i> and components that are being considered for trade-off and	
2. the applicable prescriptive requirements of Sections 5.5, 6.5, 7.5, and either 9.5 or 9.6 applying to the excluded	

Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
If the <i>simulation program</i> cannot model a component or <i>system</i> included in the <i>proposed design</i> , one of the following methods shall be used with the approval of the <i>authority having</i> <i>jurisdiction</i> :	Same as <i>proposed design</i> .
 aIgnore the component if the <i>energy</i> impact on the trade offs being considered is not significant. 	
bModel the component substituting a thermodynamically similar component model.	
c. Model the HVAC system components or systems using the budget building design's HVAC system in accordance with Section 10 of Table 11.5.1. Whichever method is selected, the component shall be modeled identically for both the proposed	
design and budget building design.	

Table 11.5.1	Modeling Requirements for	Calculating Design Ener	gy Cost and Energy Cost Budget
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Figure 11.5.2 HVAC systems map

System No.	System Type	Fan Control	Cooling Type	Heating Type
1	<i>VAV</i> with parallel fan-powered boxes ^a	VAV ^d	Chilled water ^e	Electric resistance
2	VAV with reheat ^b	VAV ^d	Chilled water ^e	Hot-water <i>fossil fuel</i> boiler ^f
3	Packaged VAV with parallel fan- powered boxes ^a	VAV ^d	Direct expansion ^c	Electric resistance
4	Packaged VAV with reheat ^b	VAV ^d	Direct expansion ^c	Hot-water <i>fossil fuel</i> boiler ^f
5	Two-pipe fan coil	Single- or two- speed fan ^{i,j}	Chilled water ^e	Electric resistance
6	Water-source heat pump	Single- or two- speed fan ^{i,j}	Direct expansion ^c	Electric heat pump and boiler ^g
7	Four-pipe fan-coil	Single- or two- speed fan ^{i,j}	Chilled water ^e	Hot-water <i>fossil fuel</i> boiler ^f
8	Packaged terminal heat pump	Single-speed fan ⁱ	Direct expansion ^c	Electric heat pump ^h
9	Packaged rooftop heat pump	Single- or two- speed fan ^{i,j}	Direct expansion ^c	Electric heat pump ^h
10	Packaged terminal air conditioner	Single-speed fan ⁱ	Direct expansion	Hot-water <i>fossil fuel</i> boiler ^f
11	Packaged rooftop air conditioner	Single- or two- speed fan ^{i,j}	Direct expansion	Fossil fuel furnace

 Table 11.5.2-1
 Budget System Descriptions

a. VAV with Parallel Fan-Powered Boxes: Fans in parallel VAV fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume *set points* for fan-powered boxes shall be equal to the minimum rate for the *space* required for *ventilation* consistent with Exception 1(b) to Section 6.5.2.1. Supply air temperature *set point* shall be constant at the *design condition* (see Section 11.5.2[g]).

b. VAV with Reheat: Minimum volume set points for VAV reheat boxes shall be the larger of the following: the minimum primary outdoor airflow rate required to meet the Simplified Procedure ventilation requirements of ASHRAE Standard 62.1 for the zone or the airflow rate required to comply with applicable codes or accreditation standards, including but not limited to pressure relationships or minimum air change rates. 30% of zone peak airflow or the minimum ventilation rate, whichever is larger, consistent with Exception 1(a) to Section 6.5.2.1. The supply air temperature for cooling shall be reset higher by 5°F under the minimum cooling load conditions.

c. Direct Expansion: The *fuel* type for the cooling system shall match that of the cooling system in the proposed design.

d. VAV: Constant volume can be modeled if the *system* qualifies for Exception (2) to Section 6.5.2.1. Otherwise, t<u>T</u>he supply, return, or relief fan motor shall be modeled assuming a variable-speed drive and shall meet the VAV fan part-load performance requirements of Section G3.1.3.15. If the *proposed design*'s *system* has a *DDC system* at the zone level, static pressure *set-point reset* based on zone requirements in accordance with Section 6.5.3.2.3 shall be modeled.

Table 11.5.2-1 Budget System Descriptions

e. **Chilled Water:** For *systems* using purchased chilled water, the chillers are not explicitly modeled, and chilled-water costs shall be based as determined in Section 11.4.3. Otherwise, the *budget building design*'s chiller plant shall be modeled with chillers having the number as indicated in Table 11.5.2-2 as a function of *budget building design* chiller plant load and type as indicated in Table 11.5.2-3 as a function of *budget building design* chiller plant load and type as indicated in Table 11.5.2-3 as a function of individual chiller load. Where chiller *fuel* source is mixed, the *system* in the *budget building design*'s chillers for each *fuel* type. Chilled-water supply temperature shall be modeled at 44°F design supply temperature and 56°F return temperature. *Piping* losses shall not be modeled in either *building* model. Chilled-water supply water temperature shall be *reset* in accordance with Section 6.5.4.4. *Pump system power* for each pumping *system* shall be the same as for the *proposed design*; if the *proposed design* has no chilled-water pumps, the *budget building design* pump power shall be 22 W/gpm (equal to a pump operating against a 75 ft head, 65% combined impeller and motor *efficiency*). The chilled-water pumps shall be modeled as riding the pump curve or with variable-speed fan *control*, if required in Section 6.5.4.2. The heat-rejection device shall be an open-circuit axial-fan cooling tower with variable-speed fan *control*, if required in Section 6.5.4, and shall meet the performance requirements of Table 6.8.1-7. Condenser water design supply temperature shall be calculated using the cooling tower approach to the 0.4% evaporation design wet-bulb temperature as generated by the formula below, with a design temperature rise of 10°F:

Approach_{10°FRange} = $25.72 - (0.24 \times WB)$

where WB is the 0.4% evaporation design wet-bulb temperature in °F, valid for wet bulbs from 55°F to 90°F.

Except during economizer operation, T_the tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at *design conditions* a cooling tower leaving water temperature, where weather permits, per Table 11.5.2-5, floating up to the design leaving water temperature for the cooling tower. *Pump system power* for each pumping *system* shall be the same as the *proposed design*; if the *proposed design* has no condenser water pumps, the *budget building design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% combined impeller and motor *efficiency*). Each chiller shall be modeled with separate condenser water and chilled-water pumps interlocked to operate with the associated chiller.

- f. *Fossil Fuel Boiler*: For *systems* using purchased hot water or steam, the *boilers* are not explicitly modeled and hot-water or steam costs shall be based on actual utility rates. Otherwise, the *boiler* plant shall use the same *fuel* as the *proposed design* and shall be natural draft. The *budget building design boiler* plant shall be modeled with a single *boiler* if the *budget building design* plant load is 600,000 Btu/h or less and with two equally sized *boilers* for plant capacities exceeding 600,000 Btu/h. *Boilers* shall be staged as required by the load. Hot-water supply temperature shall be modeled at 180°F design supply temperature and 130°F return temperature. *Piping* losses shall not be modeled in either *building* model. Hot-water supply water temperature shall be *reset* in accordance with Section 6.5.4.4. *Pump system power* for each pumping *system* shall be the same as for the *proposed design*; if the *proposed design* has no hot-water pumps, the *budget building design* pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% combined impeller and motor *efficiency*). The hot-water *system* shall be modeled as primary-only with continuous variable flow. Hot-water pumps shall be modeled as riding the pump curve or with variable-speed drives when required by Section 6.5.4.2.
- g. Electric Heat Pump and *Boiler*: Water-source heat pumps shall be connected to a common heat pump water loop controlled to maintain temperatures between 60°F and 90°F. Heat rejection from the loop shall be provided by an closed-circuit axial-fan evaporative fluid cooler with two-speed fans if fan speed control as required in Section 6.5.5.2. Heat addition to the loop shall be provided by a *boiler* that uses the same *fuel* as the *proposed design* and shall be natural draft. If no *boilers* exist in the *proposed design*, the budget *building boilers* shall be *fossil fuel*. The *budget building design boiler* plant shall be modeled with a single *boiler* if the *budget building design* plant load is 600,000 Btu/h or less and with two equally sized *boilers* for plant capacities exceeding 600,000 Btu/h. *Boilers* shall be staged as required by the load. *Piping* losses shall not be modeled in either *building model*. *Pump system power* shall be the same as for the *proposed design*; if the *proposed design* plant against a 75 ft head, with a 65% combined impeller and motor *efficiency*. Loop flow shall be variable with flow shutoff at each heat pump when its compressor cycles OFF as required by Section 6.5.4.5. Loop pumps shall be modeled as riding the pump curve or with variable-speed drives when required by Section 6.5.4.2.
- h. Electric Heat Pump: Electric air-source heat pumps shall be modeled with electric auxiliary heat. The *system* shall be controlled with a multistage *space thermostat* and an *outdoor air thermostat* wired to energize auxiliary heat only on the last *thermostat* stage and when *outdoor air* temperature is less than 40°F.
- i. Fan System Operation: Fans shall be controlled in the same manner as in the *proposed design*; i.e., fan operation whenever the *space* is occupied or fan operation cycled ON calls for heating and cooling.
- j. Fan Speed Control: Fans shall operate as one or two speed as required by Section 6.5.3.2, regardless of the fan speed control used in the proposed design.

Table 11.5.2-2 Number of Chillers

Total Chiller Plant Capacity	Number of Chillers
≤300 tons	One
>300 tons, <600 tons	Two sized equally
≥600 tons	Two minimum with chillers added so that no chiller is larger than 800 tons, all sized equally

Table 11.5.2-3Water Chiller Types

Individual Chiller Plant Capacity	Electric Chiller Type	Fossil Fuel Chiller Type
≤300 tons	ReciprocatingScroll	Single-effect absorption, direct fired
>100 tons, < <u>300600</u> tons	Screw	Double-effect absorption, direct fired
≥ 300<u>600</u> tons	Centrifugal	Double-effect absorption, direct fired

Table 11.5.2-4 Economizer High-Limit Shutoff

Economizer Type	High-Limit Shutoff	
Air	Table 6.5.1.1.3	
Fluid (integrated)	When its operation will no longer reduce HVAC system energy	

Table 11.5.2-5 Cooling Tower Leaving Water Temperature

Climate Zone	Leaving Water Temperature
<u>5B, 5C, 6B, 8</u>	<u>65°F</u>
<u>0B, 1B, 2B, 3B, 3C, 4B, 4C, 5A, 6A, 7</u>	<u>70°F</u>
<u>3A, 4A</u>	<u>75°F</u>
<u>0A, 1A, 2A</u>	<u>80°F</u>

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Informative Appendix F

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 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 <u>27, 2011 7, 2018</u>)

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</td>

Product Class	National Standards	Southeastern Region	Southwestern Region-
Central Air Conditioners and Heat Pumps ^d		Standards ^b	Standards°
Split-system air conditioners	SEER = 13	SEER = 14	SEER = 14 EER = 12.2 (for units with

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

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			a rated cooling capacity- loss 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	SEER = 1 4	SEER = 14
	HSPF = 8.2	HSPF = 8.2	HSPF = 8.2
Split-system air conditioners ^a	SEER = 14	SEER = 1 4	SEER = 14 EER = 11.0
Single-package heat pumps	SEER = 14	SEER = 1 4	SEER = 14
	HSPF = 8.0	HSPF = 8.0	H SPF = 8.0
Small-duct high-velocity systems	SEER = 13	SEER = 13	SEER = 13
	HSPF = 7.7	HSPF = 7.7	HSPF = 7.7
Space-constrained products—air conditioners ^a	SEER = 12	SEER = 12	SEER = 12
Space-constrained products—heat pumps ^a	SEER = 12	SEER = 12	SEER = 12
	HSPF = 7.4	HSPF = 7.4	HSPF = 7.4

a. The Northern region for central air conditioners and heat pumps contains the following States: Alaska, Colorado, Connecticut, Idaho, Illinois, Indiana, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Washington, West Virginia, Wisconsin, and Wyoming.

 b. The Southeastern region for central air conditioners and heat pumps contains the following States: Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia, and the District of Columbia.
 c. The Southwestern region for central air conditioners and heat pumps contains the States of Arizona, California, Nevada, and New Mexico.

d. SEER is Seasonal Energy Efficiency Ratio; EER is Energy Efficiency Ratio; HSPF is Heating Seasonal Performance Factor; and Btu/h is British thermal units per hour.

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Table F-1 Minimum Efficiency Requirements for Single-Phase Central Air Conditioners and Heat Pumps for sale in US					
	Capacity	National	Southeastern	Southwestern	
Product Class	Range	Standards	Region Standards ^a	Region Standards ^b	Test Procedure ^f
Central Air Conditioners and Heat Pumps ^c					
Split-System air	<u><45,000</u>	before 1/1/2023	before 1/1/2023	before 1/1/2023	AHRI 210/240-2017
conditioners for US	Btu/h single	<u>SEER = 13.0</u>	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	before 1/1/2023
applications	<u>phase</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	EER=12.2	
				<u>P_{W,OFF} ≤ 30 W</u>	AHRI 210/240-2023
		after 1/1/2023	after 1/1/2023		after 1/1/2023
		<u>SEER2 = 13.4</u>	<u>SEER2 = 14.3</u>	after 1/1/2023	
		<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>SEER2 = 14.3</u>	
				EER2=11.7/9.8 ^d	
				<u>P_{W,OFF} ≤ 30 W</u>	
Split-system air	≥45,000	before 1/1/2023	before 1/1/2023	before 1/1/2023	AHRI 210/240-2017
conditioners	Btu/h and	<u>SEER = 13.0</u>	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	before 1/1/2023
	<u><65,000</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	EER=11.7 ^d	
	Btu/h single			<u>P_{W,OFF} ≤ 30 W</u>	AHRI 210/240-2023
	<u>phase</u>	after 1/1/2023	after 1/1/2023		after 1/1/2023
		<u>SEER2 = 13.4</u>	<u>SEER2 = 13.8</u>	after 1/1/2023	
		<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>SEER2 = 13.8</u>	
				EER2=11.2/9.8°	
				<u>P_{W,OFF} ≤ 30 W</u>	
Split-system heat	<65,000	before 1/1/2023	before 1/1/2023	before 1/1/2023	AHRI 210/240-2017
<u>pumps</u>	Btu/h single	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	before 1/1/2023
	<u>phase</u>	<u>HSPF = 8.2</u>	<u>HSPF = 8.2</u>	<u>HSPF = 8.2</u>	
		<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	AHRI 210/240-2023
					after 1/1/2023

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		after 1/1/2023	after 1/1/2023	after 1/1/2023			
		SEER2 = 14.3	SEER2 = 14.3	SEER2 = 14.3			
		HSPF2 = 7.5	HSPF2 = 7.5	HSPF2 = 7.5			
		P _{W,OFF} ≤ 33 W	P _{W,OFF} ≤ 33 W	P _{W,OFF} ≤ 33 W			
Single-package air	<65,000	before 1/1/2023	before 1/1/2023	before 1/1/2023	AHRI 210/240-2017		
conditioners	Btu/h single	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	before 1/1/2023		
	phase	P _{W,OFF} ≤ 30 W	$P_{W,OFF} \leq 30 W$	<u>EER = 11.0</u>			
				<u>P_{W,OFF} ≤ 30 W</u>	AHRI 210/240-2023		
		after 1/1/2023	after 1/1/2023		after 1/1/2023		
		<u>SEER2 = 13.4</u>	<u>SEER2 = 13.4</u>	after 1/1/2023			
		<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>SEER2 = 13.4</u>			
				<u>EER2 = 10.6</u>			
				<u>P</u> _{W,OFF} ≤ 30 W			
Single-package	<65,000	before 1/1/2023	before 1/1/2023	before 1/1/2023	AHRI 210/240-2017		
heat pumps	Btu/h single	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	<u>SEER = 14.0</u>	before 1/1/2023		
	<u>phase</u>	<u>HSPF = 8.0</u>	<u>HSPF = 8.0</u>	<u>HSPF = 8.0</u>			
		<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	AHRI 210/240-2023		
					after 1/1/2023		
		after 1/1/2023	after 1/1/2023	after 1/1/2023			
		<u>SEER2 = 13.4</u>	<u>SEER2 = 13.4</u>	<u>SEER2 = 13.4</u>			
		<u>HSPF2 = 6.7</u>	<u>$HSPF2 = 6.7$</u>	$\underline{HSPF2} = 6.7$			
		<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>			
Small-duct high-	<u><65,000</u>	before 1/1/2023	before 1/1/2023	before 1/1/2023	AHRI 210/240-2017		
velocity systems	<u>Btu/h single</u>	<u>SEER = 12.0</u>	<u>SEER = 12.0</u>	<u>SEER = 12.0</u>	before 1/1/2023		
	<u>phase</u>	<u>HSPF = 7.2</u>	<u>HSPF = 7.2</u>	<u>HSPF = 7.2</u>			
		<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	AHRI 210/240-2023		
					after 1/1/2023		
		after 1/1/2023	after 1/1/2023	after 1/1/2023			
		<u>SEER2 = 12.0</u>	<u>SEER2 = 11.7</u>	<u>SEER2 = 12.0</u>			
		<u>HSPF2 = 6.1</u>	<u>HSPF2 = 6.1</u>	$\underline{HSPF2} = 6.1$			
		<u>P</u> _{W,OFF} ≤ 30 W	<u>P</u> _{W,OFF} ≤ 30 W	<u>P</u> _{W,OFF} ≤ 30 W			
Space-constrained	<u><65,000</u>	before 1/1/2023	before 1/1/2023	before 1/1/2023	AHRI 210/240-2017		
products-air	<u>Btu/h single</u>	<u>SEER = 12.0</u>	<u>SEER = 12.0</u>	<u>SEER = 12.0</u>	before 1/1/2023		
conditioners ^a	<u>phase</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>			
					<u>AHRI 210/240-2023</u>		
		after 1/1/2023	after 1/1/2023	<u>after 1/1/2023</u>	<u>after 1/1/2023</u>		
		<u>SEER2 = 11.7</u>	<u>SEER2 = 11.7</u>	<u>SEER2 = 11.7</u>			
		<u>P</u> w,off <u>≤30 W</u>	<u>P</u> w,off <u>≤ 30 W</u>	<u>P_{W,OFF} ≤ 30 W</u>			
Space-constrained	<u><65,000</u>	before 1/1/2023	before 1/1/2023	before 1/1/2023	<u>AHRI 210/240-2017</u>		
products—heat	Btu/h single	<u>SEER = 12.0</u>	<u>SEER = 12.0</u>	<u>SEER = 12.0</u>	before 1/1/2023		
pumps ^a	phase	$\frac{HSPF = 7.4}{P}$	$\frac{HSPF = 7.4}{100}$	$\frac{HSPF = 7.4}{100}$			
		<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	AHRI 210/240-2023		
		- (I A /A /2000)		- (L 4/4/0000	atter 1/1/2023		
		atter 1/1/2023	atter 1/1/2023	atter 1/1/2023			
		<u>SEER2 = 11.9</u>	SEER2 = 11.9	<u>SEER2 = 11.9</u>			
		$\frac{\text{HSPF2} = 6.3}{\text{P}}$	$\frac{\text{HSPF2} = 6.3}{\text{P}}$	$\frac{\text{HSPF2} = 6.3}{\text{P}}$			
		<u>P_{W,OFF} ≤ 33 W</u>	<u>P_{W,OFF} ≤ 33 W</u>	<u> P_{W,OFF} ≤ 33 W</u>			
a. The Southeastern reg	a. The Southeastern region for central air conditioners and heat pumps contains the following States: Alabama, Arkansas, Delaware, Florida, Georgia,						

 a. 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 <u>Columbia</u>.

b. The Southwestern region for central air conditioners contains the States of Arizona, California, Nevada, and New Mexico.

c. 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. SEER2 is Seasonal Energy Efficiency Ratio reflecting the new higher static that is effective 1/1/2023; EER2 is Energy Efficiency Ratio also reflecting the higher static; HSPF2 is new Heating Seasonal Performance Factor reflecting the new higher static and load line. Test and rating procedure defined in AHRI 210/240-2017 for EER, SEER and HSPF and AHRI 210/240 for EER2, SEER2, and HSPF2

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- d. The 11.7 EER2 standard applies to products with a certified SEER2 less than 15.2. The 9.8 EER2 standard applies to products with a certified SEER2 greater than or equal to 15.2.
- e. The 11.2 EER2 standard applies to products with a certified SEER2 less than 15.2. The 9.8 EER2 standard applies to products with a certified SEER2 greater than or equal to 15.2.
- f. Section 12 contains a complete specification of the referenced test procedures, including the referenced year version of the test procedure

F2 DOE Minimum Energy Efficiency Requirements for Water Heaters and Pool Heaters

These standards for Uniform Energy Factor became effective on <u>April 16, 2015December 29, 2017</u>, and apply to products manufactured on or after that dates and the thermal efficiency requirements for gas fired pool heaters manufactured on or after April 16, 2013 (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 x 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 x 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.

Table F-2 Minimum F	Table F-2 Minimum Energy Efficiency Requirements for Water Heaters and Pool Heaters						
Source: 10 CFR Part	Source: 10 CFR Part 430, Energy Conservation Program: Energy Conservation Standards for Water Heaters)						
Product Class	Rated Storage Volume and input rating (if applicable)	Draw Pattern	Uniform Energy Factor (UEF) or Thermal Efficiency (Et)	Test Procedure			
		Very Small	<u>UEF = 0.3456 – (0.0020 × Vr)</u>	<u>10 CFR 430</u>			
	>20 gal and <55 gal	Low	<u>UEF = 0.5982 – (0.0019 × Vr)</u>	<u>Appendix E</u>			
	<u>≥20 gai anu ≤55 gai</u>	Medium	<u>UEF = 0.6483 – (0.0017 × Vr)</u>				
Gas-fired storage		<u>High</u>	<u>UEF = 0.6920 - (0.0013 × Vr)</u>				
water heater	<u>>55 gal and ≤100 gal</u>	Very Small	$\underline{UEF} = 0.6470 - (0.0006 \times \mathrm{Vr})$	<u>10 CFR 430</u>			
		Low	$\underline{UEF} = 0.7689 - (0.0005 \times \mathrm{Vr})$	Appendix E			
		<u>Medium</u>	<u>UEF = $0.7897 - (0.0004 \times Vr)$</u>				
		<u>High</u>	$\underline{UEF} = 0.8072 - (0.0003 \times \mathrm{Vr})$				
		Very Small	$\underline{UEF} = 0.2509 - (0.0012 \times \mathrm{Vr})$	10 CFR 430			
Oil-fired storage	<u>≤50 gal</u>	Low	<u>UEF = 0.5330 - (0.0016 × Vr)</u>	<u>Appendix E</u>			
water heater		Medium	<u>UEF = 0.6078 - (0.0016 × Vr)</u>				
		<u>High</u>	<u>UEF = 0.6815 – (0.0014 × Vr)</u>				
		Very Small	<u>UEF = 0.8808 - (0.0008 × Vr)</u>	10 CFR 430			
	>20 gol and SEE gol	Low	$\underline{UEF} = 0.9254 - (0.0003 \times \mathrm{Vr})$	Appendix E			
Electric Storage	<u>≃∠∪ gai anu ≥əə gai</u>	Medium	<u>UEF = 0.9307 – (0.0002 × Vr)</u>				
Walth Healers		<u>High</u>	<u>UEF = 0.9349 - (0.0001 × Vr)</u>				
	<u>>55 gal and ≤100 gal</u>	Very Small	UEF = 1.9236 - (0.0011 × Vr)	10 CFR 430			

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Table F-2 Minimum Energy Efficiency Requirements for Water Heaters and Pool Heaters				
Source: 10 CFR Part	430, Energy Conservation Pro	ogram: Energy Cor	servation Standards for Water Heaters)
Product Class	Rated Storage Volume and input rating (if applicable)	<u>Draw Pattern</u>	Uniform Energy Factor (UEF) or Thermal Efficiency (Et)	Test Procedure
		Low	<u>UEF = 2.0440 – (0.0011 × Vr)</u>	<u>Appendix E</u>
		<u>Medium</u>	<u>UEF = $2.1171 - (0.0011 \times Vr)$</u>	
		<u>High</u>	<u>UEF = 2.2418 – (0.0011 × Vr)</u>	
		Very Small	$\underline{UEF} = 0.6323 - (0.0058 \times \mathrm{Vr})$	10 CFR 430
Tabletop Water	>20 gal and <120 gal	Low	<u>UEF = 0.9188 - (0.0031 × Vr)</u>	<u>Appendix E</u>
<u>Heater</u>	<u>220 gai anu 2120 gai</u>	<u>Medium</u>	<u>UEF = 0.9577 – (0.0023 × Vr)</u>	
		<u>High</u>	<u>UEF = 0.9884 – (0.0016 × Vr)</u>	
		Very Small	<u>UEF = 0.80</u>	10 CFR 430
Instantaneous Gas	<2 cal and >50.000 Btu/b	Low	<u>UEF = 0.81</u>	<u>Appendix E</u>
Fired Water Heater	<u><2 gai anu >30,000 blu/11</u>	<u>Medium</u>	<u>UEF = 0.81</u>	
		<u>High</u>	<u>UEF = 0.81</u>	
		Very Small	<u>UEF = 0.91</u>	<u>10 CFR 430</u>
Instantaneous	-2 col	Low	<u>UEF = 0.91</u>	<u>Appendix E</u>
Heater	<u><z u="" yai<=""></z></u>	<u>Medium</u>	<u>UEF = 0.91</u>	
		<u>High</u>	<u>UEF = 0.92</u>	
		Very Small	$\underline{UEF} = 1.0136 - (0.0028 \times \mathrm{Vr})$	10 CFR 430
Grid Enabled Water	> 75 gol	Low	$\underline{UEF} = 0.9984 - (0.0014 \times \mathrm{Vr})$	Appendix E
Heaters	<u>>75 gai</u>	<u>Medium</u>	<u>UEF = 0.9853 - (0.0010 × Vr)</u>	
		<u>High</u>	<u>UEF = 0.9720 – (0.0007 × Vr)</u>	
Pool heater Gas			<u>82% E_t</u>	<u>10 CFR 430</u> <u>Appendix P</u>
a. Vr is the Rated Storage	Volume (in gallons), as determined	pursuant to 10 CFR 4	<u>29.17.</u>	

b. Standards for electric storage water heaters apply to both electric resistance water heaters and heat pump water heaters.

Table F-3 Minimum Efficiency Requirements for Room Air Conditioners for US applications				
Product Class	Capacity Range	Efficiency Requirements ^a	Test Procedure ^b	
	<6,000 Btu/h	<u>CEER = 11.0</u>		
	≥6,000 Btu/h and	OFFR 44.0		
	<u><8,000 Btu/h</u>	<u>CEER = 11.0</u>		
	<u>≥8,000 Btu/h and</u>			
Room Air Conditioners without reverse cycle with	<u><14,000 Btu/h</u>	<u>CEER = 10.9</u>	10 CFR 430	
louvered sides	<u>≥14,000 Btu/h and</u>		Appendix F	
	<u><20,000 Btu/h</u>	$\underline{CEER = 10.7}$		
	≥20,000 Btu/h and			
	<u><28,000 Btu/h</u>	8,000 Btu/h		
	≥28,000 Btu/h	<u>CEER = 9.0</u>		
	<u><6,000 Btu/h</u>	<u>CEER = 10.0</u>		
	≥6,000 Btu/h and	0550 40.0		
	<u><8,000 Btu/h</u>	$\underline{CEER = 10.0}$		
	<u>≥8,000 Btu/h and</u>			
Room Air Conditioners without reverse cycle	<11,000 Btu/h	<u>CEER = 9.6</u>	10 CFR 430	
without louvered sides	≥11,000 Btu/h and		Appendix F	
	<u><14,000 Btu/h</u>	<u>UEER = 9.5</u>	-	
	≥14,000 Btu/h and	0555 0.0		
	<20,000 Btu/h	<u>CEER = 9.3</u>		
	≥20,000 Btu/h	<i>CEER</i> = 9.4		

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Room Air Conditioners with reverse cycle, with	<u><20,000 Btu/h</u>	<u>CEER = 9.8</u>	10 CFR 430	
louvered sides	<u>≥20,000 Btu/h</u>	<u>CEER = 9.3</u>	Appendix F	
Room Air Conditioners with reverse cycle without	<u><14,000 Btu/h</u>	<u>CEER = 9.3</u>	10 CFR 430	
louvered sides	<u>≥14,000 Btu/h</u>	<u>CEER = 8.7</u>	Appendix F	
	A.II.		10 CFR 430	
Room Air Conditioners, casement only		<u>CEER = 9.5</u>	Appendix F	
	A.U.		10 CFR 430	
Room Air Conditioners, casement slider	All	<u>CEER = 10.4</u>	Appendix F	
a. Source: Federal Register 76 FR 37431, June 27, 2011				
b Section 12 contains a complete specification of the referenced test procedures				

Product Class	Size Category (input)	Subcategory or rating condition	Minimum Efficiency	Test Procedure ^a
Furnace, gas fired	<u><225,000 Btu/h</u>	Non-weatherized excluding mobile home	<u>80% AFUE</u>	<u>10 CFR 430 Appendi</u> <u>N</u>
		Non-weatherized mobile home Weatherized	80% AFUE	
Furnace oil fired	<u><225, 000 Btu/h</u>	Non-weatherized excluding mo- bile home	$\frac{83\% \text{ AFUE}}{P_{W,SB} \le 11 \text{ W}}$ $\frac{P_{W,OFF} \le 11 \text{ W}}{P_{W,OFF} \le 11 \text{ W}}$	10 CFR 430 Appendi N
		Non-weatherized mobile home	$\frac{75\% \text{ AFUE}}{P_{W,SB} \le 11 \text{ W}}$ $\frac{P_{W,OFE} \le 11 \text{ W}}{P_{W,OFE} \le 11 \text{ W}}$	
Electric furnance	-225 000 Ptu/b	Weatherized	78% AFUE	10 CER 420 Appand
Electric furfiace	<u><223,000 Blu/N</u>	All	$\frac{P_{W,SB} \le 10 \text{ W}}{P_{W,OFF} \le 10 \text{ W}}$	N

^a Section 12 contains a complete specification of the referenced test procedure.

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Table F-5 Residential Boiler ^a Minimum Efficiency Requirements for US applications (Refer to 10 CFR 430)				
Product Class	Minimum Efficiency prior to January 15, 2021 ^b	Minimum Efficiency as of January 15, 2021 ^b	Standby Mode and Off Mode Power Con- sumption as of Janu- ary 15, 2021°	Design Requirements
Gas-fired hot water boiler	82% AFUE	<u>84% AFUE</u>	<u>P_{W.SB} ≤ 9 W</u> <u>P_{W,OFF} ≤ 9 W</u>	Constant burning pilot not permit- ted. Automatic means for adjusting water temperature required (except for boilers equipped with tankless domestic water heating coils).
Gas-fired steam boiler	80% AFUE	82% AFUE	<u>P_{W,SB} ≤ 8 W</u> P _{W,OFF} ≤ 8 W	Constant burning pilot not permit- ted.
Oil-fired hot water boiler	84% AFUE	86% AFUE	<u>P_{W,SB} ≤ 11 W</u> <u>P_{W,OFF} ≤ 11 W</u>	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils) ^d .
<u>Oil-fired steam</u> boiler	82% AFUE	85% AFUE	$\frac{P_{W,SB} \le 11 \text{ W}}{P_{W,OFF} \le 11 \text{ W}}$	None
Electric hot water boiler	None	None	<u>P_{W,SB} ≤ 8 W</u> <u>P_{W,OFF} ≤ 8 W</u>	Automatic means for adjusting temperature required (except for boilers equipped with tankless domestic water heating coils) ^d .
Electric steam boiler	None	None	$\frac{P_{W,SB} \le 8 W}{P_{W,OFF} \le 8 W}$	None
<u>a Has a heat input rate of less than 300.000 Btu per hour for electric boilers and low-pressure steam or hot water boilers (per § 430.2) <u>b Annual Fuel Utilization Efficiency, as determined in § 430.23(n)(2) <u>c Standby mode and off mode electric power consumption as determined in § 430.23(n)(5) </u></u></u>				

^d See § 430.23(e)(2)(iv) for additional details regarding automatic means for adjusting water temperature.

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%.

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This is a normative appendix and is part of this standard

Normative Appendix G

Performance Rating Method

G1 GENERAL

•••

G3 CALCULATION OF THE PROPOSED DESIGN AND BASELINE BUILDING PERFORMANCE

G3.1 Building Performance Calculations

The simulation model for calculating the proposed and *baseline building performance* shall be developed in accordance with the requirements in Table G3.1.

G3.1.1 Baseline HVAC System Type and Description

HVAC systems in the baseline building design shall comply with the following:

a.	HVAC systems in the baseline building design shall
1	determined in the following order of priority:
	The building type with the largest condi-
	tioned floor area.
-	Number of <i>floors</i> (including <i>floors</i> above
	grade and below grade but not including floors solely devoted to parking).
-	Gross conditioned floor area.
2	Climate zone as specified in Table <u>G3.1.1-3</u> ,
	which shall conform with the system descriptions in Table $G3.1.1-4$. For Sys-
	tems 1, 2, 3, 4, 9, 10, 11, 12, and 13, each thermal block shall be modeled
	with its own HVAC system. For Systems 5, 6, 7, and 8, each floor shall be
	modeled with a separate HVAC system. Floors with identical thermal blocks

		··· ·· · · · · ·		
Table G3 1 1-1	Baseline Ruilding	I Vertical Fenestration	Percentage of Gros	s Above-Grade-Wall Area
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Building Area Types ^a	Baseline Building Gross Above-Grade-Wall Area
Grocery store	7%
Healthcare (outpatient)	21%
Hospital	27%
Hotel/motel (≤75 rooms)	24%
Hotel/motel (>75 rooms)	34%
Office (≤5000 ft²)	19%
Office (5000 to 50,000 ft ²)	31%
Office (>50,000 ft ²)	40%
Restaurant (quick service)	34%
Restaurant (full service)	24%
Retail (stand alone)	11%
Retail (strip mall)	20%
School (primary)	22%
School (secondary and university)	22%
Warehouse (nonrefrigerated)	6%

can be grouped for modeling purposes.

a. In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.

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Building Area Type	Baseline Heating Method	Building Area Type	Baseline Heating Method
Automotive facility	Gas storage water heater	Performing arts theater	Gas storage water heater
Convenience store	Electric resistance water heater	Police station	Electric resistance storage water heater
Convention center	Electric resistance storage water heater	Post office	Electric resistance storage water heater
Courthouse	Electric resistance storage water heater	Religious facility	Electric resistance storage water heater
Dining: Bar lounge/leisure	Gas storage water heater	Retail	Electric resistance storage water heater
Dining: Cafeteria/fast food	Gas storage water heater	School/university	Gas storage water heater
Dining: Family	Gas storage water heater	Sports arena	Gas storage water heater
Dormitory	Gas storage water heater	Town hall	Electric resistance storage water heater
Exercise center	Gas storage water heater	Transportation	Electric resistance storage water heater
Fire station	Gas storage water heater	Warehouse	Electric resistance storage water heater
Grocery store	Gas storage water heater	Workshop	Electric resistance storage water heater
Gymnasium	Gas storage water heater	All others	Gas storage water heater
Health-care clinic	Electric resistance storage water heater		
Hospital and outpatient surgery center	Gas storage water heater		
Hotel	Gas storage water heater		
Library	Electric resistance storage water heater		
Manufacturing facility	Gas storage water heater		
Motel	Gas storage water heater		
Motion picture theater	Electric resistance storage water heater		
Multifamily	Gas storage water heater		
Museum	Electric resistance storage water heater		
Office	Electric resistance storage water heater		
Parking garage	Electric resistance storage water heater		
Penitentiary	Gas storage water heater		

Table G3.1.1-2 Baseline Service Water-Heating System

Table G3.1.1-3 Baseline HVAC System Types

Building Type, Number of Floors, and Gross Conditioned Floor Area	Climate Zones 3B, 3C, and 4 to 8	Climate Zones 0 to 3A
Residential	System 1—PTAC	System 2—PTHP
Public assembly <120,000 ft ²	System 3—PSZ-AC	System 4—PSZ-HP
Public assembly \geq 120,000 ft ²	System 12—SZ-CV-HW	System 13—SZ-CV-ER
Heated-only storage	System 9—Heating and ventilation	System 10—Heating and ventilation
Retail and 2 floors or fewer	System 3—PSZ-AC	System 4—PSZ-HP

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

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Other residential and 3 floors or fewer and <25,000 ${\rm ft}^2$	System 3—PSZ-AC	System 4—PSZ-HP
Other residential and 4 or 5 <i>floors</i> and <25,000 ft ² or 5 <i>floors</i> or fewer and 25,000 ft ² to 150,000 ft ²	System 5—Packaged VAV with reheat	System 6—Packaged VAV with PFP boxes
Other residential and more than 5 <i>floors</i> or >150,000 ft^2	System 7—VAV with reheat	System 8—VAV with PFP boxes

Notes:

- 1. Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.
- 2. Where attributes make a *building* eligible for more than one baseline *system* type, use the predominant condition to determine the *system* type for the entire *building* except as noted in Section <u>G3.1.1</u>.

3. For laboratory spaces in a building having a total laboratory exhaust rate greater than 15,000 cfm, use a single system of type 5 or 7 serving only those spaces.

4. For hospitals, depending on *building* type, use System 5 or 7 in all climate zones.

5. Public assembly *building* types include houses of worship, auditoriums, movie theaters, performance theaters, concert halls, arenas, enclosed stadiums, ice rinks, gymnasiums, convention centers, exhibition centers, and natatoriums.

System No.	System Type	Fan Control	Cooling Type ^a	Heating Type ^a
1. PTAC	Packaged terminal air conditioner	Constant volume	Direct expansion	Hot-water fossil fuel boiler
2. PTHP	Packaged terminal heat pump	Constant volume	Direct expansion	Electric heat pump
3. PSZ-AC	Packaged rooftop air conditioner	Constant volume	Direct expansion	Fossil fuel furnace
4. PSZ-HP	Packaged rooftop heat pump	Constant volume	Direct expansion	Electric heat pump
5. Packaged VAV with reheat	Packaged rooftop VAV with reheat	VAV	Direct expansion	Hot-water fossil fuel boiler
6. Packaged <i>VAV</i> with PFP boxes	Packaged rooftop VAV with parallel fan power boxes and <i>reheat</i>	VAV	Direct expansion	Electric resistance
7. VAV with reheat	VAV with reheat	VAV	Chilled water	Hot-water fossil fuel boiler
8. VAV with PFP boxes	VAV with parallel fan-powered boxes and <i>reheat</i>	VAV	Chilled water	Electric resistance
9. Heating and ventilation	Warm air furnace, gas fired	Constant volume	None	Fossil fuel furnace
10. Heating and ventilation	Warm air furnace, electric	Constant volume	None	Electric resistance
11. SZ– <i>VAV</i>	Single-zone VAV	VAV	Chilled water	See note (b).
12. SZ-CV-HW	Single-zone system	Constant volume	Chilled water	Hot-water fossil fuel boiler
13. SZ-CV-ER	Single-zone system	Constant volume	Chilled water	Electric resistance

Table G3.1.1-4 Baseline System Descriptions

a. For purchased chilled water and purchased heat, see G3.1.1.3.

b. For Climate Zones 0 through 3A, the heating type shall be electric resistance. For all other climate zones the heating type shall be hot-water fossil-fuel boiler.

- b. Use additional *system* types for nonpredominant conditions (i.e., *residential/nonresidential-or heating source*) if those conditions apply to more than 20,000 ft² of *conditioned floor area*.
- c. If the baseline HVAC system type is 5, 6, 7, 8, 9, 10, 11, 12, or 13 use separate single-zone systems conforming with the requirements of system 3 or system 4 (depending on building heating source) for any spaces-HVAC zones that have occupancy, or process loads internal gains, or schedules that differ significantly from the rest of the building HVAC zones served by the system. The total Peak-peak thermal loads internal gains that differ by 10 Btu/h·ft² or more from the average of other spaces-HVAC zones served by

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the *system*, or schedules that differ by more than 40 equivalent full-load hours per week from other *spaces* served by the *system*, are considered to differ significantly. Examples where this exception may be applicable include but are not limited to natatoriums and continually occupied security areas. This exception does not apply to *computer rooms*.

- d. For laboratory *spaces* in a *building* having a total laboratory exhaust rate greater than 15,000 cfm, use a single *system* of type 5 or 7 serving only those *spaces*. The lab exhaust fan shall be modeled as constant horsepower reflecting constant-volume stack discharge with *outdoor air* bypass.
- e. Thermal zones designed with heating-only *systems* in the *proposed design* 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 use *system* type 9 or 10 in the *baseline building design*.
- f. If the baseline *HVAC system* type is 9 or 10, <u>use additional system types for all spaces *HVAC zones* that are mechanically cooled in the proposed design shall be assigned to a separate baseline system determined by using the area and heating source of the mechanically *cooled spaces*.</u>
- g. Computer rooms in buildings with a total computer room peak cooling load >3,000,000 Btu/h or a total computer room peak cooling load >600,000 Btu/h where the baseline HVAC system type is 7 or 8 shall use System 11. All other computer rooms shall use System 3 or 4.
- h. For hospitals, depending on *building* type, use *System* 5 or 7 in all climate zones.

G3.1.1.1 Purchased Heat

For *systems* using purchased hot water or steam, the heating source shall be modeled as purchased hot water or steam in both the *proposed design* and *baseline building design*. Hot-water or steam costs shall be based on actual utility rates, and on-site *boilers*, electric heat, and furnaces shall not be modeled in the *baseline building design*.

G3.1.1.2 Purchased Chilled Water

For *systems* using purchased chilled water, the cooling source shall be modeled as purchased chilled water in both the *proposed design* and *baseline building design*. Purchased chilled-water costs shall be based on actual utility rates, and on-site chillers and direct expansion *equipment* shall not be modeled in the *baseline building design*.

G3.1.1.3 Baseline HVAC System Requirements for Systems Utilizing Pur-

chased

Chilled Water and/or Purchased Heat

If the *proposed design* uses purchased chilled water and/or purchased heat, the following modifications to the baseline *HVAC system* types in Table G3.1.1-4 shall be used.

G3.1.1.3.1

Purchased Heat Only

If the *proposed design* uses purchased heat, but does not use purchased chilled water, then Tables <u>G3.1.1-3</u> and <u>G3.1.1-4</u> shall be used to select the baseline *HVAC system* type, and purchased heat shall be substituted for the heating type in Table <u>G3.1.1-4</u>. The same heating source shall be used in the *proposed design* and *baseline building design*.

G3.1.1.3.2

Purchased Chilled Water Only

If the *proposed design* uses purchased chilled water but does not use purchased heat, then Tables $\underline{G3.1.1-3}$ and $\underline{G3.1.1-4}$ shall be used to select the baseline *HVAC system* type, with the modifications listed below:

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- a. Purchased chilled water shall be substituted for the cooling types in Table <u>G3.1.1-4</u>.
- b. 1. *System* 1 and 2 shall be constant-volume fancoil units with *fossil fuel boilers*.
- c. *System* 3 and 4 shall be constant-volume singlezone air handlers with *fossil fuel* furnaces.
- d. *System* 7 shall be used in place of *System* 5.
- e. *System* 8 shall be used in place of *System* 6.

G3.1.1.3.3

Purchased Chilled Water and Purchased Heat

If the *proposed design* uses purchased chilled water and purchased heat, then Tables G3.1.1-3 and G3.1.1-4 shall be used to select the baseline *HVAC system* type, with the following modifications:

- a. Purchased heat and purchased chilled water shall be substituted for the heating types and cooling types in Table $\underline{G3.1.1-4}$.
- b. 2. *System* 1 shall be constant-volume fan-coil units.
 - System 3 shall be constant-volume single-zone air
- d. *System* 7 shall be used in place of *System* 5.

G3.1.1.3.4

c.

handlers.

On-Site Distribution Pumps

All on-site distribution pumps shall be modeled in both the *proposed design* and *base building design*.

G3.1.1.4

Modeling Building Envelope Infiltration

The air leakage rate of the *building envelope* (I_{75Pa}) at a pressure differential of 0.3 in. of water shall be converted to appropriate units for the *simulation program* using one of the following formulas:

For methods describing air leakage as a function of *floor* area,

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

For methods describing air leakage as a function of the area of *above-grade walls* that separate *conditioned spaces* and *semiheated spaces* from the exterior,

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

When using the measured air leakage rate of the *building envelope* at a pressure differential of 0.3 in. of water for the *proposed design*, the air leakage rate shall be calculated as follows:

$$I_{75Pa} = Q/S$$

where

 I_{75Pa} = air leakage rate of the *building envelope* (cfm/ft²) at a *fixed building* pressure differential of 0.3 in. of water, or 1.57 psf

- Q = volume of air in cfm flowing through the *building envelope* when subjected to a pressure differential of 0.3 in. of water, or 1.57 psf, in accordance with ASTM E 779
- S = total area of the *building envelope* (ft²), including the lowest *floor*, any *below-grade walls* or *above-grade walls*, and *roof* (including *vertical fenestration* and *skylights*)
- I_{FLR} = adjusted air leakage rate of the *building envelope* (cfm/ft²) at a reference wind speed of 10 mph and relative to the *gross floor area*

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

- I_{AGW} = adjusted air leakage rate of the *building envelope* (cfm/ft²) at a reference wind speed of 10 mph and relative to the area of the *above-grade walls* of the *building envelope*
- A_{AGW} total area of *above-grade walls* of the *building envelope*, ft²

Exception to G3.1.1.4

A multizone airflow model alternative method to modeling *building envelope* air leakage may be used, provided the following criteria are met:

- 1. Where the calculations are made independently of the *energy simulation program*, the proposed method must comply with Section <u>G2.5</u>.
- 2. The method for converting the air leakage rate of the *build-ing envelope* at 0.3 in. of water, or 1.57 psf, to the appropriate units for the *simulation program* is fully documented and submitted to the *rating authority* for approval.

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 <u>G3.5.1</u> through <u>G3.5.6</u>. Chillers shall use Path A efficiencies as shown in Table <u>6.8.1-3</u>. 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 <u>6.8.1-1</u> through <u>6.8.1-4</u>. Where a full-and part-load *efficiency* rating is provided in Tables <u>6.8.1-1</u> through <u>6.8.1-4</u>, the full-load equation below shall be used:

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

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

 $COP_{\text{nfheating}} = 1.48\text{E-7} \times COP_{47} \times Q + 1.062 \times COP_{47}$ (applies to heat pump heating *efficiency* only)

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

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* coil capacities) for the *baseline building design* shall be based on sizing runs for each *orientation* (per Table <u>G3.1</u>, No. 5[a]) and shall be oversized by 15% for cooling and 25% for heating; i.e., 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.

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

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conditions or on design days developed using 99.6% *heating design temperatures* and 1% dry-bulb and 1% wet-bulb *cooling design temperatures*.

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* 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* 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.

G3.1.2.5

Ventilation

Minimum *ventilation system outdoor air* intake flow shall be the same for the *proposed design* and *baseline building design*.

Exception to G3.1.2.5

- 1. When modeling *demand control ventilation* in the *proposed design* in *systems* with *outdoor air* capacity less than or equal to 3000 cfm serving areas with an average *design capacity* of 100 people per 1000 ft² or less.
- 2. When designing *systems* in accordance with Standard 62.1, Section 6.2, "Ventilation Rate Procedure," reduced ventilation airflow rates may be calculated for each *HVAC zone* in the proposed design with a zone air distribution effectiveness $(E_z) > 1.0$ as defined by Standard 62.1, Table 6-2. Baseline ventilation airflow rates in those zones shall be calculated using the proposed design Ventilation Rate Procedure calculation with the following change only. Zone air distribution effectiveness shall be changed to $(E_z) = 1.0$ in each zone having a zone air distribution effectiveness $(E_z) > 1.0$. *Proposed design* and baseline *building design Ventilation* Rate Procedure calculations, as described in Standard 62.1, shall be submitted to the rating authority to claim credit for this exception.
- 3. Where the minimum *outdoor air* intake flow in the *proposed design* is provided in excess of the amount required by the *building* code or the *rating au-thority*, the *baseline building design* shall be modeled to reflect the greater of that required by either the *rating authority* or the *building* code and will be less than the *proposed de-sign*.
- 4. For baseline *systems* serving only laboratory *spaces* that are prohibited from recirculating return air by code or accreditation standards, the baseline *system* shall be modeled as 100% *outdoor air*.

G3.1.2.6

Economizers

Air economizers shall not be included in baseline *HVAC Systems* 1, 2, 9, and 10. *Air economizers* shall be included in baseline *HVAC Systems* 3 through 8, and 11, 12, and 13 based on climate as specified in Table <u>G3.1.2.6</u>.

Table G3.1.2.6 Climate Conditions under which Economizers are Included for Comfort Cooling for Baseline *Systems* 3 through 8 and 11, 12, and 13

Climate Zone	Conditions
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0A, 0B, 1A, 1B, 2A, 3A, 4A

Others

Economizer Included

Note: NR means that there is no conditioned *building floor* area for which economizers are included for the type of zone and climate.

NR

Exception to G3.1.2.6

Economizers shall not be included for *systems* meeting one or more of the exceptions listed below.

- 1. *Systems* that include gas-phase air cleaning to meet the requirements of Standard 62.1, Section 6.1.2. This exception shall be used only if the *system* in the *proposed design* does not match the *building* design.
- 2. Where the use of *outdoor air* for cooling will affect supermarket open refrigerated casework *systems*. This exception shall only be used if the *system* in the *proposed design* does not use an economizer. If the exception is used, an economizer shall not be included in the *baseline building design*.
- 3. *Systems* that serve *computer rooms* complying with Section G3.1.2.6.1.

G3.1.2.6.1

G3.1.2.8.1

Computer Room Economizers

nt

Systems that serve *computer rooms* that are *HVAC System* 3 or 4 shall not have an economizer. *Systems* that serve *computer rooms* that are *HVAC System* 11 shall include an integrated *fluid economizer* meeting the requirements of Section <u>6.5.1.2</u> in the *base-line building design*.

G3.1.2.7 Economizer High-Limit Shutoff

The high-limit shutoff shall be a dry-bulb *fixed* switch with *set-point* temperatures in accordance with the values in Table $\underline{G3.1.2.7}$.

Table G3.1.2.7	Economizer l	High-Limit Shutoff	Temperature
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Climate Zone	Dry-Bulb Temperature Set Point		
2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	75°F		
5A, 6A	70°F		

G3.1.2.8 Design Airflow Rates

Baseline All System Types Except System

Types 9 and 10

System design supply airflow rates for the *baseline building design* shall be based on a supply-air-to-room temperature *set-point* difference of 20°F or the minimum outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is greater. For *systems* with multiple zone *thermostat set points*, use the design *set point* that will result in the lowest supply air cooling *set point* or highest supply air heating *set point*. If return or relief fans are specified in the *proposed design*, the *baseline building design* shall also be modeled with fans serving the same functions and sized for the baseline *system* supply fan air quantity less the minimum *outdoor air*, or 90% of the supply fan air quantity, whichever is larger.

Exception to G3.1.2.8.1

- 1. For *systems* serving laboratory *spaces*, airflow rate shall be based on a supply-air-to-room temperature *set-point* difference of 17°F or the required *ventilation* air or *makeup air*, whichever is greater.
- 2. If the *proposed design HVAC system* airflow rate based on latent loads is greater than the design airflow rate based on sensible loads, then the same supply-air-to-room-air humidity ratio difference (gr/lb) used to calculate the *proposed de-*

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sign airflow shall be used to calculate design airflow rates for the baseline building design.

G3.1.2.8.2

Baseline System Types 9 and 10

System design supply airflow rates for the *baseline building design* shall be based on the temperature difference between a supply air temperature *set point* of 105°F and the design *space*-heating temperature *set point*, the minimum outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is greater. If the *proposed design* includes a fan or fans sized and controlled to provide non-*mechanical cooling*, the *baseline building design* shall include a separate fan to provide non-*mechanical* cooling, sized and controlled the same as the *proposed design*.

G3.1.2.9

System Fan Power

System fan electrical power for supply, return, exhaust, and relief (excluding power to fan-powered *VAV* boxes) shall be calculated using the following formulas:

For Systems 1 and 2,

$$P_{\rm fan} = {\rm CFMs} \times 0.3$$

For Systems 3 through 8, and 11, 12, and 13,

 $P_{\text{fan}} = \text{bhp} \times 746/\text{fan motor efficiency}$

For Systems 9 and 10 (supply fan),

$$P_{fan} = CFMs \times 0.3$$

For Systems 9 and 10 (non-mechanical cooling fan if required by Section <u>G3.1.2.8.2</u>),

0 0 7 1

		$P_{fan} = \text{CFM}_{nmc} \times 0.054$
where		
P _{fan}	=	electric power to fan motor, W
bhp	=	brake horsepower of baseline fan motor from Table <u>G3.1.2.9</u>
fan motor <i>efficiency</i>	=	the <i>efficiency</i> from Table <u>G3.9.1</u> for the next motor size greater than the bhp using a totally enclosed fan cooled motor at 1800 rpm
CFMs	=	the baseline <i>system</i> maximum design supply fan airflow rate, cfm
CFM _{nmc}	=	the baseline non-mechanical cooling fan airflow, cfm

Table G3.1.2.9	Baseline	Fan Brake	Horsepower
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Baseline Fan Motor Brake Horsepower					
Constant-Volume Systems 3 to 4	Variable-Volume Systems 5 to 8	Variable-Volume System 11			
CFM _s × 0.00094 + A	CFM _s × 0.0013 + A	CFM _s × 0.00062 + A			

Notes:

1. Where A is calculated according to Section 6.5.3.1.1 using the pressure-drop adjustment from the proposed design and the design flow rate of the baseline building system.

2. Do not include pressure-drop adjustments for evaporative coolers or heat recovery devices that are not required in the baseline *building system* by Section <u>G3.1.2.10</u>.

G3.1.2.9.1

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016

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The calculated *system* fan power shall be distributed to supply, return, exhaust, and relief fans in the same proportion as the *proposed design*.

G3.1.2.10 Exhaust Air Energy Recovery

Individual fan *systems* that have both a design supply air capacity of 5000 cfm or greater and have a minimum design *outdoor air* supply of 70% or greater shall have an *energy* recovery *system* with at least 50% *enthalpy recovery ratio*. Fifty percent *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 return air at *design conditions*. Provision shall be made to bypass or *control* the heat recovery *system* to permit *air economizer* operation, where applicable.

Exception to G3.1.2.10

4.

5.

6.

If any of these exceptions apply, exhaust air *energy* recovery shall not be included in the *baseline building design*:

- 1. *Systems* serving *spaces* that are not cooled and that are heated to less than 60°F.
- 2. *Systems* exhausting toxic, flammable, or corrosive fumes or paint or dust. This exception shall only be used if exhaust air *energy* recovery is not used in the *proposed design*.
- 3. Commercial kitchen hoods (grease) classified as Type 1 by NFPA 96. This exception shall only be used if exhaust air *energy* recovery is not used in the *proposed design*.
 - Heating systems in Climate Zones 0 through 3.
 - Cooling systems in Climate Zones 3C, 4C, 5B, 5C, 6B, 7, and 8.
 - Where the largest exhaust source is less than 75% of the design *outdoor airflow*. This exception shall only be used if exhaust air *energy* recovery is not used in the *proposed design*.
- 7. *Systems* requiring dehumidification that employ *energy* recovery in series with the cooling coil. This exception shall only be used if exhaust air *energy* recovery and series-style *energy* recovery coils are not used in the *proposed design*.

G3.1.3 System-Specific Baseline HVAC System Requirements

Baseline *HVAC systems* shall conform with provisions in this section, where applicable, to the specified baseline *system* types, as indicated in section headings.

G3.1.3.1 Heat Pumps (Systems 2 and 4)

Electric air-source heat pumps shall be modeled with electric auxiliary heat and an *outdoor air thermostat*. The *systems* shall be controlled to energize auxiliary heat only when the *outdoor air* temperature is less than 40°F. The air-source heat pump shall be modeled to continue to operate while auxiliary heat is energized.

G3.1.3.2 Type and Number of Boilers (Systems 1, 5, and 7, 11, and 12)

The *boiler* plant shall use the same *fuel* as the *proposed design* and shall be natural draft, except as noted in Section <u>G3.1.1.1</u>. The *baseline building design boiler* plant shall be modeled as having a single *boiler* if the *baseline building design* plant serves a *conditioned floor area* of 15,000 ft² or less, and as having two equally sized *boilers* for plants serving more than 15,000 ft². *Boilers* shall be staged as required by the load.

G3.1.3.3 Hot-Water Supply Temperature (Systems 1, 5, 7, <u>11,</u> and 12)

Hot-water design supply temperature shall be modeled as 180° F and design return temperature as 130° F.

G3.1.3.4 Hot-Water Supply Temperature Reset (Systems 1, 5, 7, 11, and 12)

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Hot-water supply temperature shall be *reset* based on outdoor dry-bulb temperature using the following schedule: 180°F at 20°F and below, 150°F at 50°F and above, and ramped linearly between 180°F and 150°F at temperatures between 20°F and 50°F.

ramped linearly between 180°F and 150°F at temperatures between 20°F and 50°F.			
	Exception to G	3.1.3.4	
	Systems served	by purchased heat.	
G3.1.3.5		Hot-Water Pumps	
	The <i>baseline</i> system shall mum of 25% shall be mod shall be mod	<i>building design</i> hot-water pump power shall be 19 W/gpm. The pumping be modeled as primary-only with continuous variable flow and a minipol of the design flow rate. Hot-water <i>systems</i> serving 120,000 ft ² or more eled with variable-speed drives, and <i>systems</i> serving less than 120,000 ft ² eled as riding the pump curve.	
	Exception to G	3.1.3.5	
	The pump powe	er for systems using purchased heat shall be 14 W/gpm.	
G3.1.3.6	<i>Piping</i> losses <i>design</i> for ho	Piping Losses (Systems 1, 5, 7, 8, and 11<u>, 12, and 13</u>) s shall not be modeled in either the <i>proposed design</i> or <i>baseline building</i> t-water, chilled-water, or steam <i>piping</i> .	
G3.1.3.7		Type and Number of Chillers (Systems 7, 8, 11, 12, and 13)	
Table G3.1.3.7 Type and	Electric chill energy source baseline built ber and type Number of Chille	ers shall be used in the <i>baseline building design</i> regardless of the cooling e, e.g. direct-fired absorption or absorption from purchased steam. The <i>ding design</i> 's chiller plant shall be modeled with chillers having the numas indicated in Table $\underline{G3.1.3.7}$ as a function of <i>building</i> peak cooling load.	
Building Peak Cooling Lo	ad N	lumber and Type of Chillers	
≤300 tons	1	water-cooled screw chiller	
>300 tons, <600 tons	2	water-cooled screw chillers sized equally	
≥600 tons	2 Ia	water-cooled centrifugal chillers minimum with chillers added so that no chiller is arger than 800 tons, all sized equally	
	Exception to G	3.1.3.7	
	Systems using p	urchased chilled water shall be modeled in accordance with Section G3.1.1.3.	
G3.1.3.8	and 13) Chilled-wate	Chilled-Water Design Supply Temperature (Systems 7, 8, 11, 12, r design supply temperature shall be modeled at 44°F and return water at 56°F	
G3.1.3.9	13)	Chilled-Water Supply Temperature Reset (Systems 7, 8, 11, 12, and	

Chilled-water supply temperature shall be *reset* based on outdoor dry-bulb temperature using the following schedule: 44°F at 80°F and above, 54°F at 60°F and below, and ramped linearly between 44°F and 54°F at temperatures between 80°F and 60°F.

Evcon	tion to G3 1 3 9
Except	
1.	If the baseline chilled-water system serves a computer room
	HVAC system, the supply chilled-water temperature shall be reset higher based on the
	HVAC system requiring the most cooling; i.e., the chilled-water set point is reset higher
	until one cooling-coil valve is nearly wide open. The maximum reset chilled-water supply
	temperature shall be 54°F.
2.	Systems served by purchased chilled water.
G3.1.3.10	Chilled-Water Pumps (Systems 7, 8, and 11<u>, 12, and 13</u>)

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Chilled-water *systems* shall be modeled as primary/secondary *systems* with constantflow primary loop and variable-flow secondary loop. For *systems* with cooling capacity of 300 tons or more, the secondary pump shall be modeled with variable-speed drives and a minimum flow of 25% of the design flow rate. For *systems* with less than 300 tons cooling capacity, the secondary pump shall be modeled as riding the pump curve. The baseline *building* constant-volume primary pump power shall be modeled as 9 W/gpm, and the variable-flow secondary pump power shall be modeled as 210 W/gpm at *design conditions*. For *computer room systems* using *System* 11 with an integrated *fluid economizer*, the *baseline building design* primary chilled-water pump power shall be increased by 3 W/gpm for flow associated with the *fluid economizer*.

Exception to G3.1.3.10

For systems using purchased chilled water, the *building* distribution pump shall be modeled with variable-speed drive, a minimum flow of 25% of the design flow rate, and a pump power of 16 W/gpm.

G3.1.3.11

Heat Rejection (Systems 7, 8, 9, <u>11,</u> 12, and 13)

The heat-rejection device shall be an axial-fan open-circuit cooling tower with variable-speed fan *control* and shall have an *efficiency* of 38.2 gpm/hp at the conditions specified in Table <u>6.8.1-7</u>. Condenser-water design supply temperature shall be calculated using the cooling tower approach to the 0.4% *evaporation design wet-bulb temperature* as generated by the formula below, with a design temperature rise of 5.6°C:

Approach 10° F *Range* = $25.72 - (0.24 \times WB)$

where WB is the 0.4% *evaporation design wet-bulb temperature* (°F); valid for wet bulbs from 55°F to 90°F.

The tower shall be controlled to maintain a leaving water temperature, where weather permits, per Table <u>G3.1.3.11</u>, floating up to the design leaving water temperature for the cooling tower. The *baseline building design* condenser-water pump power shall be 19 W/gpm and modeled as constant volume. For *computer room systems* using *System* 11 with an integrated water-side economizer, the *baseline building design* condenser-water-pump power shall be increased by 3 W/gpm for flow associated with the water-side economizer. Each chiller shall be modeled with separate condenser-water and chilled-water pumps interlocked to operate with the associated chiller.

Table G3.1.3.11	Heat-Rejection	Leaving Water	Temperature
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Climate Zone	Leaving Water Temperature
5B, 5C, 6B, 8	65°F
0B, 1B, 2B, 3B, 3C, 4B, 4C, 5A, 6A, 7	70°F
3A,4A	75°F
0A, 1A, 2A	80°F

G3.1.3.12

Supply Air Temperature Reset (Systems 5 through 8 and 11)

The air temperature for cooling shall be *reset* higher by 5°F under the minimum cooling load conditions.

G3.1.3.13 VAV Minimum Flow Set Points (Systems 5 and 7)

Minimum volume *set points* for *VAV reheat* boxes shall be 30% of zone peak airflow, the minimum outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is larger.

Exception to G3.1.3.13

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Systems serving laboratory *spaces* shall reduce the exhaust and *makeup air* volume during unoccupied periods to the largest of 50% of zone peak airflow, the minimum outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards.

G3.1.3.14 Fan Power and Control (Systems 6 and 8)

Fans in parallel VAV fan-powered boxes shall run as the first stage of heating before the *reheat* coil is energized. Fans in parallel VAV fan-powered boxes shall be sized for 50% of the peak design primary air (from the VAV air-handling unit) flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume *set points* for fanpowered boxes shall be equal to 30% of peak design primary airflow rate or the rate required to meet the minimum *outdoor air ventilation* requirement, whichever is larger. The supply air temperature *set point* shall be constant at the *design condition*.

G3.1.3.15 VAV Fan Part-Load Performance (Systems 5 through 8 and 11)

VAV system supply fans shall have variable-speed drives, and their part-load performance characteristics shall be modeled using either Method 1 or Method 2 specified in Table <u>G3.1.3.15</u>.

Table G3.1.3.15 Part-Load Performance for VAV Fan Systems

Method 1—Part-Load Fan Power Data				
Fan Part-Load Ratio	Fraction of Full-Load Power			
0.00	0.00			
0.10	0.03			
0.20	0.07			
0.30	0.13			
0.40	0.21			
0.50	0.30			
0.60	0.41			
0.70	0.54			
0.80	0.68			
0.90	0.83			
1.00	1.00			

Method 2—Part-Load Fan Power Equation

 $P_{fan} = 0.0013 + 0.1470 \times PLR_{fan} + 0.9506 \times (PLR_{fan})^2 - 0.0998 \times (PLR_{fan})^3$ where

 P_{fan} = fraction of full-load fan power and

 PLR_{fan} = fan part-load ratio (current cfm/design cfm).

G3.1.3.16

Computer Room Equipment Schedules

Computer room equipment schedules shall be modeled as a constant fraction of the peak design load per the following monthly schedule:

Month 1, 5, 9-25%

Month 2, 6, 10—50%

Month 3, 7, 11-75%

Month 4, 8, 12-100%

G3.1.3.17

System 11 Supply Air Temperature and Fan Control

Minimum volume *set point* shall be 50% of the maximum design airflow rate, the minimum *ventilation* outdoor airflow rate, or the airflow rate required to comply with applicable codes or accreditation standards, whichever is larger.

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Fan volume shall be *reset* from 100% airflow at 100% cooling load to minimum airflow at 50% cooling load. Supply air temperature *set point* shall be *reset* from minimum supply air temperature at 50% cooling load and above to *space* temperature at 0% cooling load. In heating mode supply air temperature shall be modulated to maintain *space* temperature, and fan volume shall be *fixed* at the minimum airflow.

G3.1.3.18 Dehumidification (Systems 3 through 8 and 11, 12, and 13)

If the proposed design HVAC systems have humidistatic controls, then the baseline building design shall use mechanical cooling for dehumidification and shall have reheat available to avoid overcooling. When the baseline building design HVAC system does not comply with any of the exceptions in Section <u>6.5.2.3</u>, then only 25% of the system reheat energy shall be included in the baseline building performance. The reheat type shall be the same as the system heating type.

G3.1.3.19 Preheat Coils (Systems 5 through 8)

The baseline *system* shall be modeled with a preheat coil controlled to a *fixed set point* 20°F less than the design room heating temperature *set point*.

Table G3.4-1 Performance Rating Method Building Envelope Requirements for Climate Zones 0 and 1 (A,B)*

	Nonresidential		Residential		Semiheated		
Opaque Elements Assembly Maximum		Maximum	Assembly	Assembly Maximum		Assembly Maximum	
Roofs							
Insulation entirely above deck	U-0.063		U-0.063		U-1.282		
Walls, Above-Grade							
Steel-framed	U-0.124		U-0.124	U-0.124		U-0.352	
Wall, Below-Grade							
Below-grade wall	C-1.140		C-1.140		C-1.140		
Floors							
Steel-joist	U-0.350		U-0.350		U-0.350		
Slab-on-Grade Floors							
Unheated	F-0.730		F-0.730		F-0.730		
Opaque Doors							
Swinging	U-0.700		U-0.700		U-0.700		
Nonswinging	U-1.450		U-1.450		U-1.450		
Fenestration	Assembl y Max. U	Assembly Max. <i>SHGC</i>	Assembl y Max. U	Assembly Max. <i>SHGC</i>	Assembl y Max. U	Assembly Max. SHGC	
Vertical Glazing, % of Wall							
0% to 10.0%	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGCall- NR	
10.1% to 20.0%	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGC _{all} - NR	
20.1% to 30.0%	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGCall- NR	
30.1% to 40.0%	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGCall- NR	
Skylight All, % of Roof							
0% to 2.0%	U _{all} -1.36	SHGC _{all} - 0.36	U _{all} -1.36	<i>SHGC_{all}-</i> 0.19	U <i>all</i> -1.36	SHGC _{all} - NR	
2.1%+	U _{all} -1.36	<i>SHGC_{all}-</i> 0.19	U _{all} -1.36	<i>SHGC_{all}-</i> 0.19	U <i>all</i> -1.36	SHGCall- NR	

ANSI/ASHRAE/IES addenda be, bm, bn, bo, bp, br, bs, bu, bv, cf, cl, cm, cq, ct, cu, cv, cw and cy to ANSI/ASHRAE/IES Standard 90.1-2016
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*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement. a. Exception to Section A3.1.3.1 applies.

	Nonresidential		Residenti	al	Semihea	Semiheated	
Opaque Elements	Assembly	y Maximum	Assembly	/ Maximum	Assemb	Assembly Maximum	
Roofs							
Insulation entirely above deck	U-0.063		U-0.063		U-0.218		
Walls, Above-Grade							
Steel-framed	U-0.124		U-0.124		U-0.352		
Wall, Below-Grade							
Below-grade wall	C-1.140		C-1.140		C-1.140		
Floors							
Steel-joist	U-0.052		U-0.052		U-0.350		
Slab-on-Grade Floors							
Unheated	F-0.730		F-0.730		F-0.730		
Opaque Doors							
Swinging	U-0.700		U-0.700		U-0.700		
Nonswinging	U-1.450		U-1.450		U-1.450		
Fenestration	Assemb ly Max. U	Assemb ly Max. SHGC	Assembl y Max. U	Assembl y Max. SHGC	Assem bly Max. U	Assem bly Max. <i>SHGC</i>	
Vertical Glazing, % of Wall							
0% to 10.0%	U _{all} -1.22	SHGCalŀ 0.25	U _{all} -1.22	SHGCall- 0.39	U _{all} -1.22	SHGCall- NR	
10.1% to 20.0%	U _{all} -1.22	SHGC _{all} - 0.25	U _{al} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGC _{all} - NR	
20.1% to 30.0%	U _{all} -1.22	SHGC _{al} - 0.25	U _{all} -1.22	SHGC _{all} - 0.25	U _{all} -1.22	SHGCall- NR	
30.1% to 40.0%	U _{all} -1.22	SHGCal⊦ 0.25	U _{all} -1.22	SHGCall- 0.25	U _{all} -1.22	SHGCall- NR	
Skylight All, % of Roof							
0% to 2.0%	U _{all} -1.36	SHGC _{all} - 0.36	U _{all} -1.36	SHGC _{all} - 0.19	U _{all} -1.36	SHGC _{all} - NR	
2.1%+	U _{all} -1.36	SHGC _{all} - 0.19	U _{all} -1.36	SHGCall- 0.19	U _{all} -1.36	SHGCall- NR	

Table G3.4-2 Performance Ra	ing Method Building	Envelope Requirements	s for Climate Zone 2	(A,B)*
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*The following definitions apply: c.i. = continuous insulation (see Section <u>3.2</u>), NR = no (insulation) requirement. a. Exception to Section <u>A3.1.3.1</u> applies.

Table G3.4-3 Performance Ratin	ng Method Building	g Envelope Red	quirements for	Climate Zone 3	(A,B,C)	t
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	Nonresidential	Residential	Semiheated		
Opaque Elements	Assembly Maximum	Assembly Maximum	Assembly Maximum		
Roofs					
Insulation entirely above deck	U-0.063	U-0.063	U-0.218		
Walls, Above-Grade					

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Steel-framed	U-0.124		U-0.084		U-0.352	
Wall, Below-Grade						
Below-grade wall	C-1.140		C-1.140		C-1.140	
Floors						
Steel-joist	U-0.052		U-0.052		U-0.069	
Slab-on-Grade Floors						
Unheated	F-0.730		F-0.730		F-0.730	
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Nonswinging	U-1.450		U-0.500		U-1.450	
Fenestration	Assemb ly Max, U	Assemb ly Max. SHGC	Assembl y Max, U	Assembl y Max. SHGC	Assemb ly Max, U	Assemb ly Max. SHGC
Vertical Glazing % of Wall						
0% to 10.0%	U _{all} -0.57	SHGC _{all} - 0.39	U _{all} -0.57	<i>SHGC₄⊪</i> - 0.39	U _{all} -1.22	SHGCa⊪ NR
10.1% to 20.0%	U _{all} -0.57	SHGCa⊪ 0.25	U _{all} -0.57	<i>SHGC_{а⊮}-</i> 0.39	U _{all} -1.22	<i>SHGCa⊪</i> NR
20.1% to 30.0%	U _{all} -0.57	SHGCa⊪ 0.25	U _{all} -0.57	SHGCall- 0.25	U _{all} -1.22	SHGCall- NR
30.1% to 40.0%	U _{all} -0.57	SHGC _{all} - 0.25	U _{all} -0.57	SHGCall- 0.25	U _{all} -1.22	SHGCa⊪ NR
Skylight All, % of Roof						
0% to 2.0%	U _{all} -0.69	SHGC _{all} - 0.39	U _{all} -0.69	SHGC _{all} - 0.36	U _{all} -1.36	SHGC _{all} - NR
2.1%+	U _{all} -0.69	<i>SHGC_{al}⊧</i> 0.19	U _{all} -0.69	SHGC _{all} - 0.19	U _{all} -1.36	SHGCa⊪ NR
Fenestration (for Zone 3C)	Assemb ly Max. U	Assemb ly Max. <i>SHGC</i>	Assembl y Max. U	Assembl y Max. SHGC	Assemb ly Max. U	Assemb Iy Max. SHGC
Vertical Glazing, % of Wall						
0% to 10.0%	U _{all} -1.22	SHGC _{all} - 0.61	U _{all} -1.22	SHGC _{all} - 0.61	U _{all} -1.22	SHGCall- NR
10.1% to 20.0%	U _{all} -1.22	SHGC _{all} - 0.39	U _{all} -1.22	<i>SHGC_{all}-</i> 0.61	U _{all} -1.22	SHGCall- NR
20.1% to 30.0%	U _{all} -1.22	SHGCall- 0.39	U _{all} -1.22	SHGC _{all} - 0.39	U _{all} -1.22	SHGCall- NR
30.1% to 40.0%	U _{all} -1.22	SHGC _{all} - 0.34	U _{all} -1.22	SHGCall- 0.34	U _{all} -1.22	SHGCall- NR
Skylight All, % of Roof						
0% to 2.0%	U _{all} -1.36	SHGC _{all} - 0.61	U _{all} -1.36	SHGC _{all} - 0.39	U _{all} -1.36	SHGCall- NR
2.1%+	U _{all} -1.36	SHGC _{all} - 0.39	U _{all} -1.36	SHGC _{all} - 0.19	U _{all} -1.36	SHGC _{all} - NR

⁻The following definitions apply: c.i. = continuous insulation (see Section <u>3.2</u>), NR = no (insulation) requirement.

^{a.} Exception to Section <u>A3.1.3.1</u> applies.

*- Insulation is not required for - nonresidential mass walls in Climate Zone 3A located below the "Warm-Humid" line, and in Zone 3B.

Table G3.4-4 Performance Rating Method Building Envelope Requirements for Climate Zone 4 (A,B,C)*

	Nonresidential	Residential	Semiheated
Opaque Elements	Assembly Maximum	Assembly Maximum	Assembly Maximum

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Roofs							
Insulation entirely above deck	U-0.063		U-0.063		U-0.218		
Walls, Above-Grade							
Steel-framed	U-0.124		U-0.064		U-0.124		
Wall, Below-Grade							
Below-grade wall	C-1.140		C-1.140		C-1.140		
Floors							
Steel-joist	U-0.052		U-0.038		U-0.069		
Slab-on-Grade Floors							
Unheated	F-0.730		F-0.730		F-0.730		
Opaque Doors							
Swinging	U-0.700		U-0.700		U-0.700		
Nonswinging	U-1.450		U-0.500		U-1.450		
Fenestration	Assemb ly Max. U	Assemb ly Max. SHGC	Assembl y Max. U	Assembl y Max. SHGC	Assem bly Max. U	Assem bly Max. SHGC	
Vertical Glazing, % of Wall							
0% to 10.0%	U _{all} -0.57	<i>SHGC_{all}-</i> 0.39	U _{all} -0.57	<i>SHGC_{all}-</i> 0.39	U _{all} -1.22	<i>SHGC_{all}-</i> NR	
10.1% to 20.0%	U _{all} -0.57	SHGC _{all} - 0.39	U _{all} -0.57	SHGC _{al} ⊦ 0.39	U _{all} -1.22	SHGC _{all} - NR	
20.1% to 30.0%	U _{all} -0.57	SHGC _{all} - 0.39	U _{all} -0.57	<i>SHGC_{all}-</i> 0.39	U _{all} -1.22	SHGCa⊪ NR	
30.1% to 40.0%	U _{all} -0.57	SHGC _{all} - 0.39	U _{all} -0.57	<i>SHGC_{all}-</i> 0.39	U _{all} -1.22	SHGCa⊪ NR	
Skylight All, % of Roof							
0% to 2.0%	U _{all} -0.69	SHGC _{all} - 0.49	U _{all} -0.58	<i>SHGC_{all}-</i> 0.36	U <i>all</i> -1.36	SHGCa⊪ NR	
2.1%+	U _{all} -0.69	SHGC _{all} - 0.39	U _{all} -0.58	<i>SHGC_{all}-</i> 0.19	U _{all} -1.36	SHGC _{all} - NR	

*The following definitions apply: c.i. = continuous insulation (see Section <u>3.2</u>), NR = no (insulation) requirement. * Exception to Section <u>A3.1.3.1</u> applies.

Table G3.4-5 Performance Rating Method Building Envelope Requirements for Climate Zone 5 (A,B,C)*

	Nonresidential	Residential	Semiheated
<i>Opaque</i> Elements	Assembly Maximum	Assembly Maximum	Assembly Maximum
Roofs			
Insulation entirely above deck	U-0.063	U-0.063	U-0.173
Walls, Above-Grade			
Steel-framed	U-0.084	U-0.064	U-0.124
Wall, Below-Grade			
Below-grade wall	C-1.140	C-1.140	C-1.140
Floors			
Steel-joist	U-0.052	U-0.038	U-0.069
Slab-on-Grade Floors			
Unheated	F-0.730	F-0.730	F-0.730
Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700

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Nonswinging	U-1.450		U-0.500		U-1.450	
Fenestration	Assemb ly Max. U	Assemb ly Max. SHGC	Assembl y Max. U	Assembl y Max. SHGC	Assem bly Max. U	Assem bly Max. SHGC
Vertical Glazing, % of Wall						
0% to 10.0%	U _{all} -0.57	<i>SHGC_{all}-</i> 0.49	Uall-0.57	<i>SHGC_{all}-</i> 0.49	U _{all} -1.22	SHGCall -NR
10.1% to 20.0%	U _{all} -0.57	SHGC _{all} - 0.39	U _{all} -0.57	SHGC _{all} - 0.39	U _{all} -1.22	<i>SHGC₄∥</i> -NR
20.1% to 30.0%	Uall-0.57	SHGC _{all} - 0.39	U _{all} -0.57	SHGCall- 0.39	U _{all} -1.22	<i>SHGC₄⊪</i> -NR
30.1% to 40.0%	Uall-0.57	SHGCall− 0.39	U _{all} -0.57	SHGC _{all} - 0.39	U _{all} -1.22	<i>SHGC₄⊪</i> -NR
Skylight All, % of Roof						
0% to 2.0%	U _{all} -0.69	SHGC _{all} - 0.49	U _{all} -0.69	SHGC _{all} - 0.49	U _{all} -1.36	<i>SHGC₄∥</i> -NR
2.1%+	U _{all} -0.69	SHGC _{all} - 0.39	U _{all} -0.69	SHGC _{all} - 0.39	U _{all} -1.36	SHGCall -NR

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

Table G3.4-6 Performance Rating Method Building Envelope Requirements for Climate Zone 6 (A,B)*

	Nonresidential		Residential			Semiheated			
Opaque Elements	Assembly	y Maximum		Assembly Maximum		Assemb	Assembly Maximum		
Roofs									
Insulation entirely above deck	U-0.063		U-0.063			U-0.173			
Walls, Above-Grade									
Steel-framed	U-0.084			U-0.064			U-0.124		
Wall, Below-Grade									
Below-grade wall	C-1.140			C-0.119			C-1.140		
Floors									
Steel-joist	U-0.038			U-0.038			U-0.069		
Slab-on-Grade Floors									
Unheated	F-0.730 F		F-0.730	F-0.730		F-0.730			
Opaque Doors									
Swinging	U-0.700			U-0.500		U-0.700			
Nonswinging	U-0.500			U-0.500		U-1.450			
Fenestration	Assemb ly Max. U	Assemb ly Max. SHGC		Assembl y Max. U	Assembl y Max. SHGC		Assem bly Max. U	Assem bly Max. <i>SHGC</i>	
Vertical Glazing, % of Wall									
0% to 10.0%	U _{all} -0.57	SHGC _{all} - 0.49		U _{all} -0.57	<i>SHGC_{all}-</i> 0.49		U _{all} -1.22	SHGCall -NR	
10.1% to 20.0%	U _{all} -0.57	SHGC _{all} - 0.39		U _{all} -0.57	<i>SHGC_{all}-</i> 0.39		U _{all} -1.22	SHGCall -NR	
20.1% to 30.0%	U _{all} -0.57	SHGC _{all} - 0.39		U _{all} -0.57	<i>SHGC_{all}-</i> 0.39		U _{all} -1.22	SHGCall -NR	
30.1% to 40.0%	U _{all} -0.57	SHGC _{all} - 0.39		U _{all} -0.57	<i>SHGC_{all}-</i> 0.39		U _{all} -1.22	SHGCall -NR	
Skylight All, % of Roof									

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0% to 2.0%	U _{all} -0.69	SHGC _{all} - 0.49	U <i>al</i> ⊢0.58	SHGC _{all} - 0.49	U _{all} -1.36	SHGCall -NR
2.1%+	U <i>all</i> -0.69	SHGC _{all} - 0.49	U _{all} -0.58	SHGC _{all} - 0.39	U _{all} -1.36	<i>SHGCa⊪</i> -NR

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

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Table G3.4-7 Performance Rating Method Building Envelope Requirements for Climate Zone 7*

	Nonresidential Residential			Semiheated				
Opaque Elements	Assembly	Maximum		Assembly Maximum			Assembly Maximum	
Roofs								
Insulation entirely above deck	U-0.063			U-0.063			U-0.173	
Walls, Above-Grade								
Steel-framed	U-0.064			U-0.064			U-0.124	
Wall, Below-Grade								
Below-grade wall	C-0.119			C-0.119			C-1.140	
Floors								
Steel-joist	U-0.038			U-0.038			U-0.052	
Slab-on-Grade Floors								
Unheated	F-0.730			F-0.540			F-0.730	
Opaque Doors								
Swinging	U-0.700			U-0.500			U-0.700	
Nonswinging	U-0.500			U-0.500			U-1.450	
Fenestration	Assemb ly Max, U	Assemb ly Max. SHGC		Assembl y Max, U	Assembl y Max. SHGC		Assem bly Max U	Assem bly Max. <i>SHGC</i>
Vertical Glazing % of Wall					0.100			
0% to 10.0%	U _{2/5} 0 57	SHGCal		U _{a/=} 0 57	SHGColle		∐ _{a/=} 1 22	SHGCou
		r0.49			0.49			-NR
10.1% to 20.0%	U _{all} -0.57	SHGCal r-0.49		U <i>all</i> -0.57	SHGC _{all} - 0.49		U _{all} -1.22	<i>SHGC₄∥</i> -NR
20.1% to 30.0%	U _{all} -0.57	<i>SHGCal</i> ⊬0.49		U _{all} -0.57	SHGC _{all} - 0.49		U _{all} -1.22	SHGCall -NR
30.1% to 40.0%	U _{all} -0.57	<i>SHGCal</i> ⊬0.49		U _{all} -0.57	SHGC _{all} - 0.49		U _{all} -1.22	SHGCall -NR
Skylight All, % of Roof								
0% to 2.0%	U _{all} -0.69	<i>SHGCal</i> ⊬0.68		U _{all} -0.69	SHGC _{all} - 0.64		U _{all} -1.36	SHGCall -NR
2.1%+	U _{all} -0.69	<i>SHGCal</i> r0.64		U _{all} -0.69	<i>SHGC_{all}-</i> 0.64		U _{all} -1.36	SHGCall -NR

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

Table G3.4-8 Performance Rating Method Building Envelope Requirements for Climate Zone 8*

	Nonresidential Residential		Semiheated
Opaque Elements	Assembly Maximum	Assembly Maximum	Assembly Maximum
Roofs			
Insulation entirely above deck	U-0.048	U-0.048	U-0.093
Walls, Above-Grade			
Steel-framed	U-0.064	U-0.055	U-0.124

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Wall, Below-Grade						
Below-grade wall	C-0.119		C-0.119		C-1.140	
Floors						
Steel-joist	U-0.038		U-0.032		U-0.052	
Slab-on-Grade Floors						
Unheated	F-0.540		F-0.520		F-0.730	
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Nonswinging	U-0.500		U-0.500		U-1.450	
Fenestration	Assemb ly Max. U	Assemb ly Max. SHGC	Assembl y Max. U	Assembl y Max. SHGC	Assemb Iy Max. U	Assemb Iy Max. SHGC
Vertical Glazing, % of Wall						
0% to 10.0%	U _{all} -0.46	SHGCall- NR	U _{all} -0.46	SHGCall- NR	U _{all} -1.22	<i>SHGCa⊪</i> NR
10.1% to 20.0%	U _{all} -0.46	SHGCall- NR	U _{all} -0.46	SHGCall- NR	U _{all} -1.22	<i>SHGCa⊪</i> NR
20.1% to 30.0%	U _{all} -0.46	SHGCall- NR	U _{all} -0.46	SHGCall- NR	U _{all} -1.22	<i>SHGCa⊪</i> NR
30.1% to 40.0%	U _{all} -0.46	SHGCall- NR	U _{all} -0.46	<i>SHGCa⊪</i> NR	U _{all} -1.22	<i>SHGCa⊪</i> NR
Skylight All, % of Roof						
0% to 2.0%	U _{all} -0.58	SHGCall- NR	U _{all} -0.58	<i>SHGCa⊪</i> NR	U _{all} -0.81	<i>SHGCa⊪</i> NR
2.1%+	U _{al} ⊢0.58	SHGCall- NR	U _{all} -0.58	SHGCall- NR	U _{all} -0.81	SHGCall- NR

*The following definitions apply: c.i. = continuous insulation (see Section <u>3.2</u>), NR = no (insulation) requirement.

* Exception to Section A3.1.3.1 applies.

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 <i>ASHRAE Handbook—Fundamentals</i> , Chapter 26).	1/12/2019	1/16/2019	12/14/2018	1/17/2019
а	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
С	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
е	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
I	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
0	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
у	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
ао	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
ар	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

ау	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
Ы	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

са	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
сс	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
се	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
со	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
су	9.4.1(e)	Revises the sidelighting requirement exceptions.	7/22/2019	8/15/2019	7/19/2019	8/19/2019

NOTE

Approved errata or interpretations for this standard can be downloaded free of charge from the ASHRAE Web site at www.ashrae.org/technology.

a. *These descriptions may not be complete and are provided for information only.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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About ASHRAE

Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

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