ANSI/ASHRAE/USGBC/IES
Standard 189.1-2009

Standard for the Design of High-Performance Green Buildings

Except Low-Rise Residential Buildings

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ASHRAE obtains consensus through participation of its national and international members, associated societies, and public review.

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b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
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NOTE

When addenda, errata, or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at www.ashrae.org/technology.

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FOREWORD

This is the first edition of ANSI/ASHRAE/USGBC/IES Standard 189.1. This standard was created in a collaborative effort between ASHRAE, the U.S. Green Building Council, and the Illuminating Engineering Society. This standard is written in code-intended language (mandatory, enforceable language) so it may be referenced or adopted by enforcement authorities as the minimum acceptable level of performance for high-performance green buildings within their jurisdiction. States and local jurisdictions within the United States that wish to adopt Standard 189.1 into law may want to review applicable federal laws regarding preemption and related waivers that are available from the U.S. Department of Energy (www1.eere.energy.gov/buildings/appliance_standards/state_petitions.html).

The environmental impact of the building design, construction, and operations industry is enormous. Development frequently alters land from natural, biologically diverse habitats to hardscape that is impervious and devoid of biodiversity. Buildings in the United States are responsible for 39% of CO_2 emissions, 40% of energy consumption, 13% water consumption, and 15% of GDP per year, making green building a source of significant environmental opportunity.

The far-reaching influence of the built environment necessitates action to reduce its impact. To meet its responsibility, the project committee undertook an extensive program to obtain input from all segments of industry and the public. Provisions in this standard can reduce negative environmental impacts through high-performance building design, construction, and operations practices.

In arriving at the set of requirements necessary to achieve the performance referenced herein, the project committee considered a variety of factors, including their professional judgement. However, there was no overall economic assessment of the criteria within the standard. Developing an economic threshold for each requirement is beyond the scope of this standard.

The standard addresses site sustainability, water use efficiency, energy efficiency, indoor environmental quality (IEQ), and the building's impact on the atmosphere, materials, and resources. These five key subject areas, as well as plans for construction and high-performance operation, are each addressed in a separate chapter using the following format:

***x.1 General.** This subsection includes a statement of scope and addresses other broad issues.*

***x.2 Compliance Paths.** This subsection indicates the compliance options for each section.*

***x.3 Mandatory Provisions.** This subsection contains the criteria that must be complied with by all projects (i.e., the criteria that cannot be traded off).*

***x.4 Prescriptive Option.** This subsection contains additional criteria specified in a manner that provides a simple way to show compliance that involves little or no calculations.*

***x.5 Performance Option.** This subsection contains an alternate way to show compliance that is typically more complex than the prescriptive option.*

This standard is now on continuous maintenance and the project committee will consider changes and propose addenda for public review. The committee welcomes suggestions for improving the standard. Users of the standard are encouraged and invited to use the continuous maintenance procedure to suggest changes. A form for submittal of a proposed change is included at the back of this standard. The committee will take formal action on every proposal received.

When addenda are approved, notices will be published on the ASHRAE Web site. Users are encouraged to sign up for the free ASHRAE Internet Listserv for this standard to receive notice of all public reviews and approved and published addenda and errata.

1. PURPOSE

The purpose of this standard is to provide minimum requirements for the siting, design, construction, and plan for operation of high-performance green buildings to:

a. balance environmental responsibility, resource efficiency, occupant comfort and well being, and community sensitivity, and
b. support the goal of development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

2. SCOPE

2.1 This standard provides minimum criteria that:

a. apply to the following elements of *building projects*:

1. new buildings and their systems
2. new portions of buildings and their systems
3. new systems and equipment in existing buildings

b. address *site* sustainability, water use efficiency, energy efficiency, indoor environmental quality (IEQ), and the building's impact on the atmosphere, materials, and resources.

2.2 The provisions of this standard do not apply to:

a. single-family houses, multi-family structures of three stories or fewer above grade, manufactured houses (mobile homes) and manufactured houses (modular), and
b. buildings that use none of the following: electricity, fossil fuel, or water.

2.3 This standard shall not be used to circumvent any safety, health, or environmental requirements.

3. DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

3.1 General. Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this standard. These definitions are applicable to all sections of this standard.

Terms that are not defined herein, but that are defined in standards that are referenced herein (e.g., ANSI/ASHRAE/IESNA Standard 90.1), shall have the meanings as defined in those standards.

Other terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based upon American standard English language usage, as documented in an unabridged dictionary accepted by the *authority having jurisdiction*.

3.2 Definitions

acceptance representative: An entity identified by the *owner* who leads, plans, schedules, and coordinates the activities needed to implement the building acceptance testing activities. The acceptance representative may be a qualified employee or consultant of the *owner*. The individual serving as the acceptance representative shall be independent of the project design and construction management, though this individual may be an employee of a firms providing those services.

adapted plants: see *plants, adapted.*

adequate transit service: at least two buses (including bus rapid transit), streetcars, or light rail trains per hour on weekdays, operating between 6:00 a.m. and 9:00 a.m., and between 3:00 p.m. and 6:00 p.m., or at least five heavy passenger rail or ferries operating between 6:00 a.m. and 9:00 a.m., and between 3:00 p.m. and 6:00 p.m.

agricultural land: land that is, or was within ten years prior to the date of the building permit application for the *building project*, primarily devoted to the commercial production of horticultural, viticultural, floricultural, dairy, apiary, vegetable, or animal products or of berries, grain, hay, straw, turf, seed, finfish in upland hatcheries, or livestock, and that has long-term commercial significance for agricultural production. Land that meets this definition is *agricultural land* regardless of how the land is zoned by the local government with zoning jurisdiction over that land.

alternate on-site sources of water: see *water, alternate on-site sources of*.

annual load factor: the calculated annual electric consumption, in kWh, divided by the product of the calculated annual peak electric demand, in kW, and 8760 hours.

attic and other roofs: see ANSI/ASHRAE/IESNA Standard 90.1.

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

basis of design (BOD): a document that records the concepts, calculations, decisions, and product selections used to meet the *owner's project requirements* and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. (See *owner's project requirements*.)

biobased product: a commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or renewable agricultural materials (including plant, animal, and marine materials) or forestry materials.

bio-diverse plantings: nonhomogeneous, multiple-species plantings.

breathing zone: see ANSI/ASHRAE Standard 62.1.

brownfield site: a *site* documented as contaminated by means of an ASTM E1903 Phase II Environmental Site Assessment or a *site* classified as a brownfield by a local, state, or federal government agency.

building entrance: see ANSI/ASHRAE/IESNA Standard 90.1.

building envelope: see ANSI/ASHRAE/IESNA Standard 90.1.

building project: a building, or group of buildings, and *site* that utilize a single submittal for a construction permit or that are within the boundary of contiguous properties under single ownership or effective control (see *owner*).

carbon dioxide equivalent (CO_2e): a measure used to compare the impact of various greenhouse gases based on their global warming potential (GWP). CO_2e approximates the time-integrated warming effect of a unit mass of a given greenhouse gas, relative to that of carbon dioxide (CO_2). GWP is an index for estimating the relative global warming contribution of atmospheric emissions of 1 kg of a particular greenhouse gas compared to emissions of 1 kg of CO_2. The following GWP values are used based on a 100-year time horizon: 1 for CO_2, 25 for methane (CH_4), and 298 for nitrous oxide (N_2O).

classroom: a space primarily used for scheduled instructional activities.

clerestory: see ANSI/ASHRAE/IESNA Standard 90.1.

climate zone: see Section 5.1.4 of ANSI/ASHRAE/IESNA Standard 90.1.

cognizant authority: see ANSI/ASHRAE Standard 62.1.

commissioning authority (CxA): An entity identified by the *owner* who leads, plans, schedules, and coordinates the commissioning team to implement the building commissioning process. (See *commissioning process*.)

commissioning plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the building commissioning process. (See *commissioning process*.)

commissioning process: A quality-focused process for enhancing the delivery of a project. The process focuses upon

verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the *owner's project requirements*. (See *owner's project requirements*.)

complete operational cycle: a period of time as long as one year so as to account for climactic variations affecting outdoor water consumption.

conditioned space: see ANSI/ASHRAE/IESNA Standard 90.1.

construction checklist: a form used by the contractor to verify that appropriate components are onsite, ready for installation, correctly installed, and functional.

continuous air barrier: the combination of interconnected materials, assemblies, and flexible sealed joints and components of the *building envelope* that provide airtightness to a specified permeability. (See *building envelope*.)

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

cycles of concentration: the ratio of makeup rate to the sum of the blowdown and drift rates.

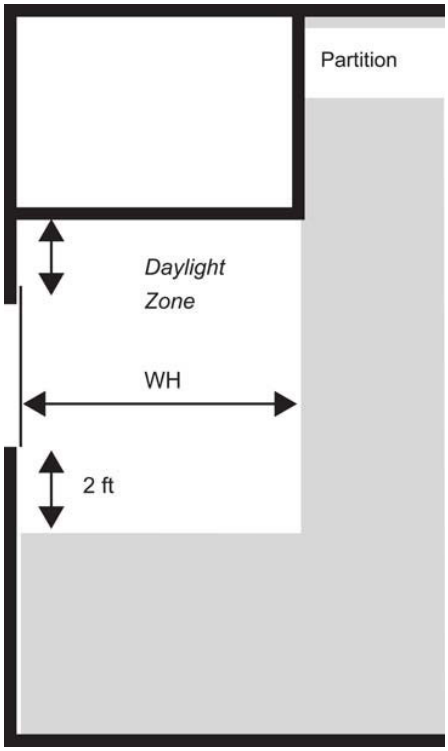


Figure 3.1 Plan view of daylight zone adjacent to vertical fenestration; W = Window Width, WH = Height above floor to head of window.

daylight zone:

a. ***adjacent to vertical fenestration*** **(see Figure 3.1)*:*** the area illuminated by vertical glazing, calculated as the daylit depth multiplied by the daylit width, where the daylit depth is the lesser of one window head height (head height is the distance from the floor to the top of the glazing) or the distance on the floor, perpendicular to the glazing, to the nearest 56 in. (1.4 m) or higher permanent partition; and the daylit width is the width of the window plus, on each side, either the distance to a 56 in. (1.4 m) or higher permanent partition or one-half the distance to the closest *skylight, roof monitor, clerestory,* or *vertical fenestration*, or 2 ft (0.6 m), whichever is least. (See *skylight, roof monitor, clerestory, tubular daylighting device,* and *vertical fenestration*.)

b. ***under skylights and tubular daylighting devices*** **(see Figure 3.2)*:*** the area illuminated by *skylights*, calculated by adding the rough opening of the *skylight* plus, in each of the lateral and longitudinal dimensions of the *skylight*, the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 56 in. (1.4 m) or higher permanent partition, or one-half the horizontal distance to the edge of the closest *skylight*, *roof monitor*, *clerestory* window, *tubular daylighting device*, or *vertical fenestration*. (See *skylight, roof monitor, clerestory, tubular daylighting device,* and *vertical fenestration*.)

c. ***under clerestory*** **(see Figures 3.3 and 3.5)*:*** the area illuminated by *vertical fenestration* in a *clerestory*, calculated as the daylit depth multiplied by the daylit width, where the daylit depth is the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 56 in. (1.4 m) or higher permanent partition, or one-half the horizontal distance to the edge of the closest *skylight*, and the daylit width is the length of the window plus the lesser of 70% of the floor-to-ceiling

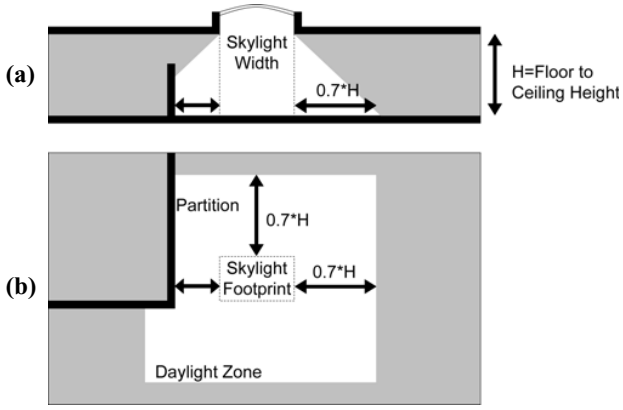
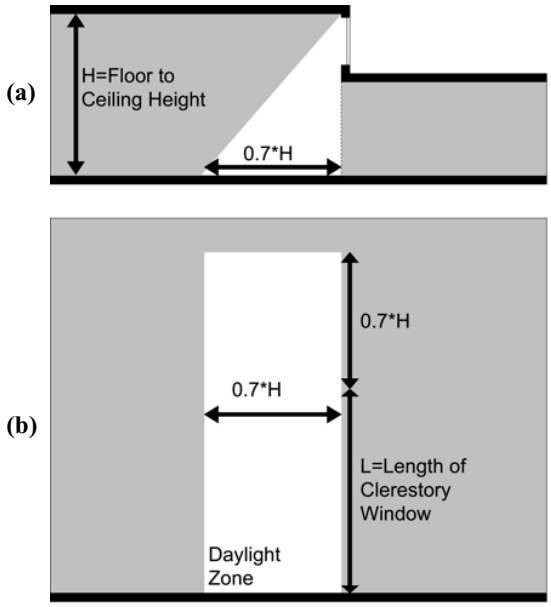


Figure 3.2 (a) Elevation view and (b) plan view of daylight zone under skylight.



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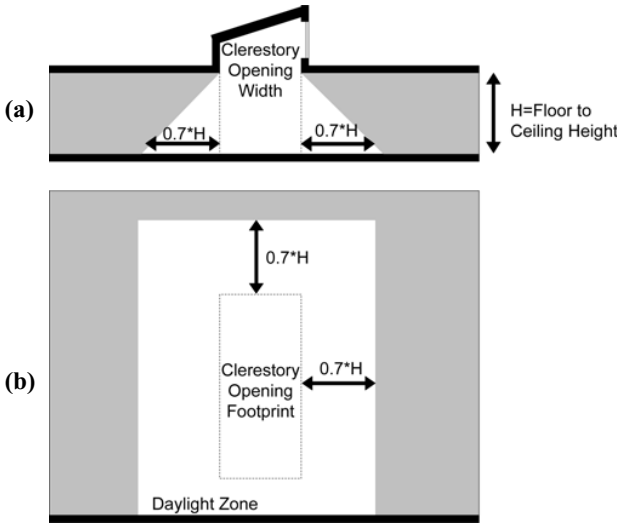


Figure 3.5 (a) Elevation view and (b) plan view of daylight zone under clerestory roof monitor.

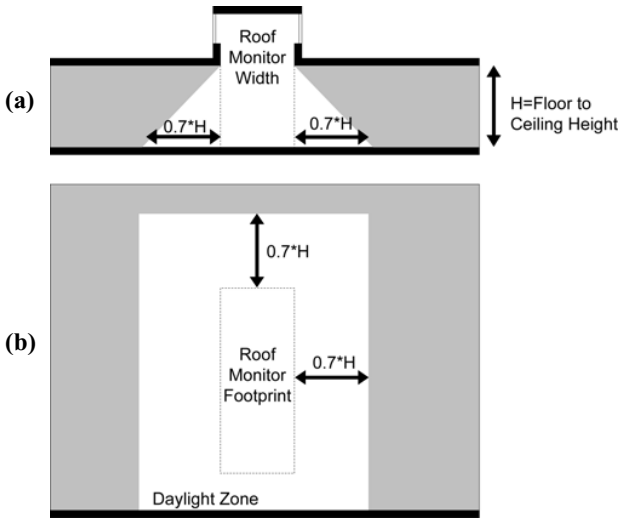


Figure 3.4 (a) Elevation view and (b) plan view of daylight zone under roof monitor.

height, the distance to the nearest 56 in. (1.4 m) or higher permanent partition, or one-half the horizontal distance to the edge of the closest *skylight*, *roof monitor*, *clerestory* window, or *vertical fenestration* in each longitudinal direction. (See *skylight, roof monitor, clerestory,* and *vertical fenestration*.)

d. ***under roof monitor*** **(see Figures 3.4 and 3.5)*:*** the area illuminated by *vertical fenestration* in a *roof monitor*, calculated by adding the rough opening of the *roof monitor* plus, in each of the lateral and longitudinal dimensions of the opening, the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 56 in. (1.4 m) or higher permanent partition, or one-half the horizontal distance to the edge of the closest *skylight*, *roof monitor*, *clerestory* window, or *vertical fenestration*. (See *skylight, roof monitor, clerestory, tubular daylighting device,* and *vertical fenestration*.)

demand control ventilation (DCV): see ANSI/ASHRAE/IESNA Standard 90.1.

densely occupied space: those spaces with a design occupant density greater than or equal to 25 people per 1000 ft^2 (100 m^2).

design outdoor airflow rate: the minimum required rate of outdoor airflow which must be provided by a ventilation system at design occupancy.

designated park land: federal-, state-, or local-government-owned land that is formally designated and set aside as park land or wildlife preserve.

development footprint: the total land area of a project *site* that will be developed with impervious surfaces, constructed as part of the project such as buildings, streets, other areas that have been graded so as to be effectively impervious, and parking areas.

dwelling unit: see ANSI/ASHRAE/IESNA Standard 90.1.

effective aperture for vertical fenestration (EA_{vf}): the product of the visible transmittance of the overall *vertical fenestration* product (entire rough opening, including glass, sash, and frame) and the *vertical fenestration* area as a percentage of the *gross wall area*. Visible transmittance is determined in accordance with Section 5.8.2.6 of ANSI/ASHRAE/IESNA

Standard 90.1. (See *fenestration area*, *gross wall area*, and *vertical fenestration*.)

emergency ride home: access to transportation home in the case of a personal emergency, or unscheduled overtime for employees who commute via transit, carpool, or vanpool.

evapotranspiration (ET): the sum of evaporation and plant transpiration. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves.

> ***ET_c:*** *Evapotranspiration* of the plant material derived by multiplying ET_o by the appropriate plant coefficient.
>
> ***ET_o:*** Maximum *evapotranspiration* as defined by the standardized Penman-Monteith equation or from the National Weather Service, where available.

expressway: a divided highway with a minimum of four lanes, which has controlled access for a minimum of 10 miles (16 kilometers) and a posted minimum speed of at least 45 mph (70 km/h).

fenestration: see ANSI/ASHRAE/IESNA Standard 90.1.

fenestration area: see ANSI/ASHRAE/IESNA Standard 90.1.

***fish and wildlife habitat conservation area*:** areas with which state or federally designated endangered, threatened, or sensitive species have a primary association.

forest land: all designated state forests, national forests, and all land that is, or was within 10 years prior to the date of the building permit for the *building project*, primarily devoted to growing trees for long-term commercial timber production.

generally accepted engineering standard: see ANSI/ASHRAE/IESNA Standard 90.1.

geothermal energy: heat extracted from the Earth's interior and used to produce electricity, mechanical power, or provide thermal energy for heating buildings or processes. Geothermal energy does not include systems that use energy independent of the geothermal source to raise the temperature of the extracted heat, such as heat pumps.

greenfield site: a *site* of which 20% or less has been previously developed with impervious surfaces.

greyfield site: a *site* of which more than 20% is already developed with impervious surfaces.

gross roof area: see ANSI/ASHRAE/IESNA Standard 90.1.

gross wall area: see ANSI/ASHRAE/IESNA Standard 90.1.

hardscape: *site* paved areas including roads, driveways, parking lots, walkways, courtyards, and plazas.

heat island effect: the tendency of urban areas to be at a warmer temperature than surrounding rural areas.

high-performance green building: a building designed, constructed, and capable of being operated in a manner that increases environmental performance and economic value over time, seeks to establish an indoor environment that supports the health of occupants, and enhances satisfaction and productivity of occupants through integration of environmentally preferable building materials and water-efficient and energy-efficient systems.

hydrozoning: to divide the landscape irrigation system into sections in order to regulate each zone's water needs based on plant materials, soil, and other factors.

improved landscape: any disturbed area of the *site* where new plant and/or grass materials are to be used, including green *roofs*, plantings for stormwater controls, planting boxes, and similar vegetative use. *Improved landscape* shall not include *hardscape* areas such as sidewalks, driveways, or other paved areas, and swimming pools or decking.

integrated design process: a design process utilizing early collaboration amongst representatives of each stakeholder and participating consultant on the project. Unlike the conventional or linear design process, integrated design requires broad stakeholder/consultant participation.

integral heat recovery: a refrigeration system that allows heating and cooling to be transferred between air-conditioned zones in a refrigeration system. In the case of a VRF system, this is typically done using a three-pipe system with compression discharge gas, liquid refrigerant, and suction gas piping being piped to each conditioned zone.

***integrated project delivery*:** see *integrated design process.*

interior projection factor: see *projection factor, interior.*

irrigation adequacy: a representation of how well irrigation meets the needs of the plant material. This reflects the percentage of required water for turf or plant material supplied by rainfall and controller-scheduled irrigations.

irrigation excess: a representation of the amount of irrigation water applied beyond the needs of the plant material. This reflects the percentage of water applied in excess of 100% of required water.

landscape establishment period: a time period, beginning on the date of completion of permanent plantings and not exceeding 18 months, intended to allow the permanent landscape to become sufficiently established to remain viable.

life cycle assessment (LCA): a compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a building system throughout its life cycle. LCA addresses the environmental aspects and potential environmental impacts (e.g., use of resources and environmental consequences of releases) throughout a building's life cycle, from raw material acquisition through manufacturing, construction, use, operation, end-of-life treatment, recycling, and final disposal (end of life). The purpose is to identify opportunities to improve the environmental performance of buildings throughout their life cycles.

light rail: a streetcar-type vehicle that has step entry or level boarding entry and is operated on city streets, semi-exclusive rights-of-way, or exclusive rights-of-way.

lighting power allowance: see ANSI/ASHRAE/IESNA Standard 90.1.

lighting zone (LZ): An area defining limitations for outdoor lighting.

LZ0: Undeveloped areas within national parks, state parks, forest land, rural areas, and other undeveloped areas as defined by the *AHJ*.

LZ1: Developed areas of national parks, state parks, forest land, and rural areas.

LZ2: Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use, and residential mixed-use areas.

LZ3: All areas not included in LZ0, LZ1, LZ2, or LZ4.

LZ4: High activity commercial districts in major metropolitan areas as designated by the local jurisdiction.

liner system (Ls): An insulation system for a metal building *roof* that includes the following components. A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated R-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal *roof* panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal *roof* panels is required, unless compliance is shown by the overall assembly U-factor, or otherwise noted.

low-impact trail: erosion-stabilized pathway or track that utilizes natural groundcover or installed system greater than 50% pervious. The pathway or track is designed and used only for pedestrian and nonmotorized vehicles (excluding power-assisted conveyances for individuals with disabilities).

maintenance plan: see *maintenance program* in ANSI/ASHRAE/ACCA Standard 180.

minimum outdoor airflow rate: the rate of outdoor airflow provided by a ventilation system when running when all *densely occupied spaces* with *demand control ventilation* are unoccupied.

native plants: see *plants, native.*

non-potable water: see *water, non-potable.*

nonresidential: see ANSI/ASHRAE/IESNA Standard 90.1.

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

occupiable space: see ANSI/ASHRAE Standard 62.1.

office furniture system: either a panel-based workstation comprised of modular interconnecting panels, hang-on components, and drawer/filing components, or a freestanding grouping of furniture items and their components that have been designed to work in concert.

on-site renewable energy system: photovoltaic, solar thermal, *geothermal energy*, and wind systems used to generate energy and located on the *building project*.

once-through cooling: The use of water as a cooling medium where the water is passed through a heat exchanger one time and is then discharged to the drainage system. This also includes the use of water to reduce the temperature of condensate or process water before discharging it to the drainage system.

open-graded (uniform-sized) aggregate: materials such as crushed stone or decomposed granite that provide 30%–40% void spaces.

outdoor air: see ANSI/ASHRAE Standard 62.1.

owner**:** The party in responsible control of development, construction, or operation of a project at any given time.

owner's project requirements (OPR): a written document that details the functional requirements of a project and the expectations of how it will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

permanently installed: see ANSI/ASHRAE/IESNA Standard 90.1.

permeable pavement: pervious concrete or porous asphalt that allows the movement of water and air through the paving material, and primarily used as paving for roads, parking lots, and walkways. Permeable paving materials have an open-graded coarse aggregate with interconnected voids.

permeable pavers: units that present a solid surface but allow natural drainage and migration of water into the base below by permitting water to drain through the spaces between the pavers.

plants:

a. ***adapted plants:*** *plants* that reliably grow well in a given habitat with minimal attention from humans in the form of winter protection, pest protection, water irrigation, or fertilization once root systems are established in the soil. Adapted *plants* are considered to be low maintenance but not invasive.
b. ***invasive plants:*** *plants*, both indigenous and non-indigenous species or strains, which are characteristically adaptable, aggressive, have a high reproductive capacity and tend to overrun the ecosystems that they inhabit. Collectively they are one of the great threats to biodiversity and ecosystem stability.
c. ***native plants:*** *plants* that adapted to a given area during a defined time period and are not invasive. In America, the term often refers to *plants* growing in a region prior to the time of settlement by people of European descent.

porous pavers (open-grid pavers): units where at least 40% of the surface area consists of holes or openings that are filled with sand, gravel, other porous material, or vegetation.

post-consumer recycled content: proportion of *recycled material* in a product generated by households or by commercial, industrial, and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purpose. This includes returns of material from the distribution chain. (See *recycled material*.)

potable water: see *water, potable.*

pre-consumer recycled content: proportion of *recycled material* in a product diverted from the waste stream during the manufacturing process. Content that shall not be considered pre-consumer recycled includes the re-utilization of materials such as rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it. (See *recycled material*.)

projection factor (PF): see ANSI/ASHRAE/IESNA Standard 90.1.

projection factor, interior: the ratio of the horizontal depth of the interior shading projection divided by the sum of the height of the *fenestration* above the interior shading projection and, if the interior projection is below the bottom of the *fenestration*, the vertical distance from the bottom of the *fenestration* to the top of the farthest point of the interior shading projection, in consistent units.

recovered material: material that would have otherwise been disposed of as waste or used for energy recovery (e.g., incinerated for power generation), but has instead been collected and recovered as a material input, in lieu of new primary material, for a recycling or a manufacturing process.

recycled content: proportion, by mass, of *recycled material* in a product or packaging. Only pre-consumer and post-consumer materials shall be considered as *recycled content*. (See *recycled material*.)

recycled material: material that has been reprocessed from *recovered* (reclaimed) *material* by means of a manufacturing process and made into a final product or into a component for incorporation into a product. (See *recovered material*.)

residential: see ANSI/ASHRAE/IESNA Standard 90.1.

roof: see ANSI/ASHRAE/IESNA Standard 90.1.

roof area, gross: see ANSI/ASHRAE/IESNA Standard 90.1.

roof monitor: a raised central portion of a *roof* having *vertical fenestration*.

seating: task and guest chairs used with office furniture systems.

semiheated space: see ANSI/ASHRAE/IESNA Standard 90.1.

service water heating: see ANSI/ASHRAE/IESNA Standard 90.1.

sidelighting: daylighting provided by *vertical fenestration* mounted below the ceiling plane.

single-rafter roof: see ANSI/ASHRAE/IESNA Standard 90.1.

skylight: see ANSI/ASHRAE/IESNA Standard 90.1.

site: a contiguous area of land that is under the ownership or control of one entity.

smart controller (weather-based irrigation controller): a device that estimates or measures depletion of water from the soil moisture reservoir and operates an irrigation system to replenish water as needed while minimizing excess.

soil gas retarding system: a combination of measures that retard vapors in the soil from entering the occupied space.

solar energy system: any device or combination of devices or elements that rely upon direct sunlight as an energy source, including but not limited to any substance or device that collects sunlight for use in:

a. the heating or cooling of a structure or building;
b. the heating or pumping of water;
c. industrial, commercial, or agricultural processes; or
d. the generation of electricity.

solar heat gain coefficient (SHGC): see ANSI/ASHRAE/IESNA Standard 90.1.

solar reflectance index (SRI): a measure of a constructed surface's ability to reflect solar heat, as shown by a small temperature rise. A standard black surface (reflectance 0.05, emittance 0.90) is 0 and a standard white surface (reflectance 0.80, emittance 0.90) is 100.

***SWAT*:** smart water application technology as defined by the Irrigation Association.

toplighting: daylighting provided by *fenestration* mounted above the ceiling plane, including *skylights*, *tubular daylighting device*s, and *vertical fenestration* in *roof monitor*s; and *fenestration* mounted above a lower adjacent ceiling plane in the space in clerestories.

tubular daylighting device: a means to capture sunlight from a rooftop. Sunlight is then redirected down from a highly reflective shaft and diffused throughout interior space.

turfgrass: grasses that are regularly mowed and, as a consequence, form a dense growth of leaf blades, shoots, and roots.

vendor: a company that furnishes products to project contractors and/or subcontractors for on-site installation.

variable air volume (VAV) system: see ANSI/ASHRAE/IESNA Standard 90.1.

verification: the process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the *owner's project requirements*. (See *owner's project requirements*.)

vertical fenestration: see ANSI/ASHRAE/IESNA Standard 90.1.

wall: see ANSI/ASHRAE/IESNA Standard 90.1.

wall area, gross: see ANSI/ASHRAE/IESNA Standard 90.1.

water, alternate on-site sources of: *alternate on-site sources of water* include, but are not limited to:

a. rainwater or stormwater harvesting,
b. air conditioner condensate,
c. gray water from interior applications and treated as required,
d. swimming pool filter backwash water,
e. cooling tower blowdown water,
f. foundation drain water,
g. industrial process water, or
h. on-site wastewater treatment plant effluent.

water, non-potable: water that is not *potable water*. (See *water, potable*.)

water, potable: water from public drinking water systems or from natural freshwater sources such as lakes, streams, and aquifers where water from such natural sources would or could meet drinking water standards.

water factor (WF):

a. ***clothes washer (residential and commercial):*** the quantity of water in gal (L) used to wash each ft^3 (m^3) of machine capacity.
b. ***residential dishwasher:*** the quantity of water use in gal (L) per full machine wash and rinse cycle.

weatherproofing system: a group of components including associated adhesives and primers that when installed create a protective envelope against water and wind.

wetlands**:** those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. This definition incorporates all areas that would meet the definition of "wetlands" under applicable federal or state guidance whether or not they are officially designated, delineated, or mapped, including man-made areas that are designed, constructed, or restored to include the ecological functions of natural wetlands.

yearly average day-night average sound levels: level of the time-mean-square A-weighted sound pressure averaged over a one-year period with ten dB added to sound levels occurring in each night-time period from 2200 hours to 0700 hours, expressed in dB.

3.3 Abbreviations and Acronyms

AC	alternating current
AHJ	*authority having jurisdiction*
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ANSI	American National Standards Institute
ASHP	air-source heat pump
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials International
BIFMA	The Business and Institutional Furniture Manufacturer's Association
BMS	Building Management System
BOD	*basis of design*
Btu	British thermal unit
Btu/h	British thermal unit per hour
CDPH	California Department of Public Health
CFC	chlorofluorocarbon
cfm	ft^3/min
ci	continuous insulation
CIE	Commission Internationale de L'Eclairage (International Commission on Illumination)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	centimeter
CO_2	carbon dioxide
CO_2e	*carbon dioxide equivalent*
CSA	Canadian Standards Association
CxA	commissioning authority
dB	decibel
DB	dry bulb
DC	direct current
DCV	*demand control ventilation*
DX	direct expansion
EA_{vf}	effective aperture for *vertical fenestration*
EISA	Energy Independence and Security Act
EMS	Energy Management System
EPAct	U.S. Energy Policy Act
ESC	erosion and sedimentation control
ET_c	*evapotranspiration*
ET_o	*maximum evapotranspiration*
ETS	environmental tobacco smoke
fc	footcandle
FF&E	furniture, fixtures, and equipment
ft	foot
gal	gallon
gpm	gallons per minute
GWP	global warming potential
h	hour
ha	hectare
HCFC	hydrochlorofluorocarbon
HVAC	heating, ventilation, and air conditioning
HVAC&R	heating, ventilation, air conditioning, and refrigeration
IAPMO	International Association of Plumbing and Mechanical Officials

I-P	inch-pound
IA	Irrigation Association
IAQ	indoor air quality
IEQ	indoor environmental quality
IES, IESNA	Illuminating Engineering Society of North America
in.	inch
kg	kilogram
kL	kiloliter
km	kilometer
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
L	liter
lb	pound
LCA	*life-cycle assessment*
LID	low impact development
lm	lumen
LPD	lighting power density
Ls	*liner system*
LZ	*lighting zone*
m	meter
M&V	measurement and verification
µg	microgram
mg	milligram
MCWB	maximum coincident wet bulb
MDF	medium density fiberboard
MERV	minimum efficiency reporting value
mi	mile
min	minute
MJ	megaJoule
mm	millimeter
mph	miles per hour
NA	not applicable
NAECA	National Appliance Energy Conservation Act
NC	noise criterion
NR	not required
O&M	operation and maintenance
OITC	outdoor-indoor transmission class
OPR	*owner's project requirements*
Pa	Pascal
PF	*projection factor*
ppb	parts per billion
ppm	parts per million
s	second
SCAQMD	South Coast Air Quality Management District
SHGC	*solar heat gain coefficient*
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SRI	*solar reflectance index*
STC	sound transmission class
TMP	transportation management plan
UL	Underwriters Laboratory
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USFEMA	United States Federal Emergency Management Agency
USGBC	United States Green Building Council
USGSA	United States General Services Administration
VAV	*variable air volume*
VOC	volatile organic compound
VRF	variable refrigerant flow system
WB	wet bulb
WF	water factor
yr	year

4. ADMINISTRATION AND ENFORCEMENT

4.1 General. *Building projects* shall comply with Sections 4 through 11. Within each of those sections, *building projects* shall comply with all Mandatory Provisions (x.3); and, where offered, either

a. Prescriptive Option (x.4) or

b. Performance Option (x.5).

4.1.1 Normative Appendices. The normative appendices to this standard are considered to be integral parts of the mandatory requirements of this standard, which for reasons of convenience, are placed apart from all other normative elements.

4.1.2 Informative Appendices. The informative appendices to this standard and informative notes located within this standard contain additional information and are not mandatory or part of this standard.

5. SITE SUSTAINABILITY

5.1 Scope. This section addresses requirements for *building projects* that pertain to *site* selection, *site* development, mitigation of *heat island effect*, and light pollution reduction.

5.2 Compliance. The *site* shall comply with Section 5.3, "Mandatory Provisions," and either

a. Section 5.4, "Prescriptive Option," or
b. Section 5.5, "Performance Option."

5.3 Mandatory Provisions

5.3.1 Site Selection. The *building project* shall comply with 5.3.1.1 and 5.3.1.2.

5.3.1.1 Allowable Sites. The *building project* shall take place on one of the following:

a. in an existing *building envelope.*
b. on a *brownfield site.*
c. on a *greyfield site.*
d. on a *greenfield site* that is within 1/2 mi (800 m) of *residential* land that is developed, or is under construction, at an average density of 10 units per acre (4 units per ha) net unless that *site* is *agricultural land* or *forest land*. Proximity is determined by drawing a circle with an 1/2 mi (800 m) radius around the center of the proposed *site*.
e. on a *greenfield site* that is within 1/2 mi (800 m) of a minimum of ten basic services and that has pedestrian access between the building and the services unless that *site* is *agricultural land* or *forest land*. Basic services include, but are not limited to: (1) financial institution, (2) place of worship, (3) convenience grocery store, (4) day care, (5) dry cleaners, (6) fire station, (7) beauty shop, (8) hardware store, (9) laundromat, (10) library, (11) medical/dental, (12) senior care facility, (13) park, (14) pharmacy, (15) post office, (16) restaurant, (17) school, (18) supermarket, (19) theater, (20) community center, (21) fitness center, (22) museum, or (23) local government facility. Proximity is determined by drawing a circle with a 1/2 mi (800 m) radius around the center of the proposed *site*.
f. on a *greenfield site* that is either within 1/2 mi (800 m) of an existing, or planned and funded, commuter rail, *light rail* or subway station or within 1/4 mi (400 m) of *adequate transit service* usable by building occupants unless that *site* is *agricultural land* or *forest land*. Proximity is determined by drawing a circle with a 1/2 mi (800 m) radius around the center of the proposed *site*.
g. on a *greenfield site* that is *agricultural land* and the building's purpose is related to the agricultural use of the land.
h. on a *greenfield site* that is *forest land* and the building's purpose is related to the forestry use of the land.
i. on a *greenfield site* that is *designated park land* and the building's purpose is related to the use of the land as a park.

5.3.1.2 Prohibited Development Activity. There shall be no *site* disturbance or development of the following:

a. previously undeveloped land having an elevation lower than 5 ft (1.5 m) above the elevation of the 100 year flood as defined by USFEMA.

Exception to 5.3.1.2a: In alluvial "AO" designated flood zones, development is allowed when provided with engineered floodproofing for building structures up to an elevation that is at least as high as the minimum lowest floor elevation determined by the *AHJ*. Drainage paths shall be constructed to guide floodwaters around and away from the structures.

b. within 150 ft (50 m) of any *fish and wildlife habitat conservation area* unless the *site* disturbance or development involves plantings or habitat enhancement of the functions and values of the area.
c. within 100 ft (35 m) of any *wetland* unless the *site* disturbance or development involves plantings or habitat enhancement of the functions and values of the *wetland.*

Exception to 5.3.1.2: Development of a *low-impact trail* is allowed within 15 ft (4.5 m) of a *fish and wildlife habitat conservation area* or *wetland*.

5.3.2 Mitigation of Heat Island Effect

5.3.2.1 Site Hardscape. The *site hardscape* includes roads, sidewalks, courtyards, and parking lots but not the constructed building surfaces and not any portion of the *site hardscape* covered by photovoltaic panels generating electricity or other *solar energy systems* used for space heating or water heating. At least 50% of the *site hardscape* shall be provided with one or any combination of the following:

a. existing trees and vegetation or new *bio-diverse plantings* of *native plants* and *adapted plants* located to provide shade within five years of issuance of the final certificate of occupancy. The effective shade coverage on the *hardscape* shall be the arithmetic mean of the shade coverage calculated at 10 a.m., noon, and 3 p.m. on the summer solstice.
b. paving materials with a minimum initial *SRI* of 29. This also applies to *porous pavers (open-grid pavers)* and *open-graded (uniform-sized) aggregate* materials. A default *SRI* value of 35 for new concrete without added color pigment is allowed to be used instead of measurements.
c. shading through the use of structures, provided that the top surface of the shading structure complies with the provisions of Section 5.3.2.3.
d. parking under a building, provided that the *roof* of the building complies with the provisions of Section 5.3.2.3.
e. buildings or structures that provide shade to the *site hardscape*. The effective shade coverage on the *hardscape* shall be the arithmetic mean of the shade coverage calculated at 10 a.m., noon, and 3 p.m. on the summer solstice.

Exception: *Building projects* in *climate zones* 6, 7, and 8.

5.3.2.2 Walls. Above-grade building *walls* and retaining *walls* shall be shaded in accordance with this section. The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and show-

ing compliance. Compliance with this section shall be achieved through the use of shade-providing *plants*, man-made structures, existing buildings, hillsides, permanent building projections, *on-site renewable energy systems* or a combination of these, using the following criteria:

a. shade shall be provided on at least 30% of the east and west above-grade *walls* and retaining *walls* from grade level to a height of 20 ft (6 m) above grade or the top of the exterior *wall*, whichever is less, within five years of issuance of the final certificate of occupancy. Shade coverage shall be calculated at 10 a.m. for the east *walls* and 3 p.m. for the west *walls* on the summer solstice.
b. where shading is provided by vegetation, such vegetation (including trees) shall be existing trees and vegetation or new *bio-diverse plantings* of *native plants* and *adapted plants* and appropriately sized, selected, planted, and maintained so that they do not interfere with overhead or underground utilities. Such trees shall be placed a minimum of 5 ft (1.5 m) from and within 50 ft (15 m) of the building or retaining *wall*.

Exceptions:

1. The requirements of this section are satisfied if 75% or more of the opaque *wall* surfaces on the east and west have a minimum *SRI* of 29. Each *wall* is allowed to be considered separately for this exception.
2. East *wall* shading is not required for buildings located in *climate zones* 5, 6, 7, and 8. West *wall* shading is not required for buildings located in *climate zones* 7 and 8.

5.3.2.3 Roofs. This section applies to the building and covered parking *roof* surfaces for *building projects* in *climate zones* 1, 2, and 3. A minimum of 75% of the entire *roof* surface not used for *roof* penetrations and associated equipment, *on-site renewable energy systems* such as photovoltaics or solar thermal energy collectors including necessary space between rows of panels or collectors, portions of the roof used to capture heat for building energy technologies, rooftop decks or walkways, or vegetated (green) roofing systems shall be covered with products that comply with one or more of the following:

a. have a minimum initial *SRI* of 78 for a low-sloped *roof* (a slope less than or equal to 2:12) and a minimum initial *SRI* of 29 for a steep-sloped *roof* (a slope of more than 2:12).
b. comply with the criteria for the USEPA's ENERGY STAR® Program Requirements for Roof Products Eligibility Criteria.

Exceptions:

1. *Building projects* where an annual energy analysis simulation demonstrates that the total annual building energy cost and total annual CO_2e, as calculated in accordance with Sections 7.5.2 and 7.5.3, are both a minimum of 2% less for the proposed *roof* than for a *roof* material complying with the requirements of Section 5.3.2.3(a), or
2. *Roofs* used to shade or cover parking and *roofs* over semi-heated spaces provided that they have a minimum initial *SRI* of 29. A default *SRI* value of 35 for new concrete without added color pigment is allowed to be used instead of measurements.

5.3.2.4 Solar Reflectance Index. The *SRI* shall be calculated in accordance with ASTM E1980 for medium-speed wind conditions. The *SRI* shall be based upon solar reflectance as measured in accordance with ASTM E1918 or ASTM C1549, and the thermal emittance as measured in accordance with ASTM E408 or ASTM C1371. For roofing products, the values for solar reflectance and thermal emittance shall be determined by a laboratory accredited by a nationally recognized accreditation organization, and shall be certified by the manufacturer. For building materials other than roofing products, the values for solar reflectance and thermal emittance shall be determined by an independent third party.

5.3.3 Reduction of Light Pollution

5.3.3.1 General. Exterior lighting systems shall comply with Section 9 of ANSI/ASHRAE/IESNA Standard 90.1 with Addendum i, with the following modifications to the *lighting power allowances* in Table 9.4.6*,* and the requirement of Sections 5.3.3.2 and 5.3.3.3.

a. For *LZ0*: there shall be no Base Site allowance and no Tradable Surface allowances.
b. For *LZ0* (Non-Tradable Surfaces): a single luminaire of 60 watts or less may be installed for each roadway/parking entry, trail head, and toilet facility, or other locations approved by the *AHJ*.

5.3.3.2 Backlight and Glare

a. All building-mounted luminaires located less than two mounting heights from any property line shall meet the maximum allowable Glare Ratings in Table 5.3.3.2B.
b. All other luminaries shall meet the maximum allowable Backlight and Glare Ratings in Table 5.3.3.2A.

5.3.3.3 Uplight: All exterior lighting shall meet one of the following Uplight requirements:

a. Exterior luminaries shall meet the maximum allowable Uplight Ratings of Table 5.3.3.2A or
b. Exterior lighting shall meet the Uplight requirements of Table 5.3.3.3.

Exceptions:

1. Lighting in *lighting zones* 3 and 4, solely for uplighting structures, building facades, or landscaping.
2. Lighting in *lighting zones* 1 and 2, solely for uplighting structures, building facades, or landscaping provided the applicable lighting power densities do not exceed 50% of the *lighting power allowances* in ANSI/ASHRAE/IESNA Standard 90.1 with Addendum i Table 9.4.6.

TABLE 5.3.3.2A Maximum Allowable Backlight, Uplight and Glare (BUG) Ratings[1, 2, 3, 4]

	LZ0	LZ1	LZ2	LZ3	LZ4
Allowed Backlight Rating					
>2 mounting heights from property line	B0	B1	B2	B3	B4
1 to 2 mounting heights from property line	B0	B1	B2	B3	B3
0.5 to 1 mounting height to property line	B0	B0	B1	B2	B2
<0.5 mounting height to property line	B0	B0	B0	B1	B2
Allowed Uplight Rating	U0	U1	U2	U3	U4
Allowed Glare Rating	G0	G1	G2	G3	G4

Notes to Table 5.3.3.2A:

1. Fixtures mounted two mounting heights or less from a property line shall have backlight towards the property line, except when mounted on buildings.
2. For property lines that abut public walkways, bikeways, plazas, and parking lots, the property line may be considered to be 5 feet (1.5 m) beyond the actual property line for purpose of determining compliance with this section. For property lines that abut public roadways and public transit corridors, the property line may be considered to be the centerline of the public roadway or public transit corridor for the purpose of determining compliance with this section.
3. If the luminaire is installed in other than the intended manner, or is an adjustable luminaire for which the aiming is specified, the rating shall be determined by the actual photometric geometry in the aimed orientation.
4. Backlight, Uplight, and Glare ratings are defined based on specific lumen limits per IESNA TM-15 Addendum A.

TABLE 5.3.3.2B Maximum Allowable Glare Ratings for Building Mounted Luminaires Within Two Mounting Heights of Any Property Line

	LZ0	LZ1	LZ2	LZ3	LZ4
Glare	G0	G0	G1	G1	G2

Notes to Table 5.3.3.2B:

1. For property lines that abut public walkways, bikeways, plazas, and parking lots, the property line may be considered to be 5 feet (1.5 m) beyond the actual property line for purpose of determining compliance with this section. For property lines that abut public roadways and public transit corridors, the property line may be considered to be the centerline of the public roadway or public transit corridor for the purpose of determining compliance with this section
2. Backlight, Uplight, and Glare ratings are defined based on specific lumen limits per IESNA TM-15 Addendum A.

TABLE 5.3.3.3 Maximum Allowable Percentage of Uplight

	LZ0	LZ1	LZ2	LZ3	LZ4
Percentage of total exterior fixture lumens allowed to be emitted above 90 degrees or higher from nadir (straight down)	0%	0%	1%	2%	5%

Exceptions to 5.3.3.2 and 5.3.3.3:

1. Specialized signal, directional, and marker lighting associated with transportation.
2. Advertising signage or directional signage.
3. Lighting integral to equipment or instrumentation and installed by its manufacturer.
4. Lighting for theatrical purposes, including performance, stage, film production, and video production.
5. Lighting for athletic playing areas.
6. Lighting that is in use for no more than 60 continuous days and is not re-installed any sooner than 60 days after being uninstalled.
7. Lighting for industrial production, material handling, transportation sites, and associated storage areas.
8. Theme elements in theme/amusement parks.
9. Roadway lighting required by governmental authorities.

5.4 Prescriptive Option

5.4.1 Site Development. *Building projects* shall comply with Sections 5.4.1.1 and 5.4.1.2.

5.4.1.1 Effective Pervious Area for All Sites. A minimum of 40% of the entire *site* shall incorporate one or any combination of the following:

a. shall be vegetated with a minimum depth of growing medium of 12 in. (300 mm). Such vegetated areas include bioretention facilities, rain gardens, filter strips, grass swales, vegetated level spreaders, constructed *wetlands*, planters, or open space with plantings. At least 60% of the vegetated area shall consist of *biodiverse planting* of *native plants* or *adapted plants*.

b. shall have a vegetated (green) *roof* with a minimum depth of growing medium of 3 in. (75 mm).

c. shall have *porous pavers (open grid pavers)*.

d. shall have *permeable pavement, permeable pavers,* or *open graded (uniform-sized) aggregate* with a minimum percolation rate of 2 gal/min·ft^2 (100 L/min·m^2) and a minimum of 6 in. (150 mm) of open-graded base below.

Exceptions:

1. The effective pervious surface is allowed to be reduced to a minimum of 20% of the entire *site* if 10% of the average annual rainfall for the entire *development footprint* is captured on *site* and reused for *site* water use or building water use.
2. The effective pervious surface is not required if 50% of the average annual rainfall for the entire *development footprint* is captured on *site* and reused for *site* water use or building water use.
3. Locations with less than 10 in. (250 mm) of average annual rainfall per year.
4. *Building projects* on a *brownfield site*.

5.4.1.2 Greenfield Sites. On a *greenfield site*:

a. where more than 20% of the area of the predevelopment *site* has existing *native plants* or *adapted plants*, a minimum of 20% of the area of *native plants* or *adapted plants* shall be retained.
b. where 20% or less of the area of the predevelopment *site* has existing *native plants* or *adapted plants*, a minimum of 20% of the *site* shall be developed or retained as vegetated area. Such vegetated areas include bioretention facilities, rain gardens, filter strips, grass swales, vegetated level spreaders, constructed *wetlands*, planters, or open space with plantings. A minimum of 60% of such vegetated area shall consist of *biodiverse planting* of *native plants* or *adapted plants*.

Exception to 5.4.1.2(b): Locations with less than 10 in. (250 mm) of average annual rainfall per year.

5.5 Performance Option

5.5.1 Site Development. *Building project*s shall comply with the following:

a. If the project is in an existing *building envelope*, a minimum of 20% of the average annual rainfall on the *development footprint* shall be managed through infiltration, reuse, or *ET*.
b. If the project is not in an existing *building envelope*, but is on a *greyfield site* or a *brownfield site*, a minimum of 40% of the average annual rainfall on the *development footprint* shall be managed through infiltration, reuse, or *ET*.
c. For all other *sites*, a minimum of 50% of the average annual rainfall on the *development footprint* shall be managed through infiltration, reuse, or *ET*.

6. WATER USE EFFICIENCY

6.1 Scope. This section specifies requirements for *potable water* and *non-potable water* use efficiency, both for the *site* and for the building, and water monitoring.

6.2 Compliance. The water systems shall comply with Section 6.3, "Mandatory Provisions," and either

a. Section 6.4, "Prescriptive Option," or
b. Section 6.5, "Performance Option."

Site water use and building water use are not required to use the same option, i.e., prescriptive or performance, for demonstrating compliance.

6.3 Mandatory Provisions

6.3.1 Site Water Use Reduction

6.3.1.1 Landscape Design. A minimum of 60% of the area of the *improved landscape* shall be in *bio-diverse planting* of *native plants* and *adapted plants* other than *turfgrass*.

Exception: The area of dedicated athletic fields, golf courses, and driving ranges shall be excluded from the calculation of the *improved landscape* for schools, *residential* common areas, or public recreational facilities.

6.3.1.2 Irrigation System Design. *Hydrozoning* of automatic irrigation systems to water different plant materials such as *turfgrass* versus shrubs is required. Landscaping sprinklers shall not be permitted to spray water directly on a building and within 3 ft (1 m) of a building.

6.3.1.3 Controls. Any irrigation system for the project *site* shall be controlled by a qualifying *smart controller* that uses *ET* and weather data to adjust irrigation schedules and that complies with the minimum requirements or an on-site rain or moisture sensor that automatically shuts the system off after a predetermined amount of rainfall or sensed moisture in the soil. Qualifying *smart controllers* shall meet the minimum requirements as listed below when tested in accordance with IA *SWAT* Climatological Based Controllers 8th Draft Testing Protocol. *Smart controllers* that use *ET* shall use the following inputs for calculating appropriate irrigation amounts:

a. *Irrigation adequacy* 80% minimum ET_c.
b. *Irrigation excess* not to exceed 10%.

Exception: A temporary irrigation system used exclusively for the establishment of new landscape shall be exempt from this requirement. Temporary irrigation systems shall be removed or permanently disabled at such time as the *landscape establishment period* has expired.

6.3.2 Building Water Use Reduction

6.3.2.1 Plumbing Fixtures and Fittings. Plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following requirements:

a. Water closets (toilets) flushometer valve type: For single flush, maximum flush volume shall be determined in accordance with ASME A112.19.2/CSA B45.1 and shall be 1.28 gal (4.8 L). For dual-flush, the effective flush volume shall be determined in accordance with ASME A112.19.14 and shall be 1.28 gal (4.8 L).
b. Water closets (toilets) tank-type: Tank-type water closets shall be certified to the performance criteria of the U.S. EPA WaterSense Tank-Type High-Efficiency Toilet Specification and shall have a maximum flush volume of 1.28 gal (4.8 L).
c. Urinals: Maximum flush volume when determined in accordance with ASME A112.19.2/CSA B45.1 0.5 gal (1.9 L). Non-water urinals shall comply with ASME A112.19.19 (vitreous china) or IAPMO Z124.9 (plastic) as appropriate.
d. Public lavatory faucets: Maximum flow rate 0.5 gpm (1.9 L/min) when tested in accordance with ASME A112.18.1/CSA B125.1.
e. Public metering self-closing faucet: Maximum water use 0.25 gal (1.0 L) per metering cycle when tested in accordance with ASME A112.18.1/CSA B125.1.
f. *Residential* bathroom lavatory sink faucets: Maximum flow rate 1.5 gpm (5.7 L/min) when tested in accordance with ASME A112.18.1/CSA B125.1. *Residential* bathroom lavatory sink faucets shall comply with the performance criteria of the USEPA WaterSense High-Efficiency Lavatory Faucet Specification.
g. *Residential* kitchen faucets: Maximum flow rate 2.2 gpm (8.3 L/min) when tested in accordance with ASME A112.18.1/CSA B125.1.
h. *Residential* showerheads: Maximum flow rate 2.0 gpm (7.6 L/min) when tested in accordance with ASME A112.18.1/CSA B125.1.
i. *Residential* shower compartment (stall) in *dwelling units* and guest rooms: The allowable flow rate from all shower outlets (including rain systems, waterfalls, bodysprays, and jets) that can operate simultaneously shall be limited to a total of 2.0 gpm (7.6 L/min).

Exception to 6.3.2.1(i): Where the area of a shower compartment exceeds 2600 in.^{2} (1.7 m^2), an additional flow of 2.0 gpm (7.6 L/min) shall be permitted for each multiple of 2600 in.^{2} (1.7 m^2) of floor area or fraction thereof.

6.3.2.2 Appliances

a. Clothes washers and dishwashers installed within *dwelling units* shall comply with the ENERGY STAR Program Requirements for Clothes Washers and ENERGY STAR Program Requirements for Dishwashers. Maximum water use shall be as follows:

   1. Clothes Washers—maximum *Water Factor* of 6.0 gal/ft^3 of drum capacity (800 L/m^{3}of drum capacity).
   2. Dishwashers—maximum *Water Factor* of 5.8 gal/full operating cycle (22 L/full operating cycle).

   (See also the energy efficiency requirements in Section 7.4.7.3.)

TABLE 6.3.2.1 Plumbing Fixtures and Fittings Requirements

Plumbing Fixture	Maximum
Water closets (toilets)—flushometer valve type	Single flush volume of 1.28 gal (4.8 L)
Water closets (toilets)—flushometer valve type	Effective dual flush volume of 1.28 gal (4.8 L)
Water closets (toilets)—tank-type	Single flush volume of 1.28 gal (4.8 L)
Water closets (toilets)—tank-type	Effective dual flush volume of 1.28 gal (4.8 L)
Urinals	Flush volume 0.5 gal (1.9 L)
Public lavatory faucets	Flow rate—0.5 gpm (1.9 L/min)
Public metering self-closing faucet	0.25 gal (1.0 L) per metering cycle
Residential bathroom lavatory sink faucets	Flow rate—1.5 gpm (5.7 L/min)
Residential kitchen faucets	Flow rate— 2.2 gpm (8.3 L/min)
Residential showerheads	Flow rate—2.0 gpm (7.6 L/min)
Residential shower compartment (stall) in *dwelling units* and guest rooms	Flow rate from all shower outlets total of 2.0 gpm (7.6 L/min)

b. Clothes washers installed in publicly accessible spaces (e.g., multifamily and hotel common areas) and coin- and card-operated clothes washers of any size used in laundromats shall have a maximum *Water Factor* of 7.5 gal/ft^3 of drum capacity-normal cycle (1.0 kL/m^{3}of drum capacity-normal cycle). (See also the energy efficiency requirements in Sections 7.4.7.3 and 7.4.7.4.)

6.3.2.3 HVAC Systems and Equipment

a. *Once-through cooling* with *potable water* is prohibited.
b. Cooling towers and evaporative coolers shall be equipped with makeup and blowdown meters, conductivity controllers, and overflow alarms in accordance with the thresholds listed in Table 6.3.3B. Cooling towers shall be equipped with efficient drift eliminators that achieve drift reduction to a maximum of 0.002% of the recirculated water volume for counterflow towers and 0.005% of the recirculated water flow for cross-flow towers.
c. Condensate from air-conditioning units with a capacity greater than 65,000 Btu/h (19 kW) and from all steam systems shall be recovered for re-use.

6.3.2.4 Roofs

a. The use of *potable water* for *roof* spray systems to thermally condition the *roof* is prohibited.
b. The use of *potable water* for irrigation of vegetated (green) *roofs* is prohibited once plant material has been established. After the *landscape establishment period* is completed, the *potable water* irrigation system shall be removed or permanently disconnected.

6.3.3 Water Consumption Measurement

6.3.3.1 Consumption Management. Measurement devices with remote communication capability shall be provided to collect water consumption data for the domestic water supply to the building. Both potable and reclaimed water entering the *building project* shall be monitored or sub-metered. In addition, for individual leased, rented, or other tenant or sub-tenant space within any building totaling in excess of 50,000 ft^2 (5000 m^2), separate submeters shall be provided. For subsystems with multiple similar units, such as multi-cell cooling towers, only one measurement device is required for the subsystem. Any project or building, or tenant or sub-tenant space within a project or building, such as a commercial car wash or aquarium, shall be submetered where consumption is projected to exceed 1000 gal/day (3800 L/day).

TABLE 6.3.3A Water Supply Source Measurement Thresholds

Water Source	Main Measurement Threshold
Potable water	1000 gal/day (3800 L/day)
Municipally reclaimed water	1000 gal/day (3800 L/day)
Alternate sources of water	500 gal/day (1900 L/day)

Measurement devices with remote capability shall be provided to collect water use data for each water supply source (e.g., *potable water,* reclaimed water, rainwater) to the *building project* that exceeds the thresholds listed in Table 6.3.3A. Utility company service entrance/interval meters are allowed to be used.

Provide sub-metering with remote communication measurement to collect water use data for each of the building subsystems, if such subsystems are sized above the threshold levels listed in Table 6.3.3B.

6.3.3.2 Consumption Data Collection. All building measurement devices, monitoring systems, and sub-meters installed to comply with the thresholds limits in Section 6.3.3.1 shall be configured to communicate water consumption data to a meter data management system. At a minimum, meters shall provide daily data and shall record hourly consumption of water.

6.3.3.3 Data Storage and Retrieval. The meter data management system shall be capable of electronically storing water meter, monitoring systems, and submeter data and creating user reports showing calculated hourly, daily, monthly,

TABLE 6.3.3B Subsystem Water Measurement Thresholds

Subsystem	Sub-Metering Threshold
Cooling towers (meter on makeup water and blowdown)	Cooling tower flow through tower >500 gpm (30 L/s)
Evaporative coolers	Makeup water >0.6 gpm (0.04 L/s)
Steam and hot-water boilers	>500,000 Btu/h (50 kW) input
Total Irrigated landscape area with controllers	>25,000 ft^2 (2500 m^2)
Separate campus or project buildings	Consumption >1000 gal/day (3800 L/day)
Separately leased or rental space	Consumption >1000 gal/day (3800 L/day)
Any large water using process	Consumption >1000 gal/day (3800 L/day)

and annual water consumption for each measurement device and submeter and provide alarming notification capabilities as needed to support the requirements of the Water User Efficiency Plan for Operation in Section 10.3.2.1.2.

6.4 Prescriptive Option

6.4.1 Site Water Use Reduction. For golf courses and driving ranges, only municipally reclaimed water and/or *alternate on-site sources of water* shall be used to irrigate the landscape. For other landscaped areas, a maximum of one-third of *improved landscape* area is allowed to be irrigated with *potable water*. The area of dedicated athletic fields shall be excluded from the calculation of the *improved landscape* for schools, *residential* common areas, or public recreational facilities. All other irrigation shall be provided from *alternate on-site sources of water* or municipally reclaimed water.

Exception: *Potable water* is allowed to be temporarily used on such newly installed landscape for the *landscape establishment period*. The amount of *potable water* that may be applied to the newly planted areas during the temporary *landscape establishment period* shall not exceed 70% of ET_o for *turfgrass* and 55% of ET_o for other plantings. If municipally-reclaimed water is available at a water main within 200 ft (60 m) of the project *site*, it shall be used in lieu of *potable water* during the *landscape establishment period*. After the *landscape establishment period* has expired, all irrigation water use shall comply with the requirements established elsewhere in this standard.

6.4.2 Building Water Use Reduction

6.4.2.1 Cooling Towers. The water being discharged from cooling towers for air conditioning systems such as chilled-water systems shall be limited in accordance with method (a) or (b):

a. For makeup waters having less than 200 ppm (200 mg/L) of total hardness expressed as calcium carbonate, by achieving a minimum of five *cycles of concentration*.
b. For makeup waters with more than 200 ppm (200 mg/L) of total hardness expressed as calcium carbonate, by achieving a minimum of 3.5 *cycles of concentration.*

Exception: Where the total dissolved solids concentration of the discharge water exceeds 1500 mg (1500 ppm/L), or the silica exceeds 150 ppm (150 mg/L) measured as silicon dioxide before the above cycles of concentration are reached.

6.4.2.2 Commercial Food Service Operations. Commercial food service operations (e.g., restaurants, cafeterias, food preparation kitchens, caterers, etc.):

a. shall use high-efficiency pre-rinse spray valves (i.e., valves which function at 1.3 gpm (4.9 L/min) or less and comply with a 26-second performance requirement when tested in accordance with ASTM F2324),
b. shall use dishwashers that comply with the requirements of the ENERGY STAR Program for Commercial Dishwashers,
c. shall use boilerless/connectionless food steamers that consume no more than 2.0 gal/hour (7.5 L/hour) in the full operational mode,
d. shall use combination ovens that consume not more than 10 gal/hour (38 L/hour) in the full operational mode,
e. shall use air-cooled ice machines that comply with the requirements of the ENERGY STAR Program for Commercial Ice Machines, and
f. shall be equipped with hands-free faucet controllers (foot controllers, sensor-activated, or other) for all faucet fittings within the food preparation area of the kitchen and the dish room, including pot sinks and washing sinks.

6.4.2.3 Medical and Laboratory Facilities. Medical and laboratory facilities, including clinics, hospitals, medical centers, physician and dental offices, and medical and non-medical laboratories of all types shall:

a. use only water-efficient steam sterilizers equipped with (1) water-tempering devices that allow water to flow only when the discharge of condensate or hot water from the sterilizer exceeds 140°F (60°C) and (2) mechanical vacuum equipment in place of venturi-type vacuum systems for vacuum sterilizers.
b. use film processor water recycling units where large frame x-ray films of more than 6 in. (150 mm) in either length or width are processed. Small dental x-ray equipment is exempt from this requirement.
c. use digital imaging and radiography systems where the digital networks are installed.
d. use a dry-hood scrubber system or, if the applicant determines that a wet-hood scrubber system is required, the

scrubber shall be equipped with a water recirculation system. For perchlorate hoods and other applications where a hood wash-down system is required, the hood shall be equipped with self-closing valves on those wash-down systems.

e. use only dry vacuum pumps, unless fire and safety codes for explosive, corrosive or oxidative gasses require a liquid ring pump.

f. use only efficient water treatment systems that comply with the following criteria:

   1. For all filtration processes, pressure gauges shall determine and display when to backwash or change cartridges.
   2. For all ion exchange and softening processes, recharge cycles shall be set by volume of water treated or based upon conductivity or hardness.
   3. For reverse osmosis and nanofiltration equipment, with capacity greater than 27 gal/h (100 L/h), reject water shall not exceed 60% of the feed water and shall be used as scrubber feed water or for other beneficial uses on the project *site*.
   4. Simple distillation is not acceptable as a means of water purification.

g. Food service operations within medical facilities shall comply with Section 6.4.2.2.

6.4.3 Special Water Features. Water use shall comply with the following:

a. Ornamental fountains and other ornamental water features shall be supplied either by *alternate on-site sources of water* or by municipally reclaimed water delivered by the local water utility acceptable to the *AHJ*. Fountains and other features shall be equipped with: (1) makeup water meters (2) leak detection devices that shut off water flow if a leak of more than 1.0 gal/h (3.8 L/h) is detected, and (3) equipment to recirculate, filter, and treat all water for reuse within the system.

Exception to 6.4.3a: Where *alternate on-site sources of water* or municipally reclaimed water are not available within 500 ft (150 m) of the *building project site*, *potable water* is allowed to be used for water features with less than 10,000 gallon (38,000 L) capacity.

b. Pools and spas:

   1. Backwash water: Recover filter backwash water for reuse on landscaping or other applications, or treat and reuse backwash water within the system.
   2. Filtration: For filters with removable cartridges, only reusable cartridges and systems shall be used. For filters with backwash capability, use only pool filter equipment that includes a pressure drop gauge to determine when the filter needs to be backwashed and a sight glass enabling the operator to determine when to stop the backwash cycle.
   3. Pool splash troughs, if provided, shall drain back into the pool system.

6.5 Performance Option. Calculations shall be done in accordance with *generally accepted engineering standards* and handbooks acceptable to the *AHJ*.

6.5.1 Site Water Use Reduction. *Potable water* (and municipally reclaimed water, where used) intended to irrigate *improved landscape* shall be limited to 35% of the water demand for that landscape. The water demand shall be based upon *ET* for that climatic area and shall not exceed 70% of ET_o for *turfgrass* areas and 55% of ET_o for all other plant material after adjustment for rainfall.

6.5.2 Building Water Use Reduction. The *building project* shall be designed to have a total annual interior water use less than or equal to that achieved by compliance with Sections 6.3.2, 6.4.2, and 6.4.3.

7. ENERGY EFFICIENCY

7.1 Scope. This section specifies requirements for energy efficiency for buildings and appliances, for *on-site renewable energy systems*, and for energy measuring.

7.2 Compliance. The energy systems shall comply with Section 7.3, "Mandatory Provisions," and either

a. Section 7.4, "Prescriptive Option," or
b. Section 7.5, "Performance Option."

7.3 Mandatory Provisions

7.3.1 General. *Building projects* shall be designed to comply with Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 of ANSI/ASHRAE/IESNA Standard 90.1.

7.3.2 On-Site Renewable Energy Systems. *Building projects* shall provide for the future installation of *on-site renewable energy systems* with a minimum rating of 3.7 W/ft^2 or 13 Btu/h·ft^2 (40 W/m^2) multiplied by the total *roof* area in ft^2 (m^2). *Building projects* design shall show allocated space and pathways for installation of *on-site renewable energy systems* and associated infrastructure.

Exception: *Building projects* that have an annual daily average incident solar radiation available to a flat plate collector oriented due south at an angle from horizontal equal to the latitude of the collector location less than 4.0 kW/m^2·day, accounting for existing buildings, permanent infrastructure that is not part of the *building project*, topography, or trees, are not required to provide for future *on-site renewable energy systems*.

7.3.3 Energy Consumption Management

7.3.3.1 Consumption Management. Measurement devices with remote communication capability shall be provided to collect energy consumption data for each energy supply source to the building, including gas, electricity, and district energy, that exceeds the thresholds listed in Table 7.3.3.1A. The measurement devices shall have the capability to automatically communicate the energy consumption data to a data acquisition system.

For all buildings that exceed the threshold in Table 7.3.3.1A, subsystem measurement devices with remote capability (including current sensors or flowmeters) shall be provided to measure energy consumption data of each subsystem for each use category that exceeds the thresholds listed in Table 7.3.3.1B.

The energy consumption data from the subsystem measurement devices shall be automatically communicated to the data acquisition system.

7.3.3.2 Energy Consumption Data Collection. All building measurement devices shall be configured to automatically communicate the energy data to the data acquisition system. At a minimum, measurement devices shall provide daily data and shall record hourly energy profiles. Such hourly energy profiles shall be capable of being used to assess building performance at least monthly.

7.3.3.3 Data Storage and Retrieval. The data acquisition system shall be capable of electronically storing the data from the measurement devices and other sensing devices, for a minimum of 36 months, and creating user reports showing hourly, daily, monthly, and annual energy consumption.

Exception: Portions of buildings used as *residential*.

7.4 Prescriptive Option

7.4.1 General Comprehensive Prescriptive Requirements. When a requirement is provided below, it supersedes the requirement in ANSI/ASHRAE/IESNA Standard 90.1. For all other criteria, the *building project* shall comply with the requirements of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.1.1 On-Site Renewable Energy Systems. *Building projects* shall contain *on-site renewable energy systems* that provide the annual energy production equivalent of not less than 6.0 KBtu/ft^2 (20 kWh/m^2) of *conditioned space*. The annual energy production shall be the combined sum of all *on-site renewable energy systems.*

Exception: Buildings that demonstrate compliance with both of the following are not required to contain *on-site renewable energy systems*:

1. An annual daily average incident solar radiation available to a flat plate collector oriented due south at an

TABLE 7.3.3.1A Energy Source Thresholds

Energy Source	Threshold
Electrical service	>200 kVA
On-site renewable electric power	All systems > 1 kVA (peak)
Gas and district services	>1,000,000 Btu/h (300 kW)
Geothermal energy	>1,000,000 Btu/h (300 kW) heating
On-site renewable thermal energy	>100,000 Btu/h (30 kW)

TABLE 7.3.3.1B System Energy Use Thresholds

Use (Total of All Loads)	Subsystem Threshold
HVAC system	Connected electric load > 100kVA
HVAC system	Connected gas or district services load > 500,000 Btu/h (150 kW)
People moving	Sum of all feeders > 50 kVA
Lighting	Connected load > 50 kVA
Process and plug process	Connected load > 50 kVA Connected gas or district services load > 250,000 Btu/h (75 kW)

angle from horizontal equal to the latitude of the collector location less than 4.0 kW/m^2·day, accounting for existing buildings, permanent infrastructure that is not part of the *building project*, topography, and trees, and

2. Purchase of renewable electricity products complying with the Green-e Energy National Standard for Renewable Electricity Products of at least 7 kWh/ft^2 (75 kWh/m^2) of conditioned space each year until the cumulative purchase totals 70 kWh/ft^2 (750 kWh/m^2) of conditioned space.

7.4.2 Building Envelope. The *building envelope* shall comply with Section 5 of ANSI/ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

7.4.2.1 Building Envelope Requirements. The *building envelope* shall comply with the requirements in Tables A-1 to A-8 in Normative Appendix A. These requirements supersede the requirements in Tables 5.5-1 to 5.5-8 of ANSI/ASHRAE/IESNA Standard 90.1.

Exception: Buildings that comply with Section 8.3.4 regardless of building area are exempt from the *SHGC* criteria for *skylights*.

7.4.2.2 Roof Insulation. *Roofs* shall comply with the provisions of Section 5.3.2.3 and Tables A-1 to A-8 of this standard. Section 5.5.3.1.1 of ANSI/ASHRAE/IESNA Standard 90.1 and Table 5.5.3.1 of ANSI/ASHRAE/IESNA Standard 90.1 shall not apply.

7.4.2.3 Single-Rafter Roof Insulation. *Single-rafter roofs* shall comply with the requirements in Table A-9 in Normative Appendix A. These requirements supersede the requirements in Section A2.4.2.4 of ANSI/ASHRAE/IESNA Standard 90.1. Section A2.4.2.4 and Table A2.4.2 of ANSI/ASHRAE/IESNA Standard 90.1 shall not apply.

7.4.2.4 Vertical Fenestration Area. The total *vertical fenestration area* shall be less than 40% of the *gross wall area*. This requirement supersedes the requirement in Section 5.5.4.2.1 of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.2.5 Permanent Projections. For *climate zones* 1–5, the *vertical fenestration* on the west, south, and east shall be shaded by permanent projections that have an area-weighted average *PF* of not less than 0.50. The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance.

Exception: *Vertical fenestration* that receives direct solar radiation for fewer than 250 hours per year because of shading by permanent external buildings, existing permanent infrastructure, or topography.

7.4.2.6 SHGC of Vertical Fenestration. For *SHGC* compliance, the methodology in exception (b) to Section 5.5.4.4.1 of ANSI/ASHRAE/IESNA Standard 90.1 is allowed, provided that the *SHGC* multipliers in Table 7.4.2.6 are used. This requirement supersedes the requirement in Table 5.5.4.4.1 of ANSI/ASHRAE/IESNA Standard 90.1. Table 5.5.4.4.1 of ANSI/ASHRAE/IESNA Standard 90.1 shall not apply. *Vertical fenestration* that is *north-oriented* shall be allowed to have a maximum *SHGC* of 0.10 greater than that specified in Tables A-1 through A-8 in Normative Appendix A. When this exception is utilized, separate calculations shall be performed for these sections of the *building envelope*, and these values shall not be averaged with any others for compliance purposes.

7.4.2.7 Vestibules. For vestibules, the exceptions to Section 5.4.3.4 of ANSI/ASHRAE/IESNA Standard 90.1 are allowed provided that *climate zone* 4 is deleted from exception (e) to Section 5.4.3.4 of ANSI/ASHRAE/IESNA Standard 90.1 and that *climate zone* 4 is added to exception (f) to Section 5.4.3.4 of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.2.8 Building Envelope Trade-Off Option. The *building envelope* trade-off option in Section 5.6 of ANSI/ASHRAE/IESNA Standard 90.1 shall not apply unless the procedure incorporates the modifications and additions to ANSI/ASHRAE/IESNA Standard 90.1 noted in Section 7.4.2.

7.4.2.9 Fenestration Orientation. To reduce solar gains from the east and west in *climate zones* 1 through 4 and from the west in *climate zones* 5 and 6, the *fenestration area* and *SHGC* shall comply with the following requirements:

a. For *climate zones* 1, 2, 3, and 4:

$$(A_N \times SHGC_N + A_S \times SHGC_S) \geq 1.1 \times (A_E \times SHGC_E + A_W \times SHGC_W)$$

b. For *climate zones* 5 and 6:

$$1/3 \times (A_N \times SHGC_N + A_S \times SHGC_S + A_E \times SHGC_E) \geq 1.1 \times (A_W \times SHGC_W)$$

where:

$SHGC_x$ = the *SHGC* for orientation x

A_x = *fenestration area* for orientation x

N = north (oriented less than 45 degrees of true north)

S = south (oriented less than 45 degrees of true south)

E = east (oriented less than or equal to 45 degrees of true east)

W = west (oriented less than or equal to 45 degrees of true west)

TABLE 7.4.2.6 SHGC Multipliers for Permanent Projections

PF	*SHGC* Multiplier (All Other Orientations)	*SHGC* Multiplier (North-Oriented)
0–0.60	1.00	1.00
>0.60–0.70	0.92	0.96
>0.70–0.80	0.84	0.94
>0.80–0.90	0.77	0.93
>0.90–1.00	0.72	0.90

Exceptions:

a. *Vertical fenestration* that complies with the exception to Section 5.5.4.4.1 (c) of ANSI/ASHRAE/IESNA Standard 90.1.
b. Buildings that have an existing building or existing permanent infrastructure within 20 ft (6 m) to the south or north that is at least half as tall as the proposed building.
c. Buildings with shade on 75% of the west- and east-oriented *vertical fenestration areas* from existing buildings, existing permanent infrastructure, or topography at 9 a.m. and 3 p.m. on the summer solstice.
d. Alterations and additions with no increase in vertical fenestration area.

7.4.2.10 Continuous Air Barrier. The *building envelope* shall be designed and constructed with a *continuous air barrier* that complies with Normative Appendix B to control air leakage into, or out of, the *conditioned space*. All air barrier components of each envelope assembly shall be clearly identified on construction documents and the joints, interconnections, and penetrations of the air barrier components shall be detailed.

Exception: *Building envelopes* of *semiheated spaces* provided that the *building envelope* complies with Section 5.4.3.1 of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.3 Heating, Ventilating, and Air Conditioning. The heating, ventilating, and air conditioning shall comply with Section 6 of ANSI/ASHRAE/IESNA Standard 90.1 with the following modifications and additions.

7.4.3.1 Minimum Equipment Efficiencies. Projects shall comply with one of the following:

a. **EPAct baseline.** Products shall comply with the minimum efficiencies addressed in the National Appliance Energy Conservation Act (NAECA), Energy Policy Act (EPAct), and the Energy Independence and Security Act (EISA).
b. **Higher Efficiency.** Products shall comply with the greater of the ENERGY STAR requirements in Section 7.4.7.3 and the values in Normative Appendix C. These requirements supersede the requirements in Tables 6.8.1A to 6.8.1J of ANSI/ASHRAE/IESNA Standard 90.1. The building project shall comply with Sections 7.4.1.1 and 7.4.5.1 with the following modifications:

    1. The on-site renewable energy systems required in Section 7.4.1.1 shall provide an annual energy production of not less than 4.0 kBtu/ft^2 (13 kWh/m^2).
    2. The peak load reduction systems required in Section 7.4.5.1 shall be capable of reducing electric peak demand by not less than 5% of the projected peak demand.

7.4.3.2 Ventilation Controls for Densely Occupied Spaces. *DCV* is required for *densely occupied spaces*. This requirement supersedes the occupant density threshold in Section 6.4.3.9 of ANSI/ASHRAE/IESNA Standard 90.1.

The *DCV* system shall be designed to be in compliance with ANSI/ASHRAE Standard 62.1. Occupancy assumptions shall be shown in the design documents for spaces required to have *DCV*. All CO_2 sensors used as part of a *DCV* system or any other system that dynamically controls outdoor air shall meet the following requirements:

a. Spaces with CO_2 sensors or air sampling probes leading to a central CO_2 monitoring station shall have one sensor or probe for each 10,000 ft² (1000 m²) of floor space and shall be located in the room between 3 and 6 ft (1 and 2 m) above the floor.
b. CO_2 sensors must be accurate to ±50 ppm at 1000 ppm.
c. O*utdoor air* CO_2 concentrations shall be determined by one of the following:

    1. O*utdoor air* CO_2 concentrations shall be dynamically measured using a CO_2 sensor located in the path of the *outdoor air* intake.
    2. When documented statistical data are available on the local ambient CO_2 concentrations, a fixed value typical of the location where the building is located shall be allowed in lieu of an outdoor sensor.

d. Occupant CO_2 generation rate assumptions shall be shown in the design documents

7.4.3.3 Duct and Plenum Leakage. For duct sealing, Seal Level A shall be used. This requirement supersedes the requirements in Table 6.4.4.2A of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.3.4 Economizers. Systems shall have economizers meeting the requirements in Section 6.5.1 of ANSI/ASHRAE/IESNA 90.1 except as noted below.

1. The minimum size requirements for economizers are defined in Table 7.4.3.4A and supersede the requirements in Table 6.5.1 of ANSI/ASHRAE/IESNA Standard 90.1.
2. High-limit controls shall comply with Table 7.4.3.4B.
3. Rooftop units with a capacity of less than 60,000 Btu/h (18 kW) shall have two stages of capacity control, with the first stage used for cooling with the economizer and the second stage to add mechanical cooling.
4. For systems that control to a fixed leaving air temperature (i.e., *VAV* systems), the system shall be capable of resetting the supply air temperature up at least 5°F (3°C) during economizer operation.

Exceptions: All the exceptions in Sections 6.5.1 and 6.5.1.3 of ANSI/ASHRAE/IESNA Standard 90.1 shall apply except as noted below.

1. For units requiring an airside economizer, the economizer is allowed to be eliminated if: for products with an IEER part load minimum requirement, the product IEER rating exceeds the minimum level defined in Appendix C by the percentage shown in the Table 7.4.3.4C or, for products with only a full load minimum metric (EER or SEER), the

TABLE 7.4.3.4A Minimum System Size for Which an Economizer is Required

Climate Zones	Cooling Capacity for Which an Economizer is Required[a]
1A, 1B, 2A	No economizer requirement
2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	≥33,000 Btu/h (9.7 kW)[a]

a Where economizers are required, the total capacity of all systems without economizers shall not exceed 480,000 Btu/h (140 kW) per building or 20% of the building's air economizer capacity, whichever is greater.

TABLE 7.4.3.4B High Limit Shutoff Control Options for Air Economizers

Climate Zones	Allowable Control Types
1A, 2A, 3A, 4A	Differential enthalpy[a]
1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	Differential enthalpy or differential dry bulb

a Differential enthalpy is the enthalpy difference between the return air and the outside air.

full load efficiency exceeds the minimum level defined in Appendix C by the percentage shown in the Table 7.4.3.4C.

2. For water-cooled units with a capacity less than 54,000 Btu/h (16 kW) that are used in systems where heating and cooling loads are transferred within the building (i.e., water-source heat pump systems), the requirement for an air or water economizer can be eliminated if the condenser-water temperature controls are capable of being set to maintain full load heat rejection capacity down to a 55°F (12°C) condenser-water supply temperature and the HVAC equipment is capable of operating with a 55°F (12°C) condenser-water supply temperature.
3. All economizers shall have integrated economizer controls as defined by Section 6.5.1.3 of ANSI/ASHRAE/IESNA Standard 90.1, but Exception 6.5.1.3 (c) shall not apply.

7.4.3.5 Zone Controls. Exception (a) to Section 6.5.2.1 of ANSI/ASHRAE/IESNA Standard 90.1 shall be replaced by the following: zones for which the volume of air that is reheated, re-cooled, or mixed is not greater than the larger of (1) the *design outdoor airflow rate* for the zone, or (2) 15% of the zone design peak supply rate.

7.4.3.6 Fan System Power Limitation. Systems shall have fan power limitations 10% below limitations specified in Table 6.5.3.1.1A of ANSI/ASHRAE/IESNA Standard 90.1. This requirement supersedes the requirement in Section 6.5.3.1 and Table 6.5.3.1.1A of ANSI/ASHRAE/IESNA Standard 90.1. All exceptions in Section 6.5.3.1 of ANSI/ASHRAE/IESNA Standard 90.1 shall apply.

7.4.3.7 Controls. The following requirements shall apply:

a. *DX* systems with a capacity greater than 65,000 Btu/h (19 kW) shall have a minimum of two stages of cooling capacity.
b. Air-handling and fan-coil units with chilled-water cooling coils and supply fans with motors greater than or equal to 5 hp shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

    1. One half of the full fan speed, or
    2. The volume of outdoor air required to meet the ventilation requirements of ANSI/ASHRAE Standard 62.1.

c. All air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at AHRI conditions greater than or equal to 110,000 Btu/h (32.2 kW) that serve single zones shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

    1. Two-thirds of the full fan speed, or
    2. The volume of outdoor air required to meet the ventilation requirements of ANSI/ASHRAE Standard 62.1.

d. All *DX* and chilled-water *VAV* units shall be equipped with variable-speed fans that result in less than 30% power at 50% flow.

Exception: When air ventilation rates or air exchange rates require constant volume fan operation.

TABLE 7.4.3.4C Minimum Efficiency Improvement to Eliminate Airside Economizer

Climate Zones	Cooling Efficiency Improvement [a]
1A, 1B, 2A	NR
2B, 3A, 3B, 4A	15%
4B, 5A, 5B	35%
6A, 6B	58%
3C, 4C, 5C, 7, 8	NA

a The incremental efficiency improvement should be applied to the unit part load or annualized metric (i.e. IPLV, IEER, SEER). For products that do not have a defined part load or annualized metric then the full load EER rating shall be used.
NR – No economizers are required by the ANSI/ASHRAE/IESNA Standard 90.1.
NA – The economizer is mandatory and cannot be eliminated by a higher efficiency unit.

7.4.3.8 Exhaust Air Energy Recovery. Each fan system shall have an energy recovery system when the system's supply airflow rate exceeds the value listed in Table 7.4.3.8 based on the climate zone and percentage of *outdoor air* at design conditions. Where a single room or space is supplied by multiple units, the aggregate supply cfm (L/s) of those units shall be used in applying this requirement.

Energy recovery systems required by this section shall have at least 60% energy recovery effectiveness. Sixty percent energy recovery effectiveness shall mean a change in the enthalpy of the *outdoor air* supply equal to 60% of the difference between the *outdoor air* and return air enthalpies at design conditions. Provisions shall be made to bypass or control the energy recovery system to permit air economizer operation as required by Section 7.4.3.4.

7.4.3.9 Variable-Speed Fan Control for Commercial Kitchen Hoods. In addition to the requirements in Section 6.5.7.1 of ANSI/ASHRAE/IESNA Standard 90.1, commercial kitchen Type I and Type II hood systems shall have variable-speed control for exhaust and makeup air fans to reduce hood airflow rates at least 50% during those times when cooking is not occurring and the cooking appliances are up to temperature in a standby, ready-to-cook mode. All exceptions in Section 6.5.7.1 of ANSI/ASHRAE/IESNA Standard 90.1 shall apply.

7.4.3.10 Duct Insulation. Duct insulation shall comply with the minimum requirements in Tables C-9 and C-10 in Normative Appendix C. These requirements supersede the requirements in Tables 6.8.2A and 6.8.2B of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.3.11 Pipe Insulation. Pipe insulation shall comply with the minimum requirements in Table C-11 in Normative Appendix C. These requirements supersede the requirements in Table 6.8.3 of ANSI/SHRAE/IESNA Standard 90.1. The exceptions a through e in Section 6.4.4.1.3 of ANSI/ASHRAE/IESNA Standard 90.1 shall apply.

7.4.3.12 Automatic Control of HVAC and Lights in Hotel/Motel Guest Rooms. In hotels and motels with over 50 guest rooms, the lighting switched outlets, television, and HVAC equipment serving each guest room shall be automatically controlled such that the lighting, switched outlets, and televisions will be turned off and the HVAC setpoint raised at least 5°F (3°C) in the cooling mode and lowered at least 5°F (3°C) in the heating mode whenever the guest room is unoccupied.

7.4.4 Service Water Heating. The *service water heating* shall comply with Section 7 of ANSI/ASHRAE/IESNA Standard 90.1 with the following modifications and additions.

7.4.4.1 Equipment Efficiency. Equipment shall comply with the minimum efficiencies in Table C-12 in Normative

TABLE 7.4.3.8 Energy Recovery Requirement (I-P)

Climate Zone	% Outside Air at Full Design Flow							
	≥10% and < 20%	≥20% and < 30%	≥30% and < 40%	≥40% and < 50%	≥50% and < 60%	≥60% and < 70%	≥70% and < 80%	≥80%
	Design Supply Fan Flow, cfm							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	≥5000	≥5000
1B, 2B, 5C	NR	NR	NR	NR	≥26,000	≥12,000	≥5000	≥4000
6B	NR	≥22,500	≥11,000	≥5500	≥4500	≥3500	≥2500	≥1500
1A, 2A, 3A, 4A, 5A, 6A	≥30,000	≥13,000	≥5500	≥4500	≥3500	≥2000	≥1000	≥0
7, 8	≥4000	≥3000	≥2500	≥1000	≥0	≥0	≥0	≥0

TABLE 7.4.3.8 Energy Recovery Requirement (SI)

Climate Zone	% Outside Air at Full Design Flow							
	≥10% and < 20%	≥20% and < 30%	≥30% and < 40%	≥40% and < 50%	≥50% and < 60%	≥60% and < 70%	≥70% and < 80%	≥80%
	Design Supply Fan Flow, L/s							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	≥2360	≥2360
1B, 2B, 5C	NR	NR	NR	NR	≥12,271	≥5663	≥2360	≥1888
6B	NR	≥10,619	≥5191	≥2596	≥2124	≥1652	≥1180	≥708
1A, 2A, 3A, 4A, 5A, 6A	≥14,158	≥6135	≥2596	≥2124	≥1652	≥944	≥472	>0
7, 8	≥1888	≥1416	≥1180	≥472	>0	>0	>0	>0

Appendix C. These requirements supersede the requirements in Table 7.8 of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.4.2 Service Hot-Water Piping Insulation. Pipe insulation shall comply with Section 7.4.3.11. These requirements supersede the requirements in Section 7.4.3 of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.4.3 Insulation for Spa Pools. Pools heated to more than 90°F (32°C) shall have side and bottom surfaces insulated on the exterior with a minimum insulation value of R-12 (R-2.1).

7.4.5 Power. The power shall comply with Section 8 of ANSI/ASHRAE/IESNA Standard 90.1 with the following modifications and additions.

7.4.5.1 Peak Load Reduction. *Building projects* shall contain automatic systems, such as demand limiting or load shifting, that are capable of reducing electric peak demand of the building by not less than 10% of the projected peak demand. Standby power generation shall not be used to achieve the reduction in peak demand.

7.4.6 Lighting. The lighting shall comply with Section 9 of ANSI/ASHRAE/IESNA Standard 90.1 as modified by Addendum i and the following modifications and additions.

7.4.6.1 Lighting Power Allowance. The *lighting power allowance* shall be a maximum of 0.9 multiplied by the values determined in accordance with Sections 9.5 and 9.6. This requirement supersedes the requirements in Sections 9.5 and 9.6 of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.6.2 Occupancy Sensor Controls. Offices 250 ft^2 (25 m^2) or smaller; *classrooms* of any size; lecture, training, or vocational rooms of less than 1000 ft^2 (100 m^2); multipurpose rooms of less than 1000 ft^2 (100 m^2); conference rooms and meeting rooms less than 1000 ft^2 (100 m^2); and meeting centers shall be equipped with occupant sensor(s) to automatically turn lighting OFF within 30 minutes of all occupants leaving a space and allow "manual OFF" control. In addition, all occupancy sensor controls shall be either "manual ON" or bi-level "automatic ON" programmed to a low light level combined with multi-level circuitry and "manual ON" switching for higher light levels. Where such occupancy sensors are utilized within a daylit area and daylighting controls are utilized, the occupancy sensors shall work in conjunction with the daylighting controls complying with Section 7.4.6.5.

7.4.6.3 Occupancy Sensor Controls with Multi-Level Switching or Dimming. The lighting in the following areas shall be controlled by an occupant sensor with multi-level switching or dimming system that reduces lighting power a minimum of 50% when no persons are present:

a. Hallways in multifamily, dormitory, hotel, and motel buildings.
b. Commercial and industrial storage stack areas.
c. Library stack areas.

Exception: Areas lit by HID lighting with a lighting power density of 0.8 W/ft^2 or less.

7.4.6.4 Automatic Controls for Egress and Security Lighting. Lighting in any area within a building that is required to be continuously illuminated for reasons of building security or emergency egress shall not exceed 0.1 W/ft^2 (1 W/m^2). Additional egress and security lighting shall be allowed, provided it is controlled by an automatic control device that turns off the additional lighting.

7.4.6.5 Automatic Controls for Lighting in Daylight Zones. Lighting in all *daylight zones*, including *daylight zones under skylights* and *daylight zones adjacent to vertical fenestration*, where the combined *daylight zone* per enclosed space is greater than 250 ft^2 (25 m^2), shall be provided with controls that automatically reduce lighting power in response to available daylight by either:

a. *Continuous daylight dimming*, or
b. A combination of stepped switching and daylight-sensing automatic controls, which are capable of incrementally reducing the light level in steps automatically and turning the lights off automatically.

Exceptions:

1. Window display and exhibition lighting.
2. Conference rooms greater than 250 ft^2 (25 m^2) that have a lighting control system with at least four scene options.
3. Lighting in conference rooms that is dimmable and controlled by dimming controls that are located within the space and accessible to the space occupants.
4. Saunas, steam rooms, and spaces containing swimming pools or spa pools.
5. Spaces where medical procedures are performed.
6. Spaces within dwelling units.
7. Spaces within hotel and motel guest rooms and suites.
8. *Daylight zones* where the height of existing adjacent structures above the window is at least twice the distance between the window and adjacent structures, measured from the top of the glazing.

7.4.6.6 "Manual ON" Occupancy Sensors. Occupancy sensors shall have "manual ON", "automatic OFF" controls.

Exception: Occupancy sensor controls required in Section 7.4.6.3.

7.4.6.7 Controls for Outdoor Lighting. All outdoor lighting controls shall comply with Section 9 of ANSI/ASHRAE/IESNA Standard 90.1 with the following modifications and additions. For lighting of building facades, parking lots, garages, canopies (sales and non-sales), and all outdoor sales areas, automatic controls shall be installed to reduce the sum of all lighting power (in watts) by a minimum of 50% one hour after normal business closing and to turn off outdoor lighting within 30 minutes after sunrise.

Exceptions:

1. Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.
2. Lighting that is controlled by a motion sensor and photocontrol.
3. Lighting for facilities that have equal lighting requirements at all hours and are designed to operate continuously.
4. Temporary outdoor lighting.

5. Externally illuminated signs and signs that are internally illuminated or have integral lamps.

7.4.7 Other Equipment. The other equipment shall comply with Section 10 of ANSI/ASHRAE/IESNA Standard 90.1 with the following modifications and additions.

7.4.7.1 Electric Motors. Motors shall comply with the minimum requirements in Table C-13 in Normative Appendix C. These requirements supersede the requirements in Section 10.4.1 and Table 10.8 of ANSI/ASHRAE/IESNA Standard 90.1.

7.4.7.2 Supermarket Heat Recovery. Supermarkets with a floor area of 25,000 ft^2 (2500 m^2) or greater shall recover waste heat from the condenser heat rejection on permanently installed refrigeration equipment meeting one of the following criteria:

1. 25% of the refrigeration system full load total heat rejection.
2. 80% of the space heat, service water heating and dehumidification reheat.

If a recovery system is used that is installed in the refrigeration system, the system shall not increase the saturated condensing temperature at design conditions by more than 5°F (3°C) and shall not impair other head pressure control/energy reduction strategies.

7.4.7.3 ENERGY STAR Equipment. The following equipment within the scope of the applicable ENERGY STAR program shall comply with the equivalent criteria required to achieve the ENERGY STAR label if installed prior to the issuance of the certificate of occupancy:

a. Appliances

   1. Clothes washers: ENERGY STAR Program Requirements for Clothes Washers (see also the water efficiency requirements in Section 6.3.2.2)
   2. Dehumidifiers: ENERGY STAR Program Requirements for Dehumidifiers
   3. Dishwashers: ENERGY STAR Program Requirements for Dishwashers (see also the water efficiency requirements in Section 6.3.2.2)
   4. Refrigerators and freezers: ENERGY STAR Program Requirements for Refrigerators and Freezers
   5. Room air conditioners: ENERGY STAR Program Requirements and Criteria for Room Air Conditioners (see also the energy efficiency requirements in Section 7.4.1)
   6. Room air cleaners: ENERGY STAR Program Requirements for Room Air Cleaners
   7. Water coolers: ENERGY STAR Program Requirements for Bottled Water Coolers

b. Heating and Cooling

   1. Residential air-source heat pumps: ENERGY STAR Program Requirements for ASHPs and Central Air Conditioners (see also the energy efficiency requirements in Section 7.4.1)
   2. Residential boilers: ENERGY STAR Program Requirements for Boilers (see also the energy efficiency requirements in Section 7.4.1)
   3. Residential central air conditioners: ENERGY STAR Program Requirements for ASHPs and Central Air Conditioners (see also the energy efficiency requirements in Section 7.4.1)
   4. Residential ceiling fans: ENERGY STAR Program Requirements for Residential Ceiling Fans
   5. Dehumidifiers: ENERGY STAR Program Requirements for Dehumidifiers
   6. Programmable thermostats: ENERGY STAR Program Requirements for Programmable Thermostats
   7. Ventilating fans: ENERGY STAR Program Requirements for Residential Ventilating Fans
   8. Residential Warm Air Furnaces: ENERGY STAR Program Requirements for Warm Air Furnaces

c. Electronics

   1. Cordless phones: ENERGY STAR Program Requirements for Telephony
   2. Combination units (TV/VCR/DVD): ENERGY STAR Program Requirements for Televisions
   3. DVD products: ENERGY STAR Program Requirements for Consumer Audio and DVD Products
   4. Audio: ENERGY STAR Program Requirements for Consumer Audio and DVD Products
   5. Televisions: ENERGY STAR Program Requirements for Televisions

d. Office Equipment

   1. Computers: ENERGY STAR Program Requirements for Computers
   2. Copiers: ENERGY STAR Program Requirements for Imaging Equipment
   3. Fax machines: ENERGY STAR Program Requirements for Imaging Equipment
   4. Laptops: ENERGY STAR Program Requirements for Computers
   5. Mailing machines: ENERGY STAR Program Requirements for Imaging Equipment
   6. Monitors: ENERGY STAR Program Requirements for Computer Monitors
   7. Multifunction devices (printer/fax/scanner): Program Requirements for Imaging Equipment
   8. Printers: ENERGY STAR Program Requirements for Imaging Equipment
   9. Scanners: ENERGY STAR Program Requirements for Imaging Equipment

e. Water Heaters: ENERGY STAR Program Requirements for Residential Water Heaters

f. Lighting

1. Compact fluorescent light bulbs (CFLs): ENERGY STAR Program Requirements for CFLs
2. Residential light fixtures: ENERGY STAR Program Requirements for Residential Light Fixtures

g. Commercial Food Service

1. Commercial fryers: ENERGY STAR Program Requirements for Commercial Fryers
2. Commercial hot food holding cabinets: ENERGY STAR Program Requirements for Hot Food Holding Cabinets
3. Commercial solid door refrigerators and freezers: ENERGY STAR Program Requirements for Solid Door Refrigerators and Freezers
4. Commercial steam cookers: ENERGY STAR Program Requirements for Commercial Steam Cookers (see also water efficiency requirements in Section 6.4.2.2)
5. Commercial ice machines: ENERGY STAR Program Requirements for Commercial Ice Machines
6. Commercial dishwashers: ENERGY STAR Program Requirements for Commercial Dishwashers

h. Other Products

1. Battery charging systems: ENERGY STAR Program Requirements for Products with Battery Charger Systems (BCSs)
2. External power adapters: ENERGY STAR Program Requirements for Single-Voltage AC-DC and AC-AC Power Supplies
3. Vending machines: ENERGY STAR Program Requirements for Refrigerated Beverage Vending Machines

Exception: Products with minimum efficiencies addressed in the Energy Policy Act (EPAct) and the Energy Independence and Security Act (EISA) when complying with Section 7.4.3.1a.

7.4.7.4 Commercial Refrigerators, Freezers, and Clothes Washers

a. Commercial refrigerators and freezers shall comply with the minimum efficiencies in Table C-14 in Normative Appendix C. Open refrigerated display cases not covered by strips or curtains are prohibited. Lighting loads, including all power supplies or ballasts, for commercial reach-in refrigerator/freezer display cases shall not exceed 42 watts per door for case doors up to 5 ft (1.5 m) in height and 46 watts per door for case doors greater than 5 ft (1.5 m) in height.
b. Commercial clothes washers shall comply with the minimum efficiencies in Table C-15 in Normative Appendix C.

7.4.8 Energy Cost Budget. The Energy Cost Budget option in Section 11 of ANSI/ASHRAE/IESNA Standard 90.1 shall not be used.

7.5 Performance Option

7.5.1 General Comprehensive Performance Requirements. Projects shall comply with Sections 7.5.2, 7.5.3, and 7.5.4.

7.5.2 Annual Energy Cost

a. The *building project* shall have an annual energy cost less than or equal to that achieved by compliance with Sections 7.3 and 7.4, and Sections 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.4, and 8.4.1. Comparisons shall be made using Normative Appendix D provided that the baseline building design is calculated in accordance with the modifications and additions in Sections 7.3.1 through 7.3.3 and Sections 7.4.1 through 7.4.7, and Sections 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.4, and 8.4.1.
b. Credit for daylighting controls is allowed to be taken up to a distance of 2.5 times window head height where all lighting more than one window head height from the perimeter (head height is the distance from the floor to the top of the glazing) is automatically controlled separately from lighting within one window head height of the perimeter.

7.5.3 Annual Carbon Dioxide Equivalent (CO_2e). The *building project* shall have an annual CO_2e less than or equal to that achieved by compliance with Sections 7.3 and 7.4, and Sections 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.4, and 8.4.1. Comparisons shall be made using Normative Appendix D provided that the baseline building design is calculated in accordance with Section 7.5.2. To determine the CO_2e value for each energy source supplied to the *building project*, multiply the energy consumption by the emissions factor. CO_2e emission factors shall be taken from Table 7.5.3.

7.5.4 Annual Load Factor/Peak Electric Demand. The *building project* shall have the same or less peak electric demand than achieved by compliance with Sections 7.3 and 7.4, and Sections 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 8.3.1, 8.3.4, and 8.4.1. Comparisons shall be made using Normative Appendix D provided that the baseline building design is calculated in accordance with Section 7.5.2. In addition, the *building project* shall have a minimum electrical *annual load factor* of 0.25.

TABLE 7.5.3 CO_2e Emission Factors

Building Project **Energy Source**	**CO_2e lb/kWh (kg/kWh)**
Grid delivered electricity and other fuels not specified in this table	1.670 (0.758)
LPG or propane	0.602 (0.274)
Fuel oil (residual)	0.686 (0.312)
Fuel oil (distillate)	0.614 (0.279)
Coal (except lignite)	0.822 (0.373)
Coal (lignite)	1.287 (0.583)
Gasoline	0.681 (0.309)
Natural gas	0.510 (0.232)

8. INDOOR ENVIRONMENTAL QUALITY (IEQ)

8.1 Scope. This section specifies requirements for indoor environmental quality, including indoor air quality, environmental tobacco smoke control, *outdoor air* delivery monitoring, thermal comfort, *building entrances*, acoustic control, daylighting, and low emitting materials.

8.2 Compliance. The indoor environmental quality shall comply with Section 8.3, "Mandatory Provisions," and either:

a. Section 8.4, "Prescriptive Option," or
b. Section 8.5, "Performance Option."

Daylighting and low-emitting materials are not required to use the same option, i.e., prescriptive or performance, for demonstrating compliance.

8.3 Mandatory Provisions

8.3.1 Indoor Air Quality. The building shall comply with Sections 4 through 7 of ANSI/ASHRAE Standard 62.1 with the following modifications and additions. When a requirement is provided below, this supersedes the requirements in ANSI/ASHRAE Standard 62.1.

8.3.1.1 Minimum Ventilation Rates

a. The Ventilation Rate Procedure of ANSI/ASHRAE Standard 62.1 shall be used to design each mechanical ventilation system in the building.
b. The zone-level *design outdoor airflow rates* in all occupiable spaces shall be greater than or equal to the airflow calculated using the Ventilation Rate Procedure in Section 6.2 of ANSI/ASHRAE Standard 62.1.
c. The system-level *design outdoor airflow rate* calculation (Sections 6.2.3 through 6.2.5 of ANSI/ASHRAE Standard 62.1) shall be based on the zone-level *design outdoor airflow rates* calculated in Section 8.3.1.1 (b).

8.3.1.2 Outdoor Air Delivery Monitoring

8.3.1.2.1 Spaces Ventilated by Mechanical Systems. A permanently mounted, direct total outdoor airflow measurement device shall be provided that is capable of measuring the system *minimum outdoor airflow rate*. The device shall be capable of measuring flow within an accuracy of ±15% of the *minimum outdoor airflow rate.* The device shall also be capable of being used to alarm the building operator or for sending a signal to a building central monitoring system when flow rates are not in compliance.

Exception: Constant volume air supply systems that use a damper position feedback system are not required to have a direct total outdoor airflow measurement device.

8.3.1.3 Filtration and Air Cleaner Requirements

a. **Particulate Matter**

1. The particulate matter filters or air cleaners shall have a MERV of not less than 8 and shall comply with and be provided where required in Section 5.9 of ANSI/ASHRAE Standard 62.1.
2. In addition to Section 6.2.1.1 of ANSI/ASHRAE Standard 62.1, when the building is located in an area that is designated "non-attainment" with the National Ambient Air Quality Standards for $PM_{2.5}$ as determined by the *AHJ*, (in the US by the USEPA), particle filters or air-cleaning devices shall be provided to clean outdoor air prior to its introduction to occupied spaces having a MERV of not less than 13 when rated in accordance with ANSI/ASHRAE Standard 52.2.

b. In addition to Section 6.2.1.2 of ANSI/ASHRAE Standard 62.1, when the building is located in an area that is designated "non-attainment" with the National Ambient Air Quality Standards for ozone as determined by the *AHJ*, air-cleaning devices having a removal efficiency of no less than the efficiency specified in Section 6.2.1.2 of ANSI/ASHRAE Standard 62.1 shall be provided to clean outdoor air prior to its introduction to occupied spaces.
c. **Bypass Pathways.** All filter frames, air cleaner racks, access doors, and air cleaner cartridges shall be sealed.

8.3.1.4 Environmental Tobacco Smoke

a. Smoking shall not be allowed inside the building. Signage stating such shall be posted within 10 ft (3 m) of each building entrance.
b. Any exterior designated smoking areas shall be located a minimum of 25 ft (7.5 m) away from *building entrances*, *outdoor air* intakes, and operable windows.
c. Section 6.2.9 of ANSI/ASHRAE Standard 62.1 shall not apply.

8.3.1.5 Building Entrances. All *building entrances* shall employ an entry mat system that shall have a scraper surface, an absorption surface, and a finishing surface. Each surface shall be a minimum of the width of the entry opening, and the minimum length is measured in the primary direction of travel.

Exceptions:

1. Entrances to individual *dwelling units*.
2. Length of entry mat surfaces is allowed to be reduced due to a barrier, such as a counter, partition, or wall, or local regulations prohibiting the use of scraper surfaces outside the entry. In this case entry mat surfaces shall have a minimum length of 3 ft (1 m) of indoor surface, with a minimum combined length of 6 ft (2 m).

8.3.1.5.1 Scraper Surface. The scraper surface shall comply with the following:

a. Shall be the first surface stepped on when entering the building.
b. Shall be either immediately outside or inside the entry.
c. Shall be a minimum of 3 ft (1 m) long.
d. Shall be either permanently mounted grates or removable mats with knobby or squeegee-like projections.

8.3.1.5.2 Absorption Surface. The absorption surface shall comply with the following:

a. Shall be the second surface stepped on when entering the building.
b. Shall be a minimum of 3 ft (1 m) long, and made from materials that can perform both a scraping action and a moisture wicking action.

8.3.1.5.3 Finishing Surface. The finishing surface shall comply with the following:

a. Shall be the third surface stepped on when entering the building.
b. Shall be a minimum of 4 ft (1.2 m) long, and made from material that will both capture and hold any remaining particles or moisture.

8.3.2 Thermal Environmental Conditions for Human Occupancy. The building shall be designed in compliance with ANSI/ASHRAE Standard 55, Sections 6.1, "Design," and 6.2, "Documentation of ANSI/ASHRAE Standard 55."

Exception: Spaces with special requirements for processes, activities, or contents that require a thermal environment outside that which humans find thermally acceptable, such as food storage, natatoriums, shower rooms, saunas, and drying rooms.

8.3.3 Acoustical Control

8.3.3.1 Exterior Sound. *Wall* and roof-ceiling assemblies that are part of the *building envelope* shall have a composite OITC rating of 40 or greater or a composite STC rating of 50 or greater, and *fenestration* that is part of the *building envelope* shall have an OITC or STC rating of 30 or greater for any of the following conditions:

a. Buildings within 1000 ft (300 m) of *expressways*.
b. Buildings within 5 mi (8 km) of airports serving more than 10,000 commercial jets per year.
c. Where *yearly average day-night average sound levels* at the property line exceed 65 decibels.

Exception: Buildings that may have to adhere to functional and operational requirements such as factories, stadiums, storage, enclosed parking structure, and utility buildings.

8.3.3.2 Interior Sound. Interior *wall* and floor/ceiling assemblies separating interior rooms and spaces shall be designed in accordance with all of the following:

a. *Wall* and floor-ceiling assemblies separating adjacent *dwelling units*, *dwelling units* and public spaces, adjacent tenant spaces, tenant spaces and public places, and adjacent *classrooms* shall have a composite STC rating of 50 or greater.
b. *Wall* and floor-ceiling assemblies separating hotel rooms, motel rooms, and patient rooms in nursing homes and hospitals shall have a composite STC rating of 45 or greater.
c. *Wall* and floor-ceiling assemblies separating *classrooms* from rest rooms and showers shall have a composite STC rating of 53 or greater.
d. *Wall* and floor-ceiling assemblies separating *classrooms* from music rooms, mechanical rooms, cafeteria, gymnasiums, and indoor swimming pools shall have a composite STC rating of 60 or greater.

8.3.3.3 Outdoor-Indoor Transmission Class and Sound Transmission Class. OITC values for assemblies and components shall be determined in accordance with ASTM E1332. STC values for assemblies and components shall be determined in accordance with ASTM E90 and ASTM E413.

8.3.4 Daylighting by Toplighting. There shall be a minimum *fenestration area* providing daylighting by *toplighting* for large enclosed spaces. In buildings three stories and less above grade, conditioned or unconditioned enclosed spaces that are greater than 20,000 ft^2 (2000 m^2) directly under a *roof* with finished ceiling heights greater than 15 ft (4 m) and that have a *lighting power allowance* for general lighting equal to or greater than 0.5 W/ft^2 (5.5 W/m^2) shall comply with the following.

Exceptions:

1. Buildings in *climate zones* 7 or 8.
2. Auditoria, theaters, museums, places of worship, and refrigerated warehouses.

8.3.4.1 Minimum Daylight Zone by Toplighting. A minimum of 50% of the floor area directly under a *roof* in spaces with a lighting power density or *lighting power allowance* greater than 0.5 W/ft^2 (5 W/m^2) shall be in the *daylight zone*. Areas that are daylit shall have a minimum *toplighting* area to *daylight zone* area ratio as shown in Table 8.3.4.1. For purposes of compliance with Table 8.3.4.1, the greater of the space lighting power density and the space *lighting power allowance* shall be used.

8.3.4.2 Skylight Characteristics. *Skylights* used to comply with Section 8.3.4.1 shall have a glazing material or diffuser that has a measured haze value greater than 90%, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the *AHJ*.

TABLE 8.3.4.1 Minimum Toplighting Area

Lighting Power Density or *Lighting Power Allowances* in Daylight Zone, W/ft^2 (W/m^2)	Minimum Toplighting Area to Daylight Zone Area Ratio
1.4 W/ft^2 (14 W/m^2) < LPD	3.6%
1.0 W/ft^2 (10 W/m^2) < LPD < 1.4 W/ft^2 (14 W/m^2)	3.3%
0.5 W/ft^2 (5 W/m^2) < LPD < 1.0 W/ft^2 (10 W/m^2)	3.0%

Exceptions:

1. *Skylights* with a measured haze value less than or equal to 90% whose combined area does not exceed 5% of the total *skylight* area.
2. *Tubular daylighting devices* having a diffuser.
3. *Skylights* that are capable of preventing direct sunlight from entering the occupied space below the well during occupied hours. This shall be accomplished using one or more of the following:
   a. orientation
   b. automated shading or diffusing devices
   c. diffusers
   d. fixed internal or external baffles
4. Airline terminals, convention centers, and shopping malls.

8.3.5 Isolation of the Building from Pollutants in Soil. Building projects that include construction or expansion of a ground-level foundation and which are located on *brownfield sites* or in "Zone 1" counties identified to have a significant probability of radon concentrations higher than 4 picocuries/liter on the USEPA map of radon zones, shall have a *soil gas retarding system* installed between the newly constructed space and the soil.

8.4 Prescriptive Option

8.4.1 Daylighting by Sidelighting

8.4.1.1 Minimum Effective Aperture. Office spaces and *classrooms* shall comply with the following criteria:

a. All north-, south-, and east-facing facades for those spaces shall have a minimum *effective aperture for vertical fenestration* (EA_{vf}) as prescribed in Table 8.4.1.1.
b. Opaque interior surfaces in *daylight zones* shall have visible light reflectances greater than or equal to 80% for ceilings and 70% for partitions higher than 56 in. (1.54 m) in *daylight zones*.

Exceptions:

1. Spaces with programming that requires dark conditions (e.g., photographic processing).
2. Spaces with *toplighting* in compliance with Section 8.3.4.
3. *Daylight zones* where the height of existing adjacent structures above the window is at least twice the distance between the window and the adjacent structures, measured from the top of the glazing.

8.4.1.2 Office Space Shading. Each west-, south-, and east-facing facade, shall be designed with a shading *PF.* The *PF* shall be not less than 0.5. Shading is allowed to be external or internal using the *interior PF.* The building is allowed to be rotated up to 45 degrees for purposes of calculations and showing compliance. The following shading devices are allowed to be used:

TABLE 8.4.1.1 Minimum Effective Aperture for Sidelighting by Vertical Fenestration

Climate Zone	Minimum Effective Aperture for Sidelighting by Vertical Fenestration
1, 2, 3A, 3B	0.10
3C, 4, 5, 6, 7, 8	0.15

a. Louvers, sun shades, light shelves, and any other permanent device. Any *vertical fenestration* that employs a combination of interior and external shading is allowed to be separated into multiple segments for compliance purposes. Each segment shall comply with the requirements for either external or *interior projection factor.*
b. Building self-shading through *roof* overhangs or recessed windows.

Exceptions:

1. Translucent panels and glazing systems with a measured haze value greater than 90%, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the *AHJ*, and that are entirely 8 ft (2.5 m) above the floor, do not require external shading devices.
2. *Vertical fenestration* that receives direct solar radiation for less than 250 hours per year because of shading by permanent external buildings, existing permanent infrastructure, or topography.

8.4.2 Materials. Reported emissions or VOC contents specified below shall be from a representative product sample and conducted with each product reformulation or at a minimum of every three years. Products certified under third-party certification programs as meeting the specific emission or VOC content requirements listed below are exempted from this three-year testing requirement but shall meet all the other requirements as listed below.

8.4.2.1 Adhesives and Sealants. Products in this category include carpet, resilient, and wood flooring adhesives; base cove adhesives; ceramic tile adhesives; drywall and panel adhesives; aerosol adhesives; adhesive primers; acoustical sealants; firestop sealants; HVAC air duct sealants, sealant primers; and caulks. All adhesives and sealants used on the interior of the building (defined as inside of the *weatherproofing system* and applied on-site) shall comply with the requirements of either Section 8.4.2.1.1 or 8.4.2.1.2:

8.4.2.1.1 Emissions Requirements. Emissions shall be determined according to CA/DHS/EHLB/R-174 (commonly referred to as California Section 01350) and shall comply with the limit requirements for either office or *classroom* spaces regardless of the space type.

8.4.2.1.2 VOC Content Requirements. VOC content shall comply with and shall be determined according to the following limit requirements:

a. Adhesives, sealants and sealant primers: SCAQMD Rule 1168. HVAC duct sealants shall be classified as "Other" category within the SCAQMD Rule 1168 sealants table.
b. Aerosol adhesives: Green Seal Standard GS-36.

Exceptions to Section 8.4.2.1: The following solvent welding and sealant products are not required to meet the emissions or the VOC content requirements listed above.

1. Cleaners, solvent cements, and primers used with plastic piping and conduit in plumbing, fire suppression, and electrical systems.
2. HVAC air duct sealants when the air temperature of the space in which they are applied is less than 40°F (4.5°C).

8.4.2.2 Paints and Coatings. Products in this category include sealers, stains, clear wood finishes, floor sealers and coatings, waterproofing sealers, primers, flat paints and coatings, non-flat paints and coatings, and rust-preventative coatings. Paints and coatings used on the interior of the building (defined as inside of the *weatherproofing system* and applied on-site) shall comply with either Section 8.4.2.2.1 or 8.4.2.2.2.

8.4.2.2.1 Emissions Requirements. Emissions shall be determined according to CA/DHS/EHLB/R-174 (commonly referred to as California Section 01350) and shall comply with the limit requirements for either office or classroom spaces regardless of the space type.

8.4.2.2.2 VOC Content Requirements. VOC content shall comply with and be determined according to the following limit requirements:

a. Architectural paints, coatings and primers applied to interior surfaces: Green Seal Standard GS-11.
b. Clear wood finishes, floor coatings, stains, sealers, and shellacs: SCAQMD Rule 1113.

8.4.2.3 Floor Covering Materials. Floor covering materials installed in the building interior shall comply with the following:

a. Carpet: Carpet shall be tested in accordance with and shown to be compliant with the requirements of CA/DHS/EHLB/R-174 (commonly referred to as California Section 01350). Products that have been verified and labeled to be in compliance with Section 9 of the CA/DHS/EHLB/R-174 comply with this requirement.
b. Hard surface flooring in office spaces and *classrooms*: Materials shall be tested in accordance with and shown to be compliant with the requirements of CA/DHS/EHLB/R-174 (commonly referred to as California Section 01350).

8.4.2.4 Composite Wood, Wood Structural Panel and Agrifiber Products. Composite wood, wood structural panel, and agrifiber products used on the interior of the building (defined as inside of the *weatherproofing system*) shall contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifiber assemblies shall contain no added urea-formaldehyde resins. Composite wood and agrifiber products are defined as: particleboard, medium density fiberboard (MDF), wheatboard, strawboard, panel substrates, and door cores. Materials considered furniture, fixtures and equipment (FF&E) are not considered base building elements and are not included in this requirement. Emissions for products covered by this section shall be determined according to and shall comply with one of the following:

a. Third-party certification shall be submitted indicating compliance with the California Air Resource Board's (CARB) regulation, *Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products*. Third-party certifier shall be approved by CARB.
b. CA/DHS/EHLB/R-174 (commonly referred to as California Section 01350) and shall comply with the limit requirements for either office or classroom spaces regardless of the space type.

Exception: Structural panel components such as plywood, particle board, wafer board, and oriented strand board identified as "EXPOSURE 1," "EXTERIOR," or "HUD-APPROVED" are considered acceptable for interior use.

8.4.2.5 Office Furniture Systems and Seating. All office furniture systems and seating installed prior to occupancy shall be tested according to ANSI/BIFMA Standard M7.1 and shall not exceed the limit requirements listed in Normative Appendix E of this standard.

8.4.2.6 Ceiling and Wall Systems. These systems include ceiling and wall insulation, acoustical ceiling panels, tackable wall panels, gypsum wall board and panels, and wall coverings. Emissions for these products shall be determined according to CA/DHS/EHLB/R-174 (commonly referred to as California Section 01350) and shall comply with the limit requirements for either office or classroom spaces regardless of the space type.

8.5 Performance Option

8.5.1 Daylighting Simulation

8.5.1.1 Usable Illuminance in Office Spaces and Classrooms. The design for the *building project* shall demonstrate an illuminance of at least 30 fc (300 lux) on a plane 3 ft (1 m) above the floor, within 75% of the area of the *daylight zones*. The simulation shall be made at noon on the equinox using an accurate physical model or computer daylighting model.

a. Computer models shall be built using daylight simulation software based on the ray-tracing or radiosity methodology.
b. Simulation shall be done using either the CIE Overcast Sky Model or the CIE Clear Sky Model.

Exception: Where the simulation demonstrates that existing adjacent structures preclude meeting the illuminance requirements.

8.5.1.2 Direct Sun Limitation on Worksurfaces in Offices. It shall be demonstrated that direct sun does not strike

anywhere on a worksurface in any daylit space for more than 20% of the occupied hours during an equinox day in regularly occupied office spaces. If the worksurface height is not defined, a height of 2.5 ft (0.75 m) above the floor shall be used.

8.5.2 Materials. The emissions of all the materials listed below and used within the building (defined as inside of the *weatherproofing system* and applied onsite) shall be modeled for individual VOC concentrations. The sum of each individual VOC concentration from the materials listed below shall be shown to be in compliance with the limits as listed in Section 4.3 of the CA/DHS/EHLB/R-174 (commonly referred to as California Section 01350) and shall be compared to 100% of its corresponding listed limit. In addition, the modeling for the building shall include at a minimum the criteria listed in Normative Appendix F. Emissions of materials used for modeling VOC concentrations shall be obtained in accordance with the testing procedures of CA/DHS/EHLB/R-174 unless otherwise noted below.

a. Tile, strip, panel, and plank products, including vinyl composition tile, resilient floor tile, linoleum tile, wood floor strips, parquet flooring, laminated flooring, and modular carpet tile.
b. Sheet and roll goods, including broadloom carpet, sheet vinyl, sheet linoleum, carpet cushion, wallcovering, and other fabric.
c. Rigid panel products, including gypsum board, other wall paneling, insulation board, oriented strand board, medium density fiber board, wood structural panel, acoustical ceiling tiles, and particleboard.
d. Insulation products.
e. Containerized products, including adhesives, sealants, paints, other coatings, primers, and other “wet” products.
f. Cabinets, shelves, and worksurfaces that are permanently attached to the building before occupancy. Emissions of these items shall be obtained in accordance with the ANSI/BIFMA Standard M7.1.
g. Office furniture systems and seating installed prior to initial occupancy. Emissions of these items shall be obtained in accordance with the ANSI/BIFMA Standard M7.1.

Exception: Salvaged materials that have not been refurbished or refinished within one year prior to installation.

9. THE BUILDING'S IMPACT ON THE ATMOSPHERE, MATERIALS, AND RESOURCES

9.1 Scope. This section specifies requirements for the building's impact on the atmosphere, materials, and resources, including construction waste management, refrigerants, storage and collection of recyclables, and reduced impact materials.

9.2 Compliance. The building materials shall comply with Section 9.3, "Mandatory Provisions," and either

a. Section 9.4, "Prescriptive Option," or
b. Section 9.5, "Performance Option."

9.3 Mandatory Provisions

9.3.1 Construction Waste Management

9.3.1.1 Diversion. A minimum of 50% of nonhazardous construction and demolition waste material shall be diverted from disposal in landfills and incinerators by recycling and/or reuse. Reuse includes donation of materials to charitable organizations, salvage of existing materials onsite, and packaging materials returned to the manufacturer, shipper, or other source that will reuse the packaging in future shipments. Excavated soil and land-clearing debris shall not be included in the calculation. Calculations are allowed to be done by either weight or volume, but shall be consistent throughout. Specific area(s) on the construction *site* shall be designated for collection of recyclable and reusable materials. Off-site storage and sorting of materials shall be allowed. Diversion efforts shall be tracked throughout the construction process.

9.3.1.2 Total Waste. For new *building projects* on *site*s with less than 5% existing buildings, structures or *hardscape*, the total amount of construction waste generated on the project shall not exceed 42 yd^3 or 12,000 lbs per 10,000 ft^2 (35 m^3 or 6000 kg per 1000 m^2) of new building floor area. This shall apply to all waste whether diverted, landfilled, incinerated, or otherwise disposed of. Excavated soil and land-clearing debris shall not be included in the calculation. The amount of waste shall be tracked throughout the construction process.

9.3.2 Extracting, Harvesting, and/or Manufacturing. Materials shall be harvested and/or extracted and products and/or assemblies shall be manufactured according to the laws and regulations of the country of origin.

Wood products in the project, other than recovered or reused wood, shall not contain wood from endangered wood species unless the trade of such wood conforms with the requirements of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

9.3.3 Refrigerants. CFC-based refrigerants in HVAC&R systems shall not be used. Fire suppression systems shall not contain ozone-depleting substances (CFCs, HCFCs, or Halons).

9.3.4 Storage and Collection of Recyclables and Discarded Goods

9.3.4.1 Recyclables. There shall be an area that serves the entire building and is dedicated to the collection and storage of non-hazardous materials for recycling, including paper, corrugated cardboard, glass, plastics, and metals. The size and functionality of the recycling areas shall be coordinated with the anticipated collection services to maximize the effectiveness of the dedicated areas.

9.3.4.2 Reusable goods. For *building projects* with *residential* spaces, there shall be an area that serves the entire building and is designed for the collection and storage of discarded but clean items in good condition. Charitable organizations or others to arrange for periodic pickups shall be identified and posted.

9.3.4.3 Fluorescent and HID Lamps and Ballasts. An area shall be provided that serves the entire building and is designed for the collection and storage of fluorescent and HID lamps and ballasts and facilitates proper disposal and/or recycling according to state and local hazardous waste requirements.

9.4 Prescriptive Option

9.4.1 Reduced Impact Materials. The *building project* shall contain materials that comply with Section 9.4.1.1, 9.4.1.2, or 9.4.1.3. Components of mechanical, electrical, plumbing, fire safety systems, and transportation devices shall not be included in the calculations except for piping, plumbing fixtures, ductwork, conduit, wiring, cabling, and elevator and escalator framing. Calculations shall only include materials *permanently installed* in the project. A value of 45% of the total construction cost is allowed to be used in lieu of the actual total cost of materials.

9.4.1.1 Recycled Content. The sum of *post-consumer recycled content* plus one-half of the *pre-consumer recycled content* shall constitute a minimum of 10%, based on cost, of the total materials in the *building project*. The *recycled content* of a material shall be determined by weight. The recycled fraction of the material in an assembly shall then be multiplied by the cost of assembly to determine its contribution to the 10% requirement.

The annual average industry values, by country of production, for the *recycled content* of steel products manufactured in basic oxygen furnaces and electric arc furnaces are allowed to be used as the *recycled content* of the steel. For the purpose of calculating the *recycled content* contribution of concrete, the constituent materials in concrete (e.g., the cementitious materials, aggregates, and water) are allowed to be treated as separate components and calculated separately.

9.4.1.2 Regional Materials. A minimum of 15% of building materials or products used, based on cost, shall be regionally extracted/harvested/recovered or manufactured within a radius of 500 mi (800 km) of the project *site.* If only a fraction of a product or material is extracted/harvested/recovered or manufactured locally, then only that percentage (by weight) shall contribute to the regional value.

Exception: For building materials or products shipped in part by rail or water, the total distance to the project shall be determined by weighted average, whereby that portion of the distance shipped by rail or water shall be multiplied by 0.25 and added to that portion not shipped by rail or water, provided that the total does not exceed 500 mi (800 km).

9.4.1.3 Biobased Products. A minimum of 5% of building materials used, based on cost, shall be *biobased prod-*

ucts. *Biobased products* shall comply with the minimum biobased contents of the USDA's Designation of Biobased Items for Federal Procurement, contain the "USDA Certified *Biobased Product*" label, or be composed of solid wood, engineered wood, bamboo, wool, cotton, cork, agricultural fibers, or other biobased materials with at least 50% biobased content.

9.4.1.3.1 Wood Building Components. Wood building components including, but not limited to, structural framing, sheathing, flooring, sub-flooring, wood window sash and frames, doors, and architectural millwork used to comply with this requirement shall contain not less than 60% certified wood content tracked through a chain of custody process either by physical separation or percentage-based approaches. Acceptable certified wood content documentation shall be provided by sources certified through a forest certification system with principles, criteria, and standards developed using ISO/IEC Guide 59, or the WTO Technical Barriers to Trade. Wood building components from a *vendor* are allowed to comply when the annual average amount of certified wood products purchased by the *vendor*, for which they have chain of custody *verification* not older than two years, is 60% or greater of their total annual wood products purchased.

9.5 Performance Option

9.5.1 Life-Cycle Assessment. A *LCA* shall be performed in accordance with ISO Standard 14044 for a minimum of two building alternatives, considering at least those material components included for consideration in Section 9.4.1, both of which shall conform to the *OPR*. Each building alternative shall consist of a common design, construction, and materials for the locale, including building size and use, as commonly approved by the *AHJ*. Each building alternative shall comply with Sections 6, 7, and 8. The service life of the buildings shall be not less than that determined using Table 10.3.2.3, except that the design life of long-life buildings shall be no less than 75 years.

9.5.1.1 LCA Performance Metric. The building alternative chosen for the project shall have a 5% improvement over the other building alternative assessed in the *LCA* in a minimum of two of the impact categories. The impact categories are: land use (or habitat alteration), resource use, climate change, ozone layer depletion, human health effects, ecotoxicity, smog, acidification, and eutrophication.

9.5.1.2 Procedure. The *LCA* shall include the following three steps:

Step 1: Perform a life-cycle inventory (LCI). The LCI accounts for all the individual environmental flows to and from the material components in a building throughout its life cycle.

1. The LCI shall include the materials and energy consumed and the emissions to air, land, and water for each of the following stages:
    a. Extracting and harvesting materials and fuel sources from nature.
    b. Processing building materials and manufacturing building components.
    c. Transporting materials and components.
    d. Assembly and construction.
    e. Maintenance, repair, and replacement during the design life with or without operational energy consumption.
    f. Demolition, disposal, recycling, and reuse of the building at the end of its life cycle.
2. The LCI shall account for emissions to air for the following:
    a. The six principal pollutants for which the USEPA has set National Ambient Air Quality Standards as required by the Clean Air Act and its amendments: carbon monoxide, nitrogen dioxide, lead, sulfur oxides, particulate matter (PM_{10} and $PM_{2.5}$), and ozone.
    b. Greenhouse gases (not including water vapor and ozone) as described in the Inventory of U.S. Greenhouse Gas Emissions and Sinks: carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, hydrochlorofluorocarbons, bromofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, sulfur dioxide, and VOCs.
    c. Hazardous air pollutants listed in the Clean Air Act and its amendments.

Step 2: Compare the two building alternatives using a published third-party impact indicator method that includes, at a minimum the impact categories listed in Section 9.5.1.1. An *LCA* report shall be prepared that meets the requirements for third-party reporting in ISO Standard 14044 and also includes:

1. A description of the two building alternatives, including:
    a. a description of the system boundary used,
    b. the design life of each building, and
    c. the physical differences between buildings.
2. The impact indicator method and impact categories used.
3. The results of the *LCA* indicating a minimum of 5% improvement in the proposed building compared to the other building alternative for a minimum of two impact categories, including an explanation of the rationale for the weighting and averaging of the impacts.

Step 3: Conduct a critical review by an external expert independent of those performing the *LCA*.

9.5.1.3 Reporting. The following shall be submitted to the *AHJ*:

a. The *LCA* report.
b. The documentation of critical peer review by a third party including the results from the review and the reviewer's name and contact information.

10. CONSTRUCTION AND PLANS FOR OPERATION

10.1 Scope. This section specifies requirements for construction and plans for operation, including the *commissioning process*, building acceptance testing, measurement and *verification*, energy use reporting, durability, transportation management, erosion and sediment control, construction, and indoor air quality during construction.

10.2 Compliance. All of the provisions of Section 10 are mandatory provisions.

10.3 Mandatory Provisions

10.3.1 Construction

10.3.1.1 Building Acceptance Testing. Acceptance testing shall be performed on all buildings in accordance with this section using *generally accepted engineering standards* and handbooks acceptable to the *AHJ*.

An acceptance testing process shall be incorporated into the design and construction of the *building project* that verifies systems specified in this section perform in accordance with construction documents.

10.3.1.1.1 Activities Prior to Building Permit. Complete the following:

a. Designate a project *Acceptance Representative* to lead, review, and oversee completion of acceptance testing activities.
b. Construction documents shall indicate who is to perform acceptance tests and the details of the tests to be performed.
c. *Acceptance representative* shall review construction documents to verify relevant sensor locations, devices, and control sequences are properly documented.

10.3.1.1.2 Activities Prior to Building Occupancy. Complete the following:

a. Verify proper installation and start-up of the systems.
b. Perform acceptance tests. For each acceptance test, complete test form and include a signature and license number, as appropriate, for the party who has performed the test.
c. Verify a system manual has been prepared that includes O&M documentation and full warranty information, and provides operating staff the information needed to understand and optimally operate building systems.

10.3.1.1.3 Systems. The following systems, if included in the *building project*, shall have acceptance testing:

a. Mechanical systems: heating, ventilating, air conditioning, IAQ, and refrigeration systems (mechanical and/or passive) and associated controls.
b. Lighting systems: automatic daylighting controls, manual daylighting controls, occupancy sensing devices, and, automatic shut-off controls
c. Renewable energy systems.
d. Water measurement devices, as required in Section 6.3.3.
e. Energy measurement devices, as required in Section 7.3.3.

10.3.1.1.4 Documentation. The *owner* shall retain completed acceptance test forms.

10.3.1.2 Building Project Commissioning. For buildings that exceed 5000 ft^2 (500 m^2) of gross floor area, commissioning shall be performed in accordance with this section using *generally accepted engineering standards* and handbooks acceptable to the *AHJ*. Buildings undergoing the *commissioning process* will be deemed to comply with the requirements of Section 10.3.1.1, "Building Acceptance Testing."

A *commissioning process* shall be incorporated into the predesign, design, construction, and first year occupancy of the *building project* that verifies that the delivered building and its components, assemblies, and systems comply with the documented *OPR*. Procedures, documentation, tools, and training shall be provided to the building operating staff to sustain features of the building assemblies and systems for the service life of the building. This material shall be assembled and organized into a systems manual that provides necessary information to the building operating staff to operate and maintain all commissioned systems identified within the building project.

10.3.1.2.1 Activities Prior to Building Permit. The following activities shall be completed:

a. Designate a project *commissioning authority* (CxA) to lead, review, and oversee completion of the *commissioning process* activities prior to completion of schematic design.
b. The *owner*, in conjunction with the design team as necessary, shall develop the *OPR* during predesign and updated during the design phase by the design team as necessary, in conjunction with the *owner* and the commissioning team. The *OPR* will be distributed to all parties participating in project programming, design, construction, and operations, and the commissioning team members.
c. The design team shall develop the *BOD*. The *BOD* document shall include all the information required in Section 6.2, "Documentation," of ANSI/ASHRAE Standard 55.
d. The CxA shall review both the *OPR* and *BOD* to ensure that no conflicting requirements or goals exist and that the *OPR* and *BOD*, based on the professional judgment and experience of the CxA, are sufficiently detailed for the project being undertaken.
e. Construction phase commissioning requirements shall be incorporated into project specifications and other construction documents developed by the design team.
f. The CxA shall conduct two focused *OPR* reviews of the construction documents: the first at near 50% design completion and the second of the final construction documents prior to delivery to the contractor. The purpose of these reviews is to verify that the documents achieve the construction phase *OPR* and the *BOD* document fully supports the *OPR*, with sufficient details.
g. Develop and implement a *commissioning plan* containing all required forms and procedures for the complete testing

of all equipment, systems, and controls included in Section 10.3.1.2.4.

10.3.1.2.2 Activities Prior to Building Occupancy. The following activities shall be completed:

a. Verify the installation and performance of the systems to be commissioned, including completion of the *construction checklist* and *verification*.

Exception to 10.3.1.2.2(a): Systems that, because their operation is seasonally dependent, cannot be fully commissioned in accordance with the *commissioning plan* at time of occupancy. These systems shall be commissioned at the earliest time after occupancy when operation of systems is allowed to be fully demonstrated as determined by CxA.

b. It shall be verified that the owner requirements for the training of operating personnel and building occupants is completed. Where systems cannot be fully commissioned at the time of occupancy because of seasonal dependence, the training of personnel and building occupants shall be completed when the systems' operation can be fully demonstrated by the CxA.
c. Complete preliminary commissioning report.
d. Verify a system manual has been prepared that includes O&M documentation, full warranty information, and provides operating staff the information needed to understand and operate the commissioned systems as designed.

10.3.1.2.3 Post-Occupancy Activities. Complete the following:

a. Complete any commissioning activities called out in the *commissioning plan* for systems whose commissioning can only be completed subsequent to building occupancy, including trend logging and off-season testing.
b. Verify the *owner* requirements for training operating personnel and building occupants are completed for those systems whose seasonal operational dependence mean they were unable to be fully commissioned prior to building occupancy.
c. Complete a final commissioning report.

10.3.1.2.4 Systems. The following systems, if included in the *building project*, shall be commissioned:

a. Heating, ventilating, air-conditioning, IAQ, and refrigeration systems (mechanical and/or passive) and associated controls. Control sequences to be verified for compliance with construction documentation as part of *verification*.
b. *Building envelope* systems, components, and assemblies to verify the thermal and moisture integrity.
c. *Building envelope* pressurization to confirm air-tightness if included in *BOD* requirements.
d. All lighting controls and shading controls.
e. Irrigation.
f. Plumbing.
g. Domestic and process water pumping and mixing systems.
h. *Service water heating* systems.
i. Renewable energy systems.
j. Water measurement devices, as required in Section 6.3.3.
k. Energy measurement devices, as required in Section 7.3.3.

10.3.1.2.5 Documentation. *Owner* shall retain the System Manual and Final Commissioning Report.

10.3.1.3 Erosion and Sediment Control (ESC). Develop and implement an erosion and sediment control (ESC) plan for all construction activities. The ESC plan shall conform to the erosion and sedimentation control requirements of the most current version of the USEPA NPDES General Permit for Stormwater Discharges From Construction Activities or local erosion and sedimentation control standards and codes, whichever is more stringent and regardless of size of project.

10.3.1.4 Indoor Air Quality (IAQ) Construction Management. Develop and implement an indoor air quality (IAQ) construction management plan to include the following:

a. Air conveyance materials shall be stored and covered so that they remain clean. All filters and controls shall be in place and operational when HVAC systems are operated during building "flush-out" or baseline IAQ monitoring. Except for system startup, testing, balancing, and commissioning, permanent HVAC systems shall not be used during construction.
b. After construction ends, prior to occupancy and with all interior finishes installed, a post-construction, pre-occupancy building flush-out as described under Section 10.3.1.4 (b) 1, or post-construction, pre-occupancy baseline IAQ monitoring as described under Section 10.3.1.4 (b) 2 shall be performed:

    1. Post-Construction, Pre-Occupancy Flush-Out: A total air volume of *outdoor air* in total air changes as defined by Equation 10.3.1.4 shall be supplied while maintaining an internal temperature of a minimum of 60°F (15°C) and relative humidity no higher than 60%. For buildings located in non-attainment areas, filtration and/or air cleaning as described in Section 8.3.1.3 shall be supplied when the Air Quality Index forecast exceeds 100 (category orange, red, purple, or maroon). One of the following options shall be followed:

        (a) Continuous Post-Construction, Pre-Occupancy Flush-Out: The flush-out shall be continuous and the supplied *outdoor air* rate shall be no less than the design minimum.
        (b) Continuous Post-Construction, Pre-Occupancy/ Post-Occupancy Flush-Out: If occupancy is desired prior to completion of the flush-out, the space is allowed to be occupied following delivery of half of the total air changes calculated from Equation 10.3.1.4 to the space. The space shall be ventilated at a minimum rate of

0.30 cfm per ft^2 (1.5 L/s per m^2) of *outdoor air* or the *design outdoor airflow rate* determined in Section 8.3.1.1, whichever is greater. These conditions shall be maintained until the total air changes calculated according to Equation 10.3.1.4 have been delivered to the space. The flush out shall be continuous.

Equation 10.3.1.4:

$$TAC = V_{ot} \times 1/A \times 1/H \times 60 \text{ min/h} \times 24 \text{ h/day} \times 14 \text{ days (I-P)}$$

$$TAC = V_{ot} \times 1 \text{ m}^3/1000 \text{ L} \times 1/A \times 1/H \times 3600 \text{ s/h} \times 24 \text{ h/day} \times 14 \text{ days (SI)}$$

where:

V_{ot} = system design *outdoor air* intake flow cfm (L/s) (according to Equation 6-8 of ANSI/ASHRAE Standard 62.1)

A = floor area ft^2 (m^2)

H = ceiling height, ft (m)

2. Post-Construction, Pre-Occupancy Baseline IAQ Monitoring: Baseline IAQ testing shall be conducted after construction ends and prior to occupancy. The ventilation system shall be operated continuously at the *design outdoor airflow rate* for a minimum of 24 hours prior to IAQ monitoring. Testing shall be done using protocols consistent with the USEPA Compendium of Methods for the Determination of Toxic Organic Pollutants in Ambient Air, TO-1, TO-11, TO-17 and ASTM Standard Method D 5197. The testing shall demonstrate that the contaminant maximum concentrations listed in Table 10.3.1.4 are not exceeded in the return airstreams of the HVAC systems that serve the space intended to be occupied. If the return airstream of the HVAC system serving the space intended to be occupied cannot be separated from other spaces either already occupied or not occupied at all, for each portion of the building served by a separate ventilation system, the testing shall demonstrate that the contaminant maximum concentrations at *breathing zone* listed in Table 10.3.1.4 are not exceeded in the larger of the following number of locations: (a) no less than one location per 25,000 ft^2 (2500 m^2) or (b) in each contiguous floor area. For each sampling point where the maximum concentration limits are exceeded conduct additional flush-out with outside air and retest the specific parameter(s) exceeded to demonstrate the requirements are achieved. Repeat procedure until all requirements have been met. When retesting non-complying building areas, take samples from the same locations as in the first test.

10.3.1.5 Moisture Control. The following items to control moisture shall be implemented during construction:

a. Materials stored onsite or materials installed that are absorptive shall be protected from moisture damage.

b. Building construction materials that show visual evidence of biological growth due to the presence of moisture shall not be installed on the *building project*.

10.3.1.6 Construction Activity Pollution Prevention: No-Idling of Construction Vehicles. Vehicle staging areas shall be established for waiting to load or unload materials. These staging areas shall be located 100 ft (30 m) from any *outdoor air* intakes, operable openings, and hospitals, schools, residences, hotels, daycare facilities, elderly housing, and convalescent facilities.

10.3.2 Plans for Operation. This section specifies the items to be included in plans for operation of a *building project* that falls under the requirements of this standard.

10.3.2.1 High Performance Building Operation Plan. A Master Building Plan for Operation shall be developed that meets the requirements specified in Sections 10.3.2.1.1 through 10.3.2.1.4.

10.3.2.1.1 Site Sustainability. A *site* sustainability portion of the Plan for Operation shall be developed and contain the following provisions. When trees and vegetation are used to comply with the shade requirements of Section 5.3.2.1, 5.4 or 5.5, the Plan for Operation shall include the maintenance procedures needed to maintain healthy vegetation growth. The Plan shall also outline the procedures for replacing any vegetation used to comply with the provisions in Section 5.

10.3.2.1.2 Water Use Efficiency. The Plan for Operation shall specify water use *verification* activities for *building projects* to track and assess building water consumption. The Plan shall describe the procedures needed to comply with the requirements outlined below.

10.3.2.1.2.1 Initial Measurement and Verification. Use the water measurement devices and collection/storage infrastructure specified in Section 6.3.3 to collect and store water use data for each device, starting no later than after building acceptance testing has been completed and certificate of occupancy has been issued.

10.3.2.1.2.2 Track and Assess Water Use. The Plan shall specify the procedures for tracking and assessing the *building project* water use, and the frequency for benchmark comparisons. The initial assessment shall be completed after 12 months but no later than 18 months after a certificate of occupancy has been issued. Ongoing assessments shall be completed at least every three years. The Plan shall include the following:

a. Usage Reports: Develop a Plan for collecting *building project* water use data for water sources and subsystems measured in Section 6.3.3.
b. Benchmark Water Performance: Develop a Plan to enter building operating characteristics and water use data into the ENERGY STAR Portfolio Manager. For building parameter inputs into Portfolio Manager (e.g., number of occupants, hours of operation, etc.), use actual average values.
c. Assess Water Use Performance: Develop a Plan to assess *building project* water use efficiency.

TABLE 10.3.1.4 Maximum Concentration of Air Pollutants Relevant to IAQ

Contaminant	Maximum Concentration, µg/m^3 (Unless Otherwise Noted)
Nonvolatile Organic Compounds	
Carbon monoxide (CO)	9 ppm and no greater than 2 ppm above outdoor levels
Ozone	0.075 ppm (8-hr)
Particulates ($PM_{2.5}$)	35 (24-hr)
Particulates (PM_{10})	150 (24-hr)
Volatile Organic Compounds	
Acetaldehyde	140
Acrylonitrile	5
Benzene	60
1,3-Butadiene	20
t-Butyl methyl ether (Methyl-t-butyl ether)	8000
Carbon disulfide	800
Caprolactam [a]	100
Carbon tetrachloride	40
Chlorobenzene	1000
Chloroform	300
1,4-Dichlorobenzene	800
Dichloromethane (Methylene chloride)	400
1,4-Dioxane	3000
Ethylbenzene	2000
Ethylene glycol	400
Formaldehyde	33
2-Ethylhexanoic acid [a]	25
n-Hexane	7000
1-Methyl-2-pyrrolidinone [a]	160
Naphthalene	9
Nonanal [a]	13
Octanal [a]	7.2
Phenol	200
4-Phenylcyclohexene (4-PCH)[a]	2.5
2-Propanol (Isopropanol)	7000
Styrene	900
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene)	35
Toluene	300
1,1,1-Trichloroethane (Methyl chloroform)	1000
Trichloroethene (Trichloroethylene)	600
Xylene isomers	700
Total Volatile Organic Compounds (TVOC)	_ [b]

a This test is only required if carpets and fabrics with styrene butadiene rubber (SBR) latex backing material are installed as part of the base building systems.

b TVOC reporting shall be in accordance with CA/DHS/EHLB/R-174 and shall be in conjunction with the individual VOCs listed above.

10.3.2.1.2.3 Documentation of Water Use. All documents associated with the measurement and *verification* of the building's water use shall be retained by owner for a minimum of three years.

10.3.2.1.3 Energy Efficiency. The Plan for Operation shall specify energy performance *verification* activities for *building projects* to track and assess building energy performance. The Plan shall describe the procedures needed to comply with the requirements outlined below.

10.3.2.1.3.1 Initial Measurement and Verification. Use the energy measurement devices and collection/storage infrastructure specified in Section 7.3.3 to collect and store energy data for each device, starting no later than after acceptance testing has been completed and certificate of occupancy has been issued.

10.3.2.1.3.2 Track and Assess Energy Consumption. The Plan for Operation shall specify the procedures for tracking and assessing the *building project* energy performance, and the frequency for benchmark comparisons. The initial assessment shall be completed after 12 months but no later than 18 months after a certificate of occupancy has been issued. Ongoing assessments shall be completed at least every three years. The Plan shall include the following:

a. Energy Usage Reports: Develop a Plan for collecting *building project* energy data for energy sources and system energy loads measured in Section 7.3.3. The reports shall include the following, as minimum:

    1. Hourly load profile for each day
    2. Monthly average daily load profile
    3. Monthly and annual energy use
    4. Monthly and annual peak demand

b. Track Energy Performance: Develop a Plan to enter building operating characteristics and energy consumption data into the ENERGY STAR Portfolio Manager for those building types addressed by this program to track building performance. For building parameter inputs into Portfolio Manager (e.g., number of occupants, hours of operation, number of PCs, etc.), use actual average values.
c. Assess Energy Performance: Develop a Plan to assess *building project* energy performance.

10.3.2.1.3.3 Documentation of Energy Efficiency. All documents associated with the measurement and *verification* of the building's energy efficiency shall be retained by owner.

10.3.2.1.4 Indoor Environmental Quality. The Plan for Operation shall include the requirements of Section 8 of ANSI/ASHRAE Standard 62.1 and shall describe the procedures for implementing a regular indoor environmental quality measurement and *verification* program after building occupancy, as outlined below.

10.3.2.1.4.1 Outdoor Airflow Measurement. The Plan for Operation shall document procedures for implementing a regular outdoor airflow monitoring program after building occupancy. The Plan shall include minimum verification frequencies of airflows supplied by mechanical ventilation systems at the system level. Verification shall be performed using hand-held airflow measuring instruments appropriate for such measurements or permanently installed airflow measuring stations. Hand-held airflow measuring instruments or airflow measuring stations used for airflow verifications must be calibrated no more than 6 months prior to such verifications. Naturally ventilated systems shall be exempted from this requirement provided that the design parameters, including but not limited to permanent openings or window opening frequency are not modified.

10.3.2.1.4.2 Outdoor Airflow Verification Procedures. The plan procedures shall contain the following requirements:

a. For each mechanical ventilation system where direct outdoor airflow measurement is required according to Section 8.3.1.2, a procedure shall be in place to react when the outdoor airflow is 15% or more lower than *minimum outdoor airflow rate*. It shall be verified that the device that measures *outdoor air* flow rate is actually measuring the flow rate within ±15% of the sensor output reading at the *minimum outdoor airflow rate*. If the sensor is not within ±15%, it shall be recalibrated. *Verification* of outdoor airflow shall be done on a quarterly basis and records maintained onsite. Direct outdoor airflow measurement devices shall be calibrated at the manufacturer's recommended interval or at least annually.
b. For each mechanical ventilation system where direct outdoor airflow measurement is not required according to Section 8.3.1, a procedure shall be in place to verify outdoor airflow and records maintained onsite and shall be made available upon request.

10.3.2.1.4.3 Outdoor Airflow Scheduling. Ventilation systems shall be operated such that spaces are ventilated when these spaces are expected to be occupied.

10.3.2.1.4.4 Outdoor Airflow Documentation. The following documentation shall be maintained concerning outdoor airflow measurement and *verification*.

a. A list of each air system requiring direct *outdoor air* flow measurement.
b. Monitoring procedures and monitoring frequencies for each monitored sensing device, including a description of the specific response measures to be taken if needed.
c. Ventilation systems shall be operated such that spaces are ventilated when these spaces are expected to be occupied.
d. Operation and calibration check procedures, and the records associated with operation checks and recalibration.

10.3.2.1.4.5 Indoor Air Quality. The Plan for Operation shall document procedures for maintaining and monitoring indoor air quality after building occupancy, and shall contain the following:

a. For buildings located in non-attainments areas for $PM_{2.5}$ as defined by the USEPA, air filtration and/or air cleaning equipment as defined in Section 8.3.1.3(a) shall be operated continuously during occupied hours or when the USEPA Air Quality Index exceeds 100 or equivalent designations by the local authorities for $PM_{2.5}$.

Exception to 10.3.2.1.4.5(a): Spaces without mechanical ventilation.

b. For buildings located in non-attainments areas for ozone as defined by the USEPA, air-cleaning equipment as defined in Section 8.3.1.3(b) shall be operated continuously during occupied hours during the local summer and fall seasons, or when the USEPA Air Quality Index exceeds 100 or equivalent designations by the local authorities for ozone.

Exception to 10.3.2.1.4.5(b): Spaces without mechanical ventilation.

c. Biennial monitoring of Indoor Air Quality by one of the following methods:

    1. Perform IAQ testing as described in Section 10.3.1.4.
    2. Monitoring occupant perceptions of indoor air quality by any method, including but not limited to occupant questionnaires.
    3. Each building shall have an occupant complaint/ response program for IEQ.

10.3.2.1.4.6 Building Green Cleaning Plan. A Green Cleaning Plan shall be developed for the *building project* in compliance with Green Seal Standard, GS-42.

Exception: *Dwelling units* of a *building project.*

10.3.2.1.4.7 Document all measurement and *verification* data.

10.3.2.2 Maintenance Plan. A *Maintenance Plan* shall be developed for mechanical, electrical, plumbing, and fire protection systems, which includes the following:

a. The Plan shall be in accordance with ANSI/ASHRAE/ ACCA Standard 180 for HVAC systems in buildings that meet the definition of commercial buildings in ANSI/ ASHRAE/ACCA Standard 180.
b. The Plan shall address all elements of Section 4 of ANSI/ ASHRAE/ACCA Standard 180 and shall develop required inspection and maintenance tasks similar to Section 5 of ANSI/ASHRAE/ACCA Standard 180 for electrical and plumbing systems in buildings that meet the definition of commercial buildings in ANSI/ASHRAE/ ACCA Standard 180.
c. Documentation of the Plan and of completed maintenance procedures shall be maintained on the building site at all times in:

    1. Electronic format for storage on the building Energy Management System (EMS), Building Management System (BMS), computerized maintenance management system (CMMS) or other computer storage means, or
    2. Maintenance manuals specifically developed and maintained for documenting completed maintenance activities.

10.3.2.3 Service Life Plan. A Service Life Plan that is consistent with the *OPR* shall be developed to estimate to what extent structural, *building envelope* (not mechanical and electrical), and *hardscape* materials will need to be repaired or replaced during the service life of the building. The design service life of the building shall be no less than that determined using Table 10.3.2.3. The estimated service life shall be documented for building assemblies, products, and materials that will need to be inspected, repaired, and/or replaced during the service life of the building. *Site* improvements and *hardscape* shall also be included. Documentation in the Service Life Plan shall include the *building project* design service life and basis for determination, and the following for each assembly or component:

a. Building assembly description
b. Materials or products
c. Design or estimated service life, years
d. Maintenance frequency
e. Maintenance access for components with an estimated service life less than the service life of the building

Provide a Service Life Plan at the completion of design development. The *owner* shall retain a copy of the Service Life Plan for use during the life of building.

10.3.2.4 Transportation Management Plan (TMP). A transportation management plan shall be developed compliant with the following requirements. *Owner* shall retain a copy of the transportation management plan.

TABLE 10.3.2.3 Minimum Design Service Life for Buildings

Category	Minimum Service Life	Building Types
Temporary	Up to 10 years	Non-permanent construction buildings (sales offices, bunkhouses) Temporary exhibition buildings
Medium life	25 years	Industrial buildings Stand-alone parking structures
Long life	50 years	All buildings not temporary or medium life, including the parking structures below buildings designed for long life category

10.3.2.4.1 All Building Projects. The Plan shall include the following:

a. Preferred parking for carpools and vanpools with parking facilities.
b. A plan for bicycle transportation.

10.3.2.4.2 Owner-Occupied Building Projects or Portions of Building Projects. For *owner*-occupied buildings, or for the employees in the *owner*-occupied portions of a building, the building *owner* shall offer at least one of the following primary benefits to the *owner's* employees:

a. Incentivize employees to commute using mass transit, vanpool, carpool, or non-motorized forms of transportation.
b. Initiate a telework or flexible work schedule program that reduces by at least 5% the number of commuting trips by the *owner's* employees.
c. Initiate a ridesharing or carpool matching program, either in-house or through an outside organization.

Exception: Multifamily residential *building project.*

In addition, the *owner* shall provide all of the following to the *owner's* employees:

a. Access to an *emergency ride home* for employees, either provided in-house or by an outside organization.
b. A central point of contact in charge of commuter benefits.
c. Maintenance of commuter benefits in a centralized location.
d. Active promotion of commuter benefits to employees.

10.3.2.4.3 Building Tenant. The building *owner*:

a. shall provide a copy of the Plan to tenants within the building.
b. shall not include parking fees in lease rates or shall identify the value of parking in the lease.

10.4 Prescriptive Option. There are no prescriptive options.

10.5 Performance Option. There are no performance options.

11. NORMATIVE REFERENCES

Section numbers indicate where the reference occurs in this document.

Reference	Title	Section
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 1791 Tullie Circle NE Atlanta, GA 30329 United States 1-404-636-8400; www.ashrae.org		
ANSI/ASHRAE Standard 52.2-2007	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size	8.3.1.3
ANSI/ASHRAE Standard 55-2004, including addendum e	Thermal Comfort Conditions for Human Occupancy	8.3.2, 10.3.1.2.1
ANSI/ASHRAE Standard 62.1-2007	Ventilation for Acceptable Indoor Air Quality	3.2, 10.3.1.4, 10.3.2.1.4, Appendix D
ANSI/ASHRAE/IESNA Standard 90.1-2007, including addendum i	Energy Standard for Buildings Except Low-Rise Residential Buildings	3.1, 3.2, 5.3.3.1, 5.3.3.3, 7.3.1, 7.4.1, 7.4.2, 7.4.3, 7.4.4, 7.4.5, 7.4.6, 7.4.7, 7.4.8, Appendix A, Appendix C, Appendix D
ANSI/ASHRAE Standard 140-2004	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs	Appendix D
ASHRAE Standard 146-2006	Method of Testing and Rating Pool Heaters	Appendix C
ANSI/ASHRAE Standard 169-2006	Weather Data for Building Design Standards	Appendix A
ANSI/ASHRAE/ACCA Standard 180-2008	Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems	3.2, 10.3.2.2
American National Standards Institute (ANSI) 25 West 43rd Street New York, NY 20036 1-212-642-4900; www.ansi.org		
ANSI Z21.10.3-1998	Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 BTU/h, Circulating with Instantaneous Water Heaters	Appendix C
ANSI Z21.47-2001	Gas-Fired Central Furnaces (Except Direct Vent and Separated Combustion System Furnaces)	Appendix C
ANSI Z83.8-2002	Gas Unit Heaters and Duct Furnaces	Appendix C
American Society of Mechanical Engineers (ASME) Three Park Avenue New York, NY 10016-5990 United States 1-800-843-2763 and 1-973-882-1170; www.asme.org		
ASME A112.18.1-2005/CSA B125.1-05	Plumbing Supply Fittings	6.3.2.1
ASME A112.19.2-2008/CSA B45.1-08	Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals	6.3.2.1
ASME A112.19.14-2006	Six-Liter Water Closets Equipped With a Dual Flushing Device	6.3.2.1
ASME A112.19.19-2006	Vitreous China Nonwater Urinals	6.3.2.1

American Society for Testing and Materials International
100 Barr Harbor Dr.
West Conshohocken, PA 19428-2959
United States
1-610-832-9585; www.astm.org

ASTM C518-04	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus	Appendix C
ASTM C1371-04a	Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers	5.3.2.4, Appendix D
ASTM C1549-04	Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer	5.3.2.4, Appendix D
ASTM D1003-07e1	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics	8.3.4.2, 8.4.1.2
ASTM D5197	Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology)	10.3.1..4
ASTM E90-04	Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements	8.3.3.3
ASTM E408-71(2008)	Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques	5.3.2.4, Appendix D
ASTM E413-04	Classification for Rating Sound Insulation	8.3.3.3
ASTM E779-03	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	Appendix B
ASTM E1332-90 (2003)	Standard Classification for the Determination of Outdoor-Indoor Transmission Class	8.3.3.3
ASTM E1677-05	Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls	Appendix B
ASTM E1903-97 (2002)	Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process	3.2
ASTM E1918-06	Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field	5.3.2.4, Appendix D
ASTM E1980-01	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces	5.3.2.4, Appendix D
ASTM E2178-03	Standard Test Method for Air Permeance of Building Materials	Appendix B
ASTM E2357-05	Standard Test Method for Determining Air Leakage of Air Barrier Assemblies	Appendix B
ASTM F2324-03	Standard Test Method for Prerinse Spray Valves	6.4.2.2

Air-Conditioning, Heating, and Refrigeration Institute (AHRI) **2111 Wilson Blvd, Suite 500** **Arlington, VA 22201** **1-703-524-8800; www.ahrinet.org**		
AHRI 210/240-2008	Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment	Appendix C
AHRI 310/380-2004	Standard for Packaged Terminal Air-Conditioners and Heat Pumps	Appendix C
AHRI 340/360-2003	Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment	Appendix C
AHRI 390-2003	Performance Rating of Single Packaged Terminal Air-Conditioners and Heat Pumps	Appendix C
AHRI 550/590-2003	Performance Rating of Water Chilling Packages Using the Vapor Compressions Cycle	Appendix C
AHRI 560-2000	Absorption Water Chilling an Water Heating Packages	Appendix C
AHAM – Association of Home Appliance Manufacturers **1111 19th Street NW, Suite 402** **Washington, DC, 20036** **1-202-872-5955; www.aham.org**		
ANSI/AHAM RAC-1-R2008	Room Air Conditioners	Appendix C
The Business and Institutional Furniture Manufacturer's Association (BIFMA) **678 Front Avenue NW, Suite 150** **Grand Rapids, MI 49504-5368** **E-mail: email@bifma.org** **1-616-285-3963; www.bifma.com**		
ANSI/BIFMA M7.1-2007	Standard Test Method For Determining VOC Emissions From Office Furniture Systems, Components And Seating	8.5.2 and Appendix E
BIFMA X7.1-2007	Standard for Formaldehyde and TVOC Emissions of Low-Emitting Office Furniture Systems and Seating	Appendix E
California Air Resources Board (CARB) **1001 "I" Street** **P.O. Box 2815** **Sacramento, CA 95812** **1-916-322-2990; www.arb.ca.gov/homepage.htm**		
No-Added Formaldehyde Based Resins	Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products. California Code of Regulations, Title 17, Sections 93120-93120.12	8.5.2

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) **International Environment House** **11 Chemin des Anémones** **CH-1219 Châtelaine, Geneva** **Switzerland** **+41-(0)22-917-81-39/40**		
CITES- 1973, amended 1979 and 1983	Convention on International Trade in Endangered Species of Wild Fauna and Flora	9.3.2
California Department of Public Health (CDPH) **Indoor Air Quality Section** **850 Marina Bay Parkway** **Richmond, CA 94804** **1-510-620-2802** **http://www.cdph.ca.gov/programs/IAQ/** **http://www.cal-iaq.org/**		
CA/DHS/EHLB/R-174	Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers	8.4.2.1.1, 8.4.2.2.1, 8.4.2.3, 8.4.2.4, 8.4.2.6, 8.5.2, Table 10.3.1.4, Appendix F
Cooling Tower Technology Institute (CTI) **P.O Box 73383** **Houston, TX 77273** **United States** **1-281-583-4087; www.cti.org**		
CTI ATC-105 (2/2000)	Acceptance Test Code	Appendix C
CTI STD 201 (1/2009)	Standard for the Certification of Water Cooling Tower Thermal Performance	Appendix C
Green-e **c/o Center for Resource Solutions** **1012 Torney Ave., Second Floor** **San Francisco, CA 94129** **1- 415-561-2100; www.green-e.org**		
Version 1.6, Dec 5, 2008	Green-e Energy National Standard for Renewable Electricity Products	7.4.1.2
Green Seal **1001 Connecticut Avenue, NW, Suite 827** **Washington, DC 20036-5525** **United States** **1-202-872-6400; www.greenseal.org**		
GS-11, May 12, 2008	Environmental Standard for Paints and Coatings	8.4.2.2.2
GS-36, October 19, 2000	Standard for Commercial Adhesives	8.4.2.1.2
GS-42, September 1, 2006	Environmental Standard for Cleaning Services	10.3.2.1.4.6
Illuminating Engineering Society of North America, **120 Wall Street, Floor 17** **New York, NY 10005-4001** **1-212-248-5017, www.ies.org**		
TM-15-2007 including addendum “a”	Backlight, Uplight, and Glare (BUG) Ratings	5.3.3.2A

International Association of Plumbing and Mechanical Officials (IAPMO) **5001 East Philadelphia Street** **Ontario, CA 91761** **United States** **1-909-472-4100; www.iapmo.org**		
Z124.9-2004	Plastic Urinal Fixtures	6.3.2.1
International Organization for Standardization (ISO), **ISO Central Secretariat, 1 rue de Varembee, Case postale 56** **CH-1211 Geneva 20** **Switzerland** **+41-22-749-01-11; www.iso.org**		
ISO-13256-1-1998	Water-source heat pumps -- Testing and rating for performance -- Part 1: Water-to-air and brine-to-air heat pumps	Appendix C
ISO 14044 – 2006	Environmental management — Life cycle assessment — Requirements and guidelines	9.5.1, 9.5.1.2
ISO/IEC Guide 59-1994	Code of Good Practice for Standardization	9.4.1.3.1
Irrigation Association (IA) **6540 Arlington Boulevard** **Falls Church, VA 22042-6638** **United States** **1-703-536-7080; www.irrigation.org**		
Smart Water Application Technology (SWAT) Climatological Based Controllers 8th Draft Testing Protocol – November 2006	Smart Water Application Technology (SWAT), Turf and Landscape Irrigation Equipment Climatologically Based Controllers	6.3.1.3
National Electric Manufacturers Association (NEMA) **1300 North 17th Street, Suite 1752** **Rosslyn, VA 22209** **1-703-841-3200; www.nema.org**		
ANSI/NEMA MG-1-2006	Motors and Generators	Appendix C
South Coast Air Quality Management District (SCAQMD) **California Air Resources Board** **1001 "I" Street** **P.O. Box 2815** **Sacramento, CA 95812** **United States** **1-916-322-2990; www.arb.ca.gov**		
SCAQMD Rule 1113- Amended July 13. 2007	Architectural Coatings	8.4.2.2
SCAQMD Rule 1168 - amended January 7, 2005	Adhesive and Sealant Applications	8.4.2.1
Underwriters Laboratories (UL), **2600 N.W. Lake Rd.** **Camas, WA 98607-8542** **United States** **1-877-854-3577; www.ul.com**		
UL 727-2006	Standard for Oil Fired Central Furnaces	Appendix C
UL 731-1995	Standard for Oil-Fired Unit Heaters	Appendix C

United States Congress Washington, DC 20515 1-202-224-3121 http://frwebgate.access.gpo.gov/cgi-bin/get-doc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf http://www.govtrack.us/data/us/bills.text/110/h/h6.pdf		
EPAct 2005 HR6 Public Law 109-58	The Energy Policy Act (EPAct) of 2005	7.4.3.1, 7.4.7.3
EISA 2007 HR6 Public Law 110-140	The Energy Independence and Security Act of 2007	7.4.3, 7.4.7
United States Department of Agriculture (USDA) BioPreferred 2272 Howe Hall, Suite 2620 Ames, Iowa 50011-2272 United States 1-877-251-6522, 1-515-294-5416; www.usda.gov/biobased		
7 CFR Part 2902, March 16, 2006 (Round 1), August 17, 2006 (Rounds 2 and 3), and October 11, 2006 (Round 4)	Designation of Biobased Items for Federal Procurement	9.4.1.3
United States Department of Energy (USDOE) Energy Information Administration Washington, DC 20585 United States 1-202-586-5000; www.eia.doe.gov/emeu/cbecs/contents.html; http://tonto.eia.doe.gov/state		
EIA Average Energy Prices	State and U.S. Historical Data	Appendix D
Title 10 – Energy Chapter II – Department of Energy- Part 430	Energy Conservation Program for Consumer Products	Appendix C
Title 10 – Energy Chapter II – Department of Energy – Part 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment	Appendix C
United States Environmental Protection Agency (USEPA) Ariel Rios Building 1200 Pennsylvania Avenue, N.W. Washington, DC 20460 1-919-541-0800; www.epa.gov ENERGY STAR ® 1-888-782-7937 WaterSense 1-866-987-7367 and 1-202-564-2660		
Clean Air Act of 1970 and as amended in 1990	Clean Air Act	9.5.1.2
Code of Federal Regulations, Title 40 Part 50 (40 CFR 50), as amended July 1, 2004	National Primary and Secondary Ambient Air Quality Standards	8.3.1.3, 9.5.1.2
January 21, 2005	NPDES General Permit for Stormwater Discharges From Construction Activities	10.3.1.3
Version 4.0, July 20, 2007	ENERGY STAR Computer Memorandum of Understanding	7.4.7
Version 1.0 April 1, 2007	ENERGY STAR Copier Memorandum of Understanding	7.4.7
November 16, 2005	ENERGY STAR Program Requirements and Criteria for Room Air Conditioners	7.4.7
Version 4.0, January 1, 2009	ENERGY STAR Program Requirements for ASHPs and Central Air Conditioners	7.4.7
Version 2. 0, April 1, 2002	ENERGY STAR Program Requirements for Boilers	7.4.7
Version 1.1, May 19, 2004	ENERGY STAR Program Requirements for Bottled Water Coolers	7.4.7

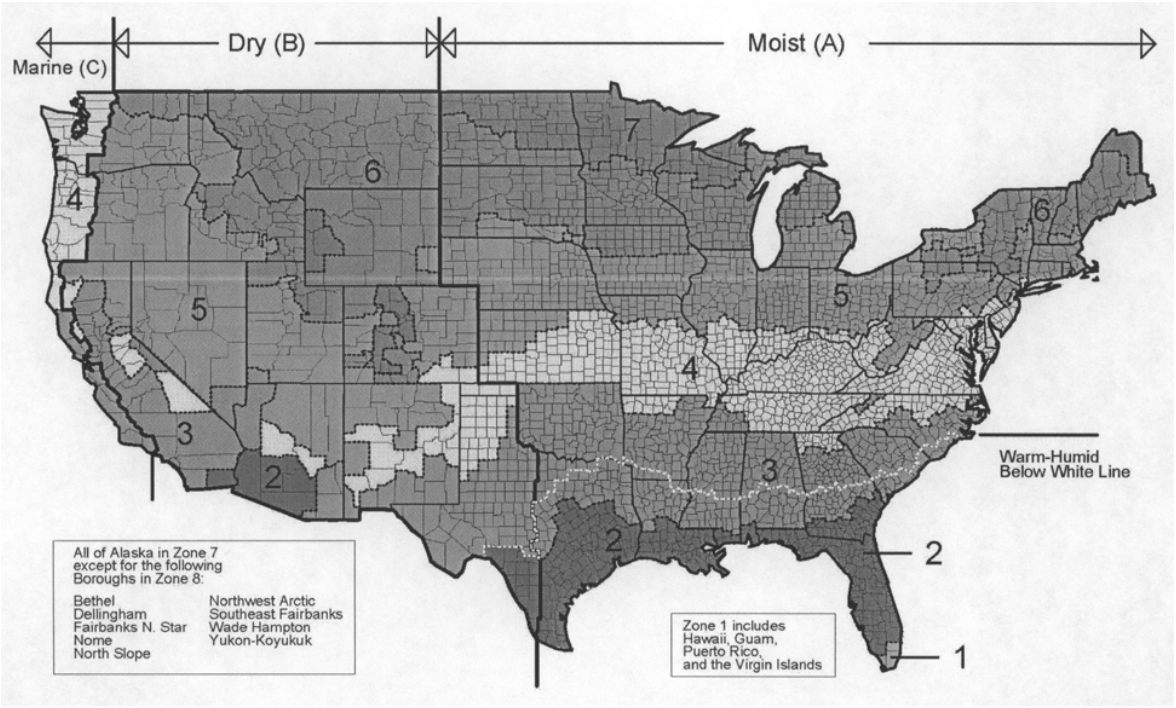
Version 4.0, December 2, 2008	ENERGY STAR Program Requirements for CFLs	7.4.7
Version 1.0, January 1, 2007	ENERGY STAR Program Requirements for Clothes Washers	6.3.2.2, 7.4.7
Version 1.1, October 11, 2007	ENERGY STAR Program Requirements for Commercial Dishwashers	6.4.2.2, 7.4.7
Version 1.0, August 15, 2003	ENERGY STAR Program Requirements for Commercial Fryers	7.4.7
Version 1.0, January 1, 2008	ENERGY STAR Program Requirements for Commercial Ice Machines	6.4.2.2, 7.4.7
Version 1.0, August 1, 2003	ENERGY STAR Program Requirements for Commercial Steam Cookers	7.4.7
Version 4.1, January 1, 2006	ENERGY STAR Program Requirements for Computer Monitors	7.4.7
Version 1.0, January 1, 2003	ENERGY STAR Program Requirements for Consumer Audio and DVD Products	7.4.7
Version 2.0, June 1, 2008	ENERGY STAR Program Requirements for Dehumidifiers	7.4.7
January 1, 2007	ENERGY STAR Program Requirements for Dishwashers	6.3.2.2, 7.4.7
Version 2.0, October 1, 2008	ENERGY STAR Program Requirements for Furnaces	7.4.7
Version 2.0, April 1, 2001	ENERGY STAR Program Requirements for Geothermal Heat Pumps	7.4.7
Version 1.0, August 15, 2003	ENERGY STAR Program Requirements for Hot Food Holding Cabinets	7.4.7
January 1, 2004	ENERGY STAR Program Requirements for Light Commercial HVAC	7.4.7
January 1 2006	ENERGY STAR Program Requirements for Products with Battery Charger Systems (BCSs)	7.4.7
Version 1.2, February 1, 2008	ENERGY STAR Program Requirements for Programmable Thermostats	7.4.7
Version 2.0, July 1, 2007	ENERGY STAR Program Requirements for Refrigerated Beverage Vending Machines	7.4.7
Version 1.0, April 28, 2008	ENERGY STAR Program Requirements for Refrigerators and Freezers	7.4.7
Version 2. 3, January 1, 2009	ENERGY STAR Program Requirements for Residential Ceiling Fans	7.4.7
Final Version, April 1, 2008	ENERGY STAR Program Requirements for Residential Water Heaters	7.4.7
Version 2.0, December 31, 2007	ENERGY STAR Program Requirements for Roof Products	5.3.2.3
Version 1.0, July 1 2004	ENERGY STAR Program Requirements for Room Air Cleaners	7.4.7
Version 2. 1, January 15, 2009	ENERGY STAR Program Requirements for Residential Ventilating Fans	7.4.7
Version 2.0, November 1, 2008	ENERGY STAR Program Requirements for Single-Voltage AC-DC and AC-AC Power Supplies	7.4.7

Version 1.1, September 1, 2001	ENERGY STAR Program Requirements for Solid Door Refrigerators and Freezers	7.4.7
Version 2. 1, November 1, 2008	ENERGY STAR Program Requirements for Telephony	7.4.7
Version 3.0, November 1, 2008	ENERGY STAR Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units	7.4.7
Version 1.0, October 4, 2007	WaterSense Tank-Type High-Efficiency Lavatory Specification	6.3.2.1
Version 1.0, January 24, 2007	WaterSense Tank-Type High-Efficiency Toilet Specification	6.3.2.1
EPA 402-R-93-071, September 1993	U.S. EPA Map of Radon Zones	8.3.5.5
EPA 430-R-07-002, April 2007	Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2005	
United States Environmental Protection Agency (USEPA) Atmospheric Research and Exposure Assessment Laboratory Research Triangle Park, NC 27711 United States 1-919-541-2258; www.epa.gov		
EPA 625/R-96/0106, January 1999	Compendium of Methods for the Determination of Toxic Organic Pollutants in Ambient Air Sections TO-1, TO-11, TO-17	10.3.1.4
World Trade Organization (WTO) Centre William Rappard, Rue de Lausanne 154, CH-1211 Geneva 21, Switzerland 41-22-739-51-11; www.wto.org		
WTO TBT-1994	WTO Technical Barriers to Trade (TBT) Agreement Annex 3 Code of Good Practice for the Preparation, Adoption and Application of Standards	9.4.1.3.1

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX A
PRESCRIPTIVE BUILDING ENVELOPE TABLES

Informative Note: Tables A-1 through A-9 appear twice in this appendix. The nine tables are shown first with I-P units, followed by nine tables with SI units.



For *climate zones*, see Section 5.1.4 of ANSI/ASHRAE/IESNA Standard 90.1 and Normative Appendix B of ANSI/ASHRAE Standard 169.

a. For the United States, the ANSI/ASHRAE Standard 169 *climate zone* map is reproduced above. A list of counties and their respective *climate zones* can be found in Table B1 in ANSI/ASHRAE Standard 169.
b. For Canada, see Table B2 in ANSI/ASHRAE Standard 169.
c. For available international locations (outside the US and Canada), see Table B3 in ANSI/ASHRAE Standard 169.
d. For locations not provided in Table B2 or B3, see Table B4 (reproduced below) in ANSI/ASHRAE Standard 169 for the international *climate zone* definitions.

International Climate Zone Definitions

Climate Zone Number	Name	Thermal Criteria (I-P)	Thermal Criteria (SI)
1	Very Hot – Humid (1A), Dry (1B)	9000 < CDD50°F	5000 < CDD10°C
2	Hot – Humid (2A), Dry (2B)	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤5000
3A, 3B	Warm – Humid (3A), Dry (3B)	4500 < CDD50°F ≤ 6300	2500 < CDD10°C ≤ 3500
3C	Warm – Marine (3C)	CDD50°F ≤ 4500 and HDD65°F ≤ 3600	CDD10°C ≤ 2500 and HDD18°C ≤ 2000
4A, 4B	Mixed – Humid (4A), Dry (4B)	CDD50°F ≤ 4500 and 3600 < HDD65°F ≤ 5400	2500 ≤ CDD10°C and 2000 < HDD18°C ≤ 3000
4C	Mixed – Marine (4C)	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5A, 5B, 5C	Cool– Humid (5A), Dry (5B), Marine (5C)	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤4000
6A, 6B	Cold – Humid (6A), Dry (6B)	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	Very Cold	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	Subarctic	12600 < HDD65°F	7000 < HDD18°C

TABLE A-1 (Supersedes Table 5.5-1 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 1 (A, B) (I-P)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	**Max.**	**Min. R-Value**	**Max.**	**Min. R-Value**	**Max.**	**Min.R-Value**
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 ci	U-0.039	R-25.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.044	R-19.0 + R-11.0 Ls[d]	U-0.035	R-19.0 + R-11.0 Ls	U-0.082	R-19.0
Attic and Other	U-0.027	R-38.0	U-0.021	R-49.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.123	R-7.6 ci	U-0.151[a]	R-5.7 ci[a]
Metal Building	U-0.079	R-13.0 + R-6.5 ci	U-0.079	R-13.0 + R-6.5 ci	U-0.147	R-19.0
Steel Framed	U-0.077	R-13.0 + R-5.0 ci	U-0.077	R-13.0 + R-5.0 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.064	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-3.8 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	R-4.2 ci	U-0.137	R-4.2 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.350	NR
Wood Framed and Other	U-0.051	R-19.0	U-0.051	R-19.0	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.640	R-7.5 for 12 in. + R-5 ci below	F-0.640	R-7.5 for 12 in. + R-5 ci below	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.600		U-0.600		U-0.600	
Non-Swinging	U-0.500		U-0.500		U-0.500	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-1.20	SHGC-0.25 all	U-1.20	SHGC-0.25 all	U-1.20	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-1.20		U-1.20		U-1.20	
Metal framing: entrance door[c]	U-1.20		U-1.20		U-1.20	
Metal framing: all other[c]	U-1.20		U-1.20		U-1.20	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.71	$SHGC_{all}$-0.19	U_{all}-0.71	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.71	$SHGC_{all}$-0.19	U_{all}-0.71	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·°F which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.
[d] Liner system without thermal spacer blocks for this case only.

TABLE A-2 (Supersedes Table 5.5-2 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 2 (A, B) (I-P)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Max.	Min. R-Value	Max.	Min. R-Value	Max.	Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.039	R-25.0 ci	U-0.039	R-25.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.035	R-19.0 + R-11.0 Ls	U-0.035	R-19.0 + R-11.0 Ls	U-0.068	R-13.0 +R- 19.0
Attic and Other	U-0.021	R-49.0	U-0.021	R-49.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.123	R-7.6 ci	U-0.104	R-9.5 ci	U-0.151[a]	R-5.7 ci[a]
Metal Building	U-0.079	R-13.0 + R-6.5 ci	U-0.052	R-13.0 + R-13.0 ci	U-0.147	R-19.0
Steel Framed	U-0.077	R-13.0 + R-5.0 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.084	R-13.0 + R-3.8 ci
Wood Framed and Other	U-0.064	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-3.8 ci
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0
Wood Framed and Other	U-0.033	R-30.0	U-0.026	R-30.0 + R-7.5 ci	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.640	R-7.5 for 12 in. + R-5 ci below	F-0.640	R-7.5 for 12 in. + R-5 ci below	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.600		U-0.600		U-0.600	
Non-Swinging	U-0.500		U-0.400		U-0.500	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	Max. U	Max. SHGC	Max. U	Max. SHGC	Max. U	Max. SHGC
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-0.75	SHGC-0.25 all	U-0.75	SHGC-0.25 all	U-1.20	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-0.70		U-0.70		U-1.20	
Metal framing: entrance door[c]	U-1.10		U-1.10		U-1.20	
Metal framing: all other[c]	U-0.75		U-0.75		U-1.20	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.71	$SHGC_{all}$-0.19	U_{all}-0.71	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.71	$SHGC_{all}$-0.19	U_{all}-0.71	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.12	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-0.57	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·ºF which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-3 (Supersedes Table 5.5-3 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 3 (A, B, C) (I-P)

	Nonresidential		Residential		Semiheated	
Opaque Elements	Assembly Max.	Insulation Min. R-Value	Assembly Max.	Insulation Min. R-Value	Assembly Max.	Insulation Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.039	R-25.0 ci	U-0.039	R-25.0 ci	U-0.119	R-7.6 ci
Metal Building	U-0.035	R-19.0 + R-11.0 Ls	U-0.035	R-19.0 + R-11.0 Ls	U-0.068	R-13.0 + R- 19.0
Attic and Other	U-0.021	R-49.0	U-0.021	R-49.0	U-0.034	R-30.0
Walls, Above Grade						
Mass	U-0.104	R-9.5 ci	U-0.090	R-11.4 ci	U-0.151[a]	R-5.7 ci[a]
Metal Building	U-0.079	R-13.0 + R-6.5 ci	U-0.052	R-13.0 + R-13.0 ci	U-0.079	R-13.0 + R-6.5 ci
Steel Framed	U-0.077	R-13.0 + R-5.0 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.084	R-13.0 + R-3.8 ci
Wood Framed and Other	U-0.064	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-3.8 ci
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.332	NR
Steel Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0
Wood Framed and Other	U-0.033	R-30.0	U-0.026	R-30.0 + R-7.5 ci	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.640	R-7.5 for 12 in. + R-5 ci below	F-0.640	R-7.5 for 12 in. + R-5 ci below	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.600		U-0.600		U-0.600	
Non-Swinging	U-0.500		U-0.400		U-0.500	

Fenestration	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-0.45	SHGC-0.25 all	U-0.45	SHGC-0.25 all	U-0.55	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-0.50		U-0.50		U-0.60	
Metal framing: entrance door[c]	U-0.80		U-0.80		U-0.80	
Metal framing: all other[c]	U-0.55		U-0.55		U-0.65	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-0.69	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-0.69	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-0.69	$SHGC_{all}$-0.27	U_{all}-0.69	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.69	$SHGC_{all}$-0.27	U_{all}-0.69	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.45	$SHGC_{all}$-0.19	U_{all}-0.45	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.45	$SHGC_{all}$-0.19	U_{all}-0.45	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·ºF which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-4 (Supersedes Table 5.5-4 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 4 (A, B, C) (I-P)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Max.	Min. R-Value	Max.	Min. R-Value	Max.	Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.039	R-25.0 ci	U-0.039	R-25.0 ci	U-0.119	R-7.6 ci
Metal Building	U-0.035	R-19.0 + R-11.0 Ls	U-0.035	R-19.0 + R-11.0 Ls	U-0.068	R-13.0 +R- 19.0
Attic and Other	U-0.021	R-49.0	U-0.021	R-49.0	U-0.034	R-30.0
Walls, Above Grade						
Mass	U-0.090	R-11.4 ci	U-0.080	R-13.3 ci	U-0.151[a]	R-5.7 ci[a]
Metal Building	U-0.052	R-13.0 + R-13.0 ci	U-0.052	R-13.0 + R-13.0 ci	U-0.079	R-13.0 + R-6.5 ci
Steel Framed	U-0.055	R-13.0 + R-10.0 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.084	R-13.0 + R-3.8 ci
Wood Framed and Other	U-0.064	R-13.0 + R-3.8 ci	U-0.051	R-13.0 + R-7.5 ci	U-0.064	R-13.0 + R-3.8 ci
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.092	R-10.0 ci	C-0.119	R-7.5 ci
Floors						
Mass	U-0.074	R-10.4 ci	U-0.064	R-12.5 ci	U-0.107	R-6.3 ci
Steel Joist	U-0.032	R-38.0	U-0.032	R-38.0	U-0.052	R-19.0
Wood Framed and Other	U-0.026	R-30.0 + R-7.5 ci	U-0.026	R-30.0 + R-7.5 ci	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.540	R-10 for 24 in.	F-0.520	R-15 for 24 in.	F-0.540	R-10 for 24 in.
Heated	F-0.550	R-10.0 for 24 in. + R-5 ci below	F-0.550	R-10.0 for 24 in. + R-5 ci below	F-0.950	R-7.5 for 24 in.
Opaque Doors						
Swinging	U-0.600		U-0.600		U-0.600	
Non-Swinging	U-0.400		U-0.400		U-0.500	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	Max. U	Max. SHGC	Max. U	Max. SHGC	Max. U	Max. SHGC
Vertical Fenestration,0-40% of Wall						
Nonmetal framing: all[b]	U-0.30	SHGC-0.35 all	U-0.30	SHGC-0.40 all	U-0.55	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-0.40		U-0.40		U-0.60	
Metal framing: entrance door[c]	U-0.75		U-0.75		U-0.80	
Metal framing: all other[c]	U-0.45		U-0.45		U-0.65	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.69	$SHGC_{all}$-0.32	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.69	$SHGC_{all}$-0.32	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-0.69	$SHGC_{all}$-0.34	U_{all}-0.69	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.69	$SHGC_{all}$-0.34	U_{all}-0.69	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.45	$SHGC_{all}$-0.32	U_{all}-0.45	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.45	$SHGC_{all}$-0.32	U_{all}-0.45	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·ºF which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-5 (Supersedes Table 5.5-5 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 5 (A, B, C) (I-P)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Max.	Min. R-Value	Max.	Min. R-Value	Max.	Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.039	R-25.0 ci	U-0.039	R-25.0 ci	U-0.093	R-10.0 ci
Metal Building	U-0.035	R-19.0 + R-11.0 Ls	U-0.035	R-19.0 + R-11.0 Ls	U-0.068	R-13.0 +R- 19.0
Attic and Other	U-0.021	R-49.0	U-0.021	R-49.0	U-0.034	R-30.0
Walls, Above Grade						
Mass	U-0.080	R-13.3 ci	U-0.071	R-15.2 ci	U-0.123	R-7.6 ci
Metal Building	U-0.052	R-13.0 + R-13.0 ci	U-0.052	R-13.0 + R-13.0 ci	U-0.079	R-13.0 + R-6.5 ci
Steel Framed	U-0.055	R-13.0 + R-10.0 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.084	R-13.0 + R-3.8 ci
Wood Framed and Other	U-0.051	R-13.0 + R-7.5 ci	U-0.045	R-13.0 + R-10.0 ci	U-0.064	R-13.0 + R-3.8 ci
Wall, Below Grade						
Below Grade Wall	C-0.092	R-10.0 ci	C-0.092	R-10.0 ci	C-0.119	R-7.5 ci
Floors						
Mass	U-0.064	R-12.5 ci	U-0.057	R-14.6 ci	U-0.107	R-6.3 ci
Steel Joist	U-0.032	R-38.0	U-0.032	R-38.0	U-0.038	R-30.0
Wood Framed and Other	U-0.026	R-30.0 + R-7.5 ci	U-0.026	R-30.0 + R-7.5 ci	U-0.033	R-30.0
Slab-On-Grade Floors						
Unheated	F-0.540	R-10 for 24 in.	F-0.520	R-15 for 24 in.	F-0.540	R-10 for 24 in.
Heated	F-0.440	R-15.0 for 36 in. + R-5 ci below	F-0.440	R-15.0 for 36 in. + R-5 ci below	F-0.900	R-10 for 24 in.
Opaque Doors						
Swinging	U-0.400		U-0.400		U-0.600	
Non-Swinging	U-0.400		U-0.400		U-0.500	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	Max. U	Max. SHGC	Max. U	Max. SHGC	Max. U	Max. SHGC
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-0.25	SHGC-0.35 all	U-0.25	SHGC-0.40 all	U-0.55	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-0.35		U-0.35		U-0.60	
Metal framing: entrance door[c]	U-0.70		U-0.70		U-0.80	
Metal framing: all other[c]	U-0.45		U-0.45		U-0.65	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.67	$SHGC_{all}$-0.36	U_{all}-0.67	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.67	$SHGC_{all}$-0.36	U_{all}-0.67	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2% 0%	U_{all}-0.69	$SHGC_{all}$-0.34	U_{all}-0.69	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.69	$SHGC_{all}$-0.34	U_{all}-0.69	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.45	$SHGC_{all}$-0.36	U_{all}-0.45	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.45	$SHGC_{all}$-0.36	U_{all}-0.45	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·ºF which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-6 (Supersedes Table 5.5-6 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 6 (A, B) (I-P)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	**Max.**	**Min. R-Value**	**Max.**	**Min. R-Value**	**Max.**	**Min.R-Value**
Roofs						
Insulation Entirely above Deck	U-0.032	R-30.0 ci	U-0.032	R-30.0 ci	U-0.063	R-15.0 ci
Metal Building	U-0.031	R-25.0 + R-11.0 Ls	U-0.031	R-25.0 + R-11.0 Ls	U-0.068	R-13.0 +R- 19.0
Attic and Other	U-0.021	R-49.0	U-0.021	R-49.0	U-0.027	R-38.0
Walls, Above Grade						
Mass	U-0.071	R-15.2 ci	U-0.060	R-20.0 ci	U-0.104	R-9.5 ci
Metal Building	U-0.052	R-13.0 + R-13.0 ci	U-0.052	R-13.0 + R-13.0 ci	U-0.079	R-13.0 + R-6.5 ci
Steel Framed	U-0.055	R-13.0 + R-10.0 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.084	R-13.0 + R-3.8 ci
Wood Framed and Other	U-0.045	R-13.0 + R-10.0 ci	U-0.045	R-13.0 + R-10.0 ci	U-0.064	R-13.0 + R-3.8 ci
Wall, Below Grade						
Below Grade Wall	C-0.092	R-10.0 ci	C-0.092	R-10.0 ci	C-0.119	R-7.5 ci
Floors						
Mass	U-0.057	R-14.6 ci	U-0.051	R-16.7 ci	U-0.107	R-6.3 ci
Steel Joist	U-0.032	R-38.0	U-0.023	R-38.0 + R-12.5 ci	U-0.038	R-30.0
Wood Framed and Other	U-0.026	R-30.0 + R-7.5 ci	U-0.026	R-30.0 + R-7.5 ci	U-0.033	R-30.0
Slab-On-Grade Floors						
Unheated	F-0.520	R-15 for 24 in.	F-0.510	R-20 for 24 in.	F-0.540	R-10 for 24 in.
Heated	F-0.440	R-15.0 for 36 in. + R-5 ci below	F-0.440	R-15.0 for 36 in. + R-5 ci below	F-0.900	R-10 for 24 in.
Opaque Doors						
Swinging	U-0.400		U-0.400		U-0.600	
Non-Swinging	U-0.400		U-0.400		U-0.500	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-0.25	SHGC-0.40 all	U-0.25	SHGC-0.40 all	U-0.45	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-0.35		U-0.35		U-0.50	
Metal framing: entrance door[c]	U-0.70		U-0.70		U-0.80	
Metal framing: all other[c]	U-0.45		U-0.45		U-0.55	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.90	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.45	$SHGC_{all}$-0.46	U_{all}-0.45	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.45	$SHGC_{all}$-0.46	U_{all}-0.45	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·°F which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-7 (Supersedes Table 5.5-7 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 7 (I-P)

	Nonresidential		Residential		Semiheated	
	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Opaque Elements	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Roofs						
Insulation Entirely above Deck	U-0.028	R-35.0 ci	U-0.028	R-35.0 ci	U-0.063	R-15.0 ci
Metal Building	U-0.029	R-30.0 + R-11.0 Ls	U-0.029	R-30.0 + R-11.0 Ls	U-0.068	R-13.0 + R-19.0
Attic and Other	U-0.017	R-60.0	U-0.017	R-60.0	U-0.027	R-38.0
Walls, Above Grade						
Mass	U-0.060	R-20.0 ci	U-0.060	R-20.0 ci	U-0.090	R-11.4 ci
Metal Building	U-0.052	R-13.0 + R-13.0 ci	U-0.039	R-13.0 + R-19.5 ci	U-0.079	R-13.0 + R-6.5 ci
Steel Framed	U-0.055	R-13.0 + R-10.0 ci	U-0.037	R-13.0 + R-18.8 ci	U-0.084	R-13.0 + R-3.8 ci
Wood Framed and Other	U-0.045	R-13.0 + R-10.0 ci	U-0.045	R-13.0 + R-10.0 ci	U-0.064	R-13.0 + R-3.8 ci
Wall, Below Grade						
Below Grade Wall	C-0.092	R-10.0 ci	C-0.075	R-12.5 ci	C-0.119	R-7.5 ci
Floors						
Mass	U-0.043	R-20.0 ci	U-0.043	R-20.0 ci	U-0.087	R-8.3 ci
Steel Joist	U-0.032	R-38.0	U-0.023	R-38.0 + R-12.5 ci	U-0.038	R-30.0
Wood Framed and Other	U-0.026	R-30.0 + R-7.5 ci	U-0.026	R-30.0 + R-7.5 ci	U-0.033	R-30.0
Slab-On-Grade Floors						
Unheated	F-0.300	R-15 for 24 in. + R-5 ci below	F-0.300	R-15 for 24 in. + R-5 ci below	F-0.540	R-10 for 24 in.
Heated	F-0.373	R-20.0 for 36 in. + R-5 ci below	F-0.373	R-20.0 for 36 in. + R-5 ci below	F-0.688	R-20 for 48 in.
Opaque Doors						
Swinging	U-0.400		U-0.400		U-0.600	
Non-Swinging	U-0.400		U-0.400		U-0.500	

	Assembly	Assembly Max.	Assembly	Assembly Max.	Assembly	Assembly Max.
Fenestration	**Max. U**	**SHGC**	**Max. U**	**SHGC**	**Max. U**	**SHGC**
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-0.25	SHGC-0.45 all	U-0.25	SHGC-NR all	U-0.45	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-0.30		U-0.30		U-0.50	
Metal framing: entrance door[c]	U-0.70		U-0.70		U-0.80	
Metal framing: all other[c]	U-0.35		U-0.35		U-0.55	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-0.67	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-0.69	$SHGC_{all}$-0.50	U_{all}-0.69	$SHGC_{all}$-0.50	U_{all}-1.90	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.69	$SHGC_{all}$-0.50	U_{all}-0.69	$SHGC_{all}$-0.50	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.45	$SHGC_{all}$-0.46	U_{all}-0.45	$SHGC_{all}$-0.46	U_{all}-1.36	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.45	$SHGC_{all}$-0.46	U_{all}-0.45	$SHGC_{all}$-0.46	U_{all}-1.36	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·°F which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-8 (Supersedes Table 5.5-8 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 8 (I-P)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	**Max.**	**Min. R-Value**	**Max.**	**Min. R-Value**	**Max.**	**Min.R-Value**
Roofs						
Insulation Entirely above Deck	U-0.028	R-35.0 ci	U-0.028	R-35.0 ci	U-0.048	R-20.0 ci
Metal Building	U-0.029	R-30.0 + R11.0 Ls	U-0.029	R-30.0 + R11.0 Ls	U-0.044	R-19.0 + R11.0 Ls[d]
Attic and Other	U-0.017	R-60.0	U-0.017	R-60.0	U-0.027	R-38.0
Walls, Above Grade						
Mass	U-0.060	R-20.0 ci	U-0.043	R-31.3 ci	U-0.080	R-13.3 ci
Metal Building	U-0.052	R-13.0 + R-13.0 ci	U-0.031	R-13.0 + R-26 ci	U-0.052	R-13.0 + R-13 ci
Steel Framed	U-0.055	R-13.0 + R-10.0 ci	U-0.033	R-13.0 + R-21.9 ci	U-0.064	R-13.0 + R-7.5 ci
Wood Framed and Other	U-0.045	R-13.0 + R-10.0 ci	U-0.032	R-13.0 + R-18.8 ci	U-0.064	R-13.0 + R-3.8 ci
Wall, Below Grade						
Below Grade Wall	C-0.092	R-10.0 ci	C-0.063	R-15.0 ci	C-0.119	R-7.5 ci
Floors						
Mass	U-0.043	R-20.0 ci	U-0.043	R-20.0 ci	U-0.064	R-12.5 ci
Steel Joist	U-0.023	R-38.0 + R-12.5 ci	U-0.023	R-38.0 + R-12.5 ci	U-0.038	R-30.0
Wood Framed and Other	U-0.026	R-30.0 + R-7.5 ci	U-0.026	R-30.0 + R-7.5 ci	U-0.026	R-30.0 + R-7.5 ci
Slab-On-Grade Floors						
Unheated	F-0.300	R-15 for 24 in. + R-5 ci below	F-0.300	R-15 for 24 in. + R-5 ci below	F-0.540	R-10 for 24 in.
Heated	F-0.373	R-20.0 for 36 in. + R-5 ci below	F-0.373	R-20.0 for 36 in. + R-5 ci below	F-0.688	R-20 for 48 in.
Opaque Doors						
Swinging	U-0.400		U-0.400		U-0.400	
Non-Swinging	U-0.400		U-0.400		U-0.400	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b] Metal fr: curtainwall/storefront[c] Metal framing: entrance door[c] Metal framing: all other[c]	U-0.25 U-0.30 U-0.70 U-0.35	SHGC-0.45 all	U-0.25 U-0.30 U-0.70 U-0.35	SHGC-NR all	U-0.45 U-0.50 U-0.80 U-0.55	SHGC-NR all
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-0.45	$SHGC_{all}$-NR	U_{all}-0.45	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-0.45	$SHGC_{all}$-NR	U_{all}-0.45	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 12 Btu/ft^2·ºF which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.
[d] Liner system without thermal spacer blocks for this case only.

TABLE A-9 (Supersedes Table A2.4.2 in ANSI/ASHRAE/IESNA Standard 90.1)
Single-Rafter Roof Requirements (I-P)

Climate Zone	Minimum Insulation R-Value or Maximum Assembly U-Factor		
	Nonresidential	Residential	Semiheated
1	R-38 U-0.029	R-38 + R10 ci U-0.022	R-19 U-0.055
2	R-38 + R10 ci U-0.022	R-38 + R10 ci U-0.022	R-19 U-0.055
3, 4, 5	R-38 + R10 ci U-0.022	R-38 + R10 ci U-0.022	R-30 U-0.036
6	R-38 + R10 ci U-0.022	R-38 + R10 ci U-0.022	R-38 U-0.029
7, 8	R-38 + R15 ci U-0.020	R-38 + R15 ci U-0.020	R-38 U-0.029

TABLE A-1 (Supersedes Table 5.5-1 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 1 (A, B) (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	**Max.**	**Min. R-Value**	**Max.**	**Min. R-Value**	**Max.**	**Min.R-Value**
Roofs						
Insulation Entirely above Deck	U-0.27	R-3.5 ci	U-0.22	R-4.4 ci	U-0.98	R-0.9 ci
Metal Building	U-0.25	R-3.3 +R-1.9 Ls[d]	U-0.20	R-3.3 + R-1.9 Ls	U-0.47	R-3.3
Attic and Other	U-0.15	R-6.7	U-0.12	R-8.6	U-0.30	R-3.3
Walls, Above Grade						
Mass	U-0.86 [a]	R-1.0 ci [a]	U-0.70	R-1.3 ci	U-0.86 [a]	R-1.0 ci [a]
Metal Building	U-0.45	R-2.3 + R-1.1 ci	U-0.45	R-2.3 + R-1.1 ci	U-0.84	R-3.3
Steel Framed	U-0.43	R-2.3 + R-0.9 ci	U-0.43	R-2.3 + R-0.9 ci	U-0.71	R-2.3
Wood Framed and Other	U-0.36	R-2.3 + R-0.7 ci	U-0.36	R-2.3 + R-0.7 ci	U-0.50	R-2.3
Wall, Below Grade						
Below Grade Wall	C-6.47	NR	C-6.47	NR	C-6.47	NR
Floors						
Mass	U-0.78	R-0.7 ci	U-0.78	R-0.7 ci	U-1.83	NR
Steel Joist	U-0.30	R-3.3	U-0.30	R-3.3	U-1.99	NR
Wood Framed and Other	U-0.29	R-3.3	U-0.29	R-3.3	U-1.60	NR
Slab-On-Grade Floors						
Unheated	F-1.26	NR	F-1.26	NR	F-1.26	NR
Heated	F-1.11	R-1.3 for 300 mm + R-0.9 ci below	F-1.11	R-1.3 for 300 mm + R-0.9 ci below	F-1.77	R-1.3 for 300mm
Opaque Doors						
Swinging	U-3.41		U-3.41		U-3.41	
Non-Swinging	U-2.84		U-2.84		U-2.84	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Vertical Fenestration,0-40% of Wall						
Nonmetal framing: all[b]	U-6.81	SHGC-0.25 all	U-6.81	SHGC-0.25 all	U-6.81	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-6.81		U-6.81		U-6.81	
Metal framing: entrance door[c]	U-6.81		U-6.81		U-6.81	
Metal framing: all other[c]	U-6.81		U-6.81		U-6.81	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-4.03	$SHGC_{all}$-0.19	U_{all}-4.03	$SHGC_{all}$-0.16	U_{all}-11.24	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-4.03	$SHGC_{all}$-0.19	U_{all}-4.03	$SHGC_{all}$-0.16	U_{all}-11.24	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement
[a] Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.
[d] Liner system without thermal spacer blocks for this case only.

TABLE A-2 (Supersedes Table 5.5-2 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 2 (A, B) (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	**Max.**	**Min. R-Value**	**Max.**	**Min. R-Value**	**Max.**	**Min.R-Value**
Roofs						
Insulation Entirely above Deck	U-0.22	R-4.4 ci	U-0.22	R-4.4 ci	U-0.98	R-0.9 ci
Metal Building	U-0.20	R-3.3 + R-1.9 Ls	U-0.20	R-3.3 + R-1.9 Ls	U-0.39	R-2.3 + R-3.3
Attic and Other	U-0.12	R-8.6	U-0.12	R-8.6	U-0.30	R-3.3
Walls, Above Grade						
Mass	U-0.70	R-1.3 ci	U-0.59	R-1.7 ci	U-0.86 [a]	R-1.0 ci [a]
Metal Building	U-0.45	R-2.3 + R-1.1 ci	U-0.30	R-2.3 + R-2.3 ci	U-0.84	R-3.3
Steel Framed	U-0.43	R-2.3 + R-0.9 ci	U-0.31	R-2.3 + R-1.8 ci	U-0.48	R-2.3 + R-0.7 ci
Wood Framed and Other	U-0.36	R-2.3 + R-0.7 ci	U-0.36	R-2.3 + R-0.7 ci	U-0.36	R-2.3 + R-0.7 ci
Wall, Below Grade						
Below Grade Wall	C-6.47	NR	C-6.47	NR	C-6.47	NR
Floors						
Mass	U-0.61	R-1.1 ci	U-0.50	R-1.5	U-1.83	NR
Steel Joist	U-0.21	R-5.3	U-0.21	R-5.3	U-0.30	R-3.3
Wood Framed and Other	U-0.19	R-5.3	U-0.15	R-5.3 + R-1.3 ci	U-0.29	R-3.3
Slab-On-Grade Floors						
Unheated	F-1.26	NR	F-1.26	NR	F-1.26	NR
Heated	F-1.11	R-1.3 for 300 mm + R-0.9 ci below	F-1.11	R-1.3 for 300 mm + R-0.9 ci below	F-1.77	R-1.3 for 300mm
Opaque Doors						
Swinging	U-3.41		U-3.41		U-3.41	
Non-Swinging	U-2.84		U-2.27		U-2.84	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Vertical Fenestration, 0% 40% of Wall						
Nonmetal framing: all[b]	U-4.26	SHGC-0.25 all	U-4.26	SHGC-0.25 all	U-6.81	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-3.97		U-3.97		U-6.81	
Metal framing: entrance door[c]	U-6.25		U-6.25		U-6.81	
Metal framing: all other[c]	U-4.26		U-4.26		U-6.81	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-4.03	$SHGC_{all}$-0.19	U_{all}-4.03	$SHGC_{all}$-0.16	U_{all}-11.24	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-4.03	$SHGC_{all}$-0.19	U_{all}-4.03	$SHGC_{all}$-0.16	U_{all}-11.24	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-6.36	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-3.24	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement
a Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-3 (Supersedes Table 5.5-3 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 3 (A, B, C) (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Max.	Min. R-Value	Max.	Min. R-Value	Max.	Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.22	R-4.4 ci	U-0.22	R-4.4 ci	U-0.68	R-1.3 ci
Metal Building	U-0.20	R-3.3 + R-1.9 Ls	U-0.20	R-3.3 + R-1.9 Ls	U-0.39	R-2.3 + R-3.3
Attic and Other	U-0.12	R-8.6	U-0.12	R-8.6	U-0.19	R-5.3
Walls, Above Grade						
Mass	U-0.59	R-1.7 ci	U-0.51	R-2.0 ci	U-0.86 [a]	R-1.0 ci [a]
Metal Building	U-0.45	R-2.3 + R-1.1 ci	U-0.30	R-2.3 + R-2.3 ci	U-0.45	R-2.3 + R-1.1 ci
Steel Framed	U-0.43	R-2.3 + R-0.9 ci	U-0.31	R-2.3 + R-1.8 ci	U-0.48	R-2.3 + R-0.7 ci
Wood Framed and Other	U-0.36	R-2.3 + R-0.7 ci	U-0.36	R-2.3 + R-0.7 ci	U-0.36	R-2.3 + R-0.7 ci
Wall, Below Grade						
Below Grade Wall	C-6.47	NR	C-6.47	NR	C-6.47	NR
Floors						
Mass	U-0.61	R-1.1 ci	U-0.50	R-1.5 ci	U-1.83	NR
Steel Joist	U-0.21	R-5.3	U-0.21	R-5.3	U-0.30	R-3.3
Wood Framed and Other	U-0.19	R-5.3	U-0.15	R-5.3 + R-1.3 ci	U-0.29	R-3.3
Slab-On-Grade Floors						
Unheated	F-1.26	NR	F-1.26	NR	F-1.26	NR
Heated	F-1.11	R-1.3 for 300 mm + R-0.9 ci below	F-1.11	R-1.3 for 300 mm + R-0.9 ci below	F-1.77	R-1.3 for 300mm
Opaque Doors						
Swinging	U-3.41		U-3.41		U-3.41	
Non-Swinging	U-2.84		U-2.27		U-2.84	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	Max. U	Max. SHGC	Max. U	Max. SHGC	Max. U	Max. SHGC
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-2.56	SHGC-0.25 all	U-2.56	SHGC-0.25 all	U-3.12	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-2.84		U-2.84		U-3.41	
Metal framing: entrance door[c]	U-4.54		U-4.54		U-4.54	
Metal framing: all other[c]	U-3.12		U-3.12		U-3.69	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-3.92	$SHGC_{all}$-0.19	U_{all}-3.92	$SHGC_{all}$-0.16	U_{all}-11.24	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.92	$SHGC_{all}$-0.19	U_{all}-3.92	$SHGC_{all}$-0.16	U_{all}-11.24	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-3.92	$SHGC_{all}$-0.27	U_{all}-3.92	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.92	$SHGC_{all}$-0.27	U_{all}-3.92	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-2.56	$SHGC_{all}$-0.19	U_{all}-2.56	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-2.56	$SHGC_{all}$-0.19	U_{all}-2.56	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement
[a] Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-4 (Supersedes Table 5.5-4 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 4 (A, B, C) (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	**Max.**	**Min. R-Value**	**Max.**	**Min. R-Value**	**Max.**	**Min.R-Value**
Roofs						
Insulation Entirely above Deck	U-0.22	R-4.4 ci	U-0.22	R-4.4 ci	U-0.68	R-1.3 ci
Metal Building	U-0.20	R-3.3 + R-1.9 Ls	U-0.20	R-3.3 + R-1.9 Ls	U-0.39	R-2.3 + R-3.3
Attic and Other	U-0.12	R-8.6	U-0.12	R-8.6	U-0.19	R-5.3
Walls, Above Grade						
Mass	U-0.51	R-2.0 ci	U-0.45	R-2.3 ci	U-0.86 [a]	R-1.0 ci [a]
Metal Building	U-0.30	R-2.3 + R-2.3 ci	U-0.30	R-2.3 + R-2.3 ci	U-0.45	R-2.3 + R-1.1 ci
Steel Framed	U-0.31	R-2.3 + R-1.8 ci	U-0.31	R-2.3 + R-1.8 ci	U-0.48	R-2.3 + R-0.7 ci
Wood Framed and Other	U-0.36	R-2.3 + R-0.7 ci	U-0.29	R-2.3 + R-1.3 ci	U-0.36	R-2.3 + R-0.7 ci
Wall, Below Grade						
Below Grade Wall	C-0.68	R-1.3 ci	C-0.52	R-1.8 ci	C-0.68	R-1.3 ci
Floors						
Mass	U-0.42	R-1.8 ci	U-0.36	R-2.2 ci	U-0.61	R-1.1 ci
Steel Joist	U-0.18	R-6.7	U-0.18	R-6.7	U-0.30	R-3.3
Wood Framed and Other	U-0.15	R-5.3 + R-1.3 ci	U-0.15	R-5.3 + R-1.3 ci	U-0.29	R-3.3
Slab-On-Grade Floors						
Unheated	F-0.93	R-1.8 for 600 mm	F-0.90	R-2.6 for 600 mm	F-0.93	R-1.8 for 600 mm
Heated	F-0.95	R-1.8 for 600 mm + R-0.9 ci below	F-0.95	R-1.8 for 600 mm + R-0.9 ci below	F-1.64	R-1.3 for 600 mm
Opaque Doors						
Swinging	U-3.41		U-3.41		U-3.41	
Non-Swinging	U-2.27		U-2.27		U-2.84	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all [b]	U-1.70	SHGC-0.35 all	U-1.70	SHGC-0.40 all	U-3.12	SHGC-NR all
Metal fr: curtainwall/storefront [c]	U-2.27		U-2.27		U-3.41	
Metal framing: entrance door [c]	U-4.26		U-4.26		U-4.54	
Metal framing: all other [c]	U-2.56		U-2.56		U-3.69	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-3.92	$SHGC_{all}$-0.32	U_{all}-3.92	$SHGC_{all}$-0.19	U_{all}-11.24	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.92	$SHGC_{all}$-0.32	U_{all}-3.92	$SHGC_{all}$-0.19	U_{all}-11.24	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-3.92	$SHGC_{all}$-0.34	U_{all}-3.92	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.92	$SHGC_{all}$-0.34	U_{all}-3.92	$SHGC_{all}$-0.27	U_{all}-10.79	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-2.56	$SHGC_{all}$-0.32	U_{all}-2.56	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-2.56	$SHGC_{all}$-0.32	U_{all}-2.56	$SHGC_{all}$-0.19	U_{all}-7.72	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement
[a] Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-5 (Supersedes Table 5.5-5 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 5 (A, B, C) (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Max.	Min. R-Value	Max.	Min. R-Value	Max.	Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.22	R-4.4 ci	U-0.22	R-4.4 ci	U-0.53	R-1.8 ci
Metal Building	U-0.20	R-3.3 + R-1.9 Ls	U-0.20	R-3.3 + R-1.9 Ls	U-0.39	R-2.3 + R-3.3
Attic and Other	U-0.12	R-8.6	U-0.12	R-8.6	U-0.19	R-5.3
Walls, Above Grade						
Mass	U-0.45	R-2.3 ci	U-0.40	R-2.7 ci	U-0.70	R-1.3 ci
Metal Building	U-0.30	R-2.3 + R-2.3 ci	U-0.30	R-2.3 + R-2.3 ci	U-0.45	R-2.3 + R-1.1 ci
Steel Framed	U-0.31	R-2.3 + R-1.8 ci	U-0.31	R-2.3 + R-1.8 ci	U-0.48	R-2.3 + R-0.7 ci
Wood Framed and Other	U-0.29	R-2.3 + R-1.3 ci	U-0.26	R-2.3 + R-1.8 ci	U-0.36	R-2.3 + R-0.7 ci
Wall, Below Grade						
Below Grade Wall	C-0.52	R-1.8 ci	C-0.52	R-1.8 ci	C-0.68	R-1.3 ci
Floors						
Mass	U-0.36	R-2.2 ci	U-0.32	R-2.6 ci	U-0.61	R-1.1 ci
Steel Joist	U-0.18	R-6.7	U-0.18	R-6.7	U-0.21	R-5.3
Wood Framed and Other	U-0.15	R-5.3 + R-1.3 ci	U-0.15	R-5.3 + R-1.3 ci	U-0.19	R-5.3
Slab-On-Grade Floors						
Unheated	F-0.93	R-1.8 for 600 mm	F-0.90	R-2.6 for 600 mm	F-0.93	R-1.8 for 600 mm
Heated	F-0.76	R-2.6 for 900 mm + R-0.9 ci below	F-0.76	R-2.6 for 900 mm + R-0.9 ci below	F-1.56	R-1.8 for 600 mm
Opaque Doors						
Swinging	U-2.27		U-2.27		U-3.41	
Non-Swinging	U-2.27		U-2.27		U-2.84	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	Max. U	Max. SHGC	Max. U	Max. SHGC	Max. U	Max. SHGC
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-1.42	SHGC-0.35 all	U-1.42	SHGC-0.40 all	U-3.12	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-1.99		U-1.99		U-3.41	
Metal framing: entrance door[c]	U-3.97		U-3.97		U-4.54	
Metal framing: all other[c]	U-2.56		U-2.56		U-3.69	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-3.80	$SHGC_{all}$-0.36	U_{all}-3.80	$SHGC_{all}$-0.36	U_{all}-11.24	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.80	$SHGC_{all}$-0.36	U_{all}-3.80	$SHGC_{all}$-0.36	U_{all}-11.24	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-3.92	$SHGC_{all}$-0.34	U_{all}-3.92	$SHGC_{all}$-0.34	U_{all}-10.79	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.92	$SHGC_{all}$-0.34	U_{all}-3.92	$SHGC_{all}$-0.34	U_{all}-10.79	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-2.56	$SHGC_{all}$-0.36	U_{all}-2.56	$SHGC_{all}$-0.36	U_{all}-7.72	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-2.56	$SHGC_{all}$-0.36	U_{all}-2.56	$SHGC_{all}$-0.36	U_{all}-7.72	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement
[a] Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-6 (Supersedes Table 5.5-6 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 6 (A, B) (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Max.	Min. R-Value	Max.	Min. R-Value	Max.	Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.18	R-5.3 ci	U-0.18	R-5.3 ci	U-0.36	R-2.6 ci
Metal Building	U-0.18	R-4.4 + R 1.9 Ls	U-0.18	R-4.4 + R 1.9 Ls	U-0.39	R-2.3 + R-3.3
Attic and Other	U-0.12	R-8.6	U-0.12	R-8.6	U-0.15	R-6.7
Walls, Above Grade						
Mass	U-0.40	R-2.7 ci	U-0.34	R-3.5 ci	U-0.59	R-1.7 ci
Metal Building	U-0.30	R-2.3 + R-2.3 ci	U-0.30	R-2.3 + R-2.3 ci	U-0.45	R-2.3 + R-1.1 ci
Steel Framed	U-0.31	R-2.3 + R-1.8 ci	U-0.31	R-2.3 + R-1.8 ci	U-0.48	R-2.3 + R-0.7 ci
Wood Framed and Other	U-0.26	R-2.3 + R-1.8 ci	U-0.26	R-2.3 + R-1.8 ci	U-0.36	R-2.3 + R-0.7 ci
Wall, Below Grade						
Below Grade Wall	C-0.52	R-1.8 ci	C-0.52	R-1.8 ci	C-0.68	R-1.3 ci
Floors						
Mass	U-0.32	R-2.6 ci	U-0.29	R-2.9 ci	U-0.61	R-1.1 ci
Steel Joist	U-0.18	R-6.7	U-0.13	R-6.7 + R-2.2 ci	U-0.21	R-5.3
Wood Framed and Other	U-0.15	R-5.3 + R-1.3 ci	U-0.15	R-5.3 + R-1.3 ci	U-0.19	R-5.3
Slab-On-Grade Floors						
Unheated	F-0.90	R-2.6 for 600 mm	F-0.88	R-3.5 for 600 mm	F-0.93	R-1.8 for 600 mm
Heated	F-0.76	R-2.6 for 900 mm + R-0.9 ci below	F-0.76	R-2.6 for 900 mm + R-0.9 ci below	F-1.56	R-1.8 for 600 mm
Opaque Doors						
Swinging	U-2.27		U-2.27		U-3.41	
Non-Swinging	U-2.27		U-2.27		U-2.84	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	Max. U	Max. SHGC	Max. U	Max. SHGC	Max. U	Max. SHGC
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-1.42	SHGC-0.40 all	U-1.42	SHGC-0.40 all	U-2.56	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-1.99		U-1.99		U-2.84	
Metal framing: entrance door[c]	U-3.97		U-3.97		U-4.54	
Metal framing: all other[c]	U-2.56		U-2.56		U-3.12	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-11.24	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-11.24	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-3.92	$SHGC_{all}$-0.49	U_{all}-3.92	$SHGC_{all}$-0.49	U_{all}-10.79	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.92	$SHGC_{all}$-0.49	U_{all}-3.92	$SHGC_{all}$-0.49	U_{all}-10.79	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-2.56	$SHGC_{all}$-0.46	U_{all}-2.56	$SHGC_{all}$-0.39	U_{all}-7.72	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-2.56	$SHGC_{all}$-0.46	U_{all}-2.56	$SHGC_{all}$-0.39	U_{all}-7.72	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement
[a] Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-7 (Supersedes Table 5.5-7 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 7 (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Opaque Elements	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**	**Max. U**	**Max. SHGC**
Roofs						
Insulation Entirely above Deck	U-0.16	R-6.2 ci	U-0.16	R-6.2 ci	U-0.36	R-2.6 ci
Metal Building	U-0.16	R-5.3 + R-1.9 Ls	U-0.16	R-5.3 + R-1.9 Ls	U-0.39	R-2.3 + R-3.3
Attic and Other	U-0.10	R-10.6	U-0.10	R-10.6	U-0.15	R-6.7
Walls, Above Grade						
Mass	U-0.34	R-3.5 ci	U-0.34	R-3.5 ci	U-0.51	R-2.0 ci
Metal Building	U-0.30	R-2.3 + R-2.3 ci	U-0.22	R-2.3 + R-3.4 ci	U-0.45	R-2.3 + R-1.1 ci
Steel Framed	U-0.31	R-2.3 + R-1.8 ci	U-0.21	R-2.3 + R-3.3 ci	U-0.48	R-2.3 + R-0.7 ci
Wood Framed and Other	U-0.26	R-2.3 + R-1.8 ci	U-0.26	R-2.3 + R-1.8 ci	U-0.36	R-2.3 + R-0.7 ci
Wall, Below Grade						
Below Grade Wall	C-0.52	R-1.8 ci	C-0.42	R-2.2 ci	C-0.68	R-1.3 ci
Floors						
Mass	U-0.25	R-3.5 ci	U-0.25	R-3.5 ci	U-0.50	R-1.5 ci
Steel Joist	U-0.18	R-6.7	U-0.13	R-6.7 + R-2.2 ci	U-0.21	R-5.3
Wood Framed and Other	U-0.15	R-5.3 + R-1.3 ci	U-0.15	R-5.3 + R-1.3 ci	U-0.19	R-5.3
Slab-On-Grade Floors						
Unheated	F-0.52	R-2.6 for 600 mm + R-0.9 ci below	F-0.52	R-2.6 for 600 mm + R-0.9 ci below	F-0.93	R-1.8 for 600 mm
Heated	F-0.65	R-3.5 for 900 mm + R-0.9 ci below	F-0.65	R-3.5 for 900 mm + R-0.9 ci below	F-1.19	R-3.5 for1200 mm
Opaque Doors						
Swinging	U-2.27		U-2.27		U-3.41	
Non-Swinging	U-2.27		U-2.27		U-2.84	

	Assembly	Assembly Max.	Assembly	Assembly Max.	Assembly	Assembly Max.
Fenestration	**Max. U**	**SHGC**	**Max. U**	**SHGC**	**Max. U**	**SHGC**
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-1.42	SHGC-0.45 all	U-1.42	SHGC-NR all	U-2.56	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-1.70		U-1.70		U-2.84	
Metal framing: entrance door[c]	U-3.97		U-3.97		U-4.54	
Metal framing: all other[c]	U-1.99		U-1.99		U-3.12	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-11.24	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-3.80	$SHGC_{all}$-0.46	U_{all}-11.24	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-3.92	$SHGC_{all}$-0.50	U_{all}-3.92	$SHGC_{all}$-0.50	U_{all}-10.79	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.92	$SHGC_{all}$-0.50	U_{all}-3.92	$SHGC_{all}$-0.50	U_{all}-10.79	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-2.56	$SHGC_{all}$-0.46	U_{all}-2.56	$SHGC_{all}$-0.46	U_{all}-7.72	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-2.56	$SHGC_{all}$-0.46	U_{all}-2.56	$SHGC_{all}$-0.46	U_{all}-7.72	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement
[a] Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.

TABLE A-8 (Supersedes Table 5.5-8 in ANSI/ASHRAE/IESNA Standard 90.1) Building Envelope Requirements for Climate Zone 8 (SI)

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Max.	Min. R-Value	Max.	Min. R-Value	Max.	Min.R-Value
Roofs						
Insulation Entirely above Deck	U-0.16	R-6.2 ci	U-0.16	R-6.2 ci	U-0.27	R-3.5 ci
Metal Building	U-0.16	R-5.3 + R-1.9 Ls	U-0.16	R-5.3 + R-1.9 Ls	U-0.25	R-3.3 + R-1.9 Ls[d]
Attic and Other	U-0.10	R-10.6	U-0.10	R-10.6	U-0.15	R-6.7
Walls, Above Grade						
Mass	U-0.34	R-3.5 ci	U-0.24	R-5.5 ci	U-0.45	R-2.3 ci
Metal Building	U-0.30	R-2.3 + R-2.3 ci	U-0.18	R-2.3 + R-4.6 ci	U-0.30	R-2.3 + R-2.3 ci
Steel Framed	U-0.31	R-2.3 + R-1.8 ci	U-0.19	R-2.3 + R-3.9 ci	U-0.37	R-2.3 + R-1.3 ci
Wood Framed and Other	U-0.26	R-2.3 + R-1.8 ci	U-0.18	R-2.3 + R-3.3 ci	U-0.36	R-2.3 + R-0.7 ci
Wall, Below Grade						
Below Grade Wall	C-0.52	R-1.8 ci	C-0.36	R-2.6 ci	C-0.68	R-1.3 ci
Floors						
Mass	U-0.25	R-3.5 ci	U-0.25	R-3.5 ci	U-0.36	R-2.2 ci
Steel Joist	U-0.13	R-6.7 + R-2.2 ci	U-0.13	R-6.7 + R-2.2 ci	U-0.21	R-5.3
Wood Framed and Other	U-0.15	R-5.3 + R-1.3 ci	U-0.15	R-5.3 + R-1.3 ci	U-0.15	R-5.3 + R-1.3 ci
Slab-On-Grade Floors						
Unheated	F-0.52	R-2.6 for 600 mm + R-0.9 ci below	F-0.52	R-2.6 for 600 mm + R-0.9 ci below	F-0.93	R-1.8 for 600 mm
Heated	F-0.65	R-3.5 for 900 mm + R-0.9 ci below	F-0.65	R-3.5 for 900 mm + R-0.9 ci below	F-1.19	R-3.5 for1200 mm
Opaque Doors						
Swinging	U-2.27		U-2.27		U-2.27	
Non-Swinging	U-2.27		U-2.27		U-2.27	

	Assembly	Assembly	Assembly	Assembly	Assembly	Assembly
Fenestration	Max. U	Max. SHGC	Max. U	Max. SHGC	Max. U	Max. SHGC
Vertical Fenestration,0% 40% of Wall						
Nonmetal framing: all[b]	U-1.42	SHGC-0.45 all	U-1.42	SHGC-NR all	U-2.56	SHGC-NR all
Metal fr: curtainwall/storefront[c]	U-1.70		U-1.70		U-2.84	
Metal framing: entrance door[c]	U-3.97		U-3.97		U-4.54	
Metal framing: all other[c]	U-1.99		U-1.99		U-3.12	
Skylight with Curb, Glass,% of Roof						
0% 2.0%	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-7.38	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-7.38	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0% 2.0%	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-6.25	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-3.29	$SHGC_{all}$-NR	U_{all}-6.25	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0% 2.0%	U_{all}-2.56	$SHGC_{all}$-NR	U_{all}-2.56	$SHGC_{all}$-NR	U_{all}-4.60	$SHGC_{all}$-NR
2.1% 5.0%	U_{all}-2.56	$SHGC_{all}$-NR	U_{all}-2.56	$SHGC_{all}$-NR	U_{all}-4.60	$SHGC_{all}$-NR

The following definitions apply: ci = continuous insulation, Ls = *liner system*, NR = no (insulation) requirement.
[a] Mass *walls* with a heat capacity greater than 245 kJ/m^2·K which are unfinished or finished only on the interior do not need to be insulated.
[b] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c] Metal framing includes metal framing with or without thermal break. The all other subcategory includes operable windows, fixed windows, and non-entrance doors.
[d] Liner system without thermal spacer blocks for this case only.-

TABLE A-9 (Supersedes Table A2.4.2 in ANSI/ASHRAE/IESNA Standard 90.1)
Single-Rafter Roof Requirements (SI)

Climate Zone	Minimum Insulation R-Value or Maximum Assembly U-Factor		
	Nonresidential	Residential	Semiheated
1	R-6.7 U-0.165	R-6.7 + R-1.8 ci U-0.112	R-3.3 U-0.312
2	R-6.7 + R-1.8 ci U-0.112	R-6.7 + R-1.8 ci U-0.112	R-3.3 U-0.312
3, 4, 5	R-6.7 + R-1.8 ci U-0.112	R-6.7 + R-1.8 ci U-0.112	R-5.3 U-0.204
6	R-6.7 + R-1.8 ci U-0.112	R-6.7 + R-1.8 ci U-0.112	R-6.7 U-0.165
7, 8	R-6.7 + R-2.6 ci U-0.111	R-6.7 + R-2.6 ci U-0.111	R-6.7 U-0.165

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX B
PRESCRIPTIVE CONTINUOUS AIR BARRIER

B1. CHARACTERISTICS

The *continuous air barrier* shall have the following characteristics:

a. It shall be continuous throughout the envelope (at the lowest *floor*, exterior *walls*, and ceiling or *roof*), with all joints and seams sealed and with sealed connections between all transitions in planes and changes in materials and at all penetrations.
b. The air barrier component of each assembly shall be joined and sealed in a flexible manner to the air barrier component of adjacent assemblies, allowing for the relative movement of these assemblies and components.
c. It shall be capable of withstanding positive and negative combined design wind, fan, and stack pressures on the air barrier without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.
d. It shall be installed in accordance with the *manufacturer's* instructions and in such a manner as to achieve the performance requirements.
e. Where lighting *fixtures* with ventilation holes or other similar objects are to be installed in such a way as to penetrate the *continuous air barrier*, provisions shall be made to maintain the integrity of the *continuous air barrier*.

Exception: Buildings that comply with (c) below are not required to comply with either (a) or (e) above.

B2. COMPLIANCE

Compliance of the *continuous air barrier* for the *opaque building envelope* shall be demonstrated by one of the following:

a. **Materials.** Using individual materials that have an air permeability not to exceed 0.004 cfm/ft^2 under a pressure differential of 0.3 in. water (1.57 lb/ft^2) (0.02 L/s·m^2 under a pressure differential of 75 Pa) when tested in accordance with ASTM E2178. These materials comply with this requirement when all joints are sealed and the above section on characteristics are met:

    1. Plywood—minimum 3/8 in. (10 mm)
    2. Oriented strand board—minimum 3/8 in. (10 mm)
    3. Extruded polystyrene insulation board—minimum 3/4 in. (19 mm)
    4. Foil-back urethane insulation board—minimum 3/4 in. (19 mm)
    5. Exterior or interior gypsum board—minimum 1/2 in. (12 mm)
    6. Cement board—minimum 1/2 in. (12 mm)
    7. Built up roofing membrane
    8. Modified bituminous *roof* membrane
    9. Fully adhered single-ply *roof* membrane
    10. A Portland cement/sand parge, or gypsum plaster minimum 5/8 in. (16 mm) thick
    11. Cast-in-place and precast concrete
    12. Fully grouted concrete block masonry
    13. Sheet steel

b. **Assemblies.** Using assemblies of materials and components that have an average air leakage not to exceed 0.04 cfm/ft^2 under a pressure differential of 0.3 in. water (1.57 lb/ft^2) (0.2 L/s·m^2 under a pressure differential of 75 Pa) when tested in accordance with ASTM E2357 or ASTM E1677. These assemblies comply with this requirement when all joints are sealed and the above section on characteristics are met:

    1. Concrete masonry *walls* coated with:

        a. one application of block filler and two applications of a paint or sealer coating, or
        b. a Portland cement/sand parge, stucco or plaster minimum 1/2 in. (12 mm) thick.

c. **Building.** Testing the completed building and demonstrating that the air leakage rate of the *building envelope* does not exceed 0.4 cfm/ft^2 under a pressure differential of 0.3 in. water (1.57 lb/ft^2) (2.0 L/s·m^2 under a pressure differential of 75 Pa) in accordance with ASTM E779 or an equivalent approved method.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX C
PRESCRIPTIVE EQUIPMENT EFFICIENCY TABLES

Informative Note: The first 15 tables are in I-P units, followed by15 tables in SI units.

TABLE C-1 (Supersedes Table 6.8.1A in ANSI/ASHRAE/IESNA Standard 90.1) Electrical-Operated Unitary Air Conditioners and Condensing Units (I-P)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure[a]
Air conditioners, air-cooled	<65,000 Btu/h	All	Split systems	14.0 SEER 12.0 EER	ARI 210/240
			Single packaged	14.0 SEER 11.6 EER	
Through-the-wall, air-cooled	<30,000 Btu/h	All	Split systems	12.0 SEER	
			Single packaged	12.0 SEER	
Small-duct high velocity, air-cooled	<65,000 Btu/h	All	Split systems	10 SEER	
Air conditioners, air-cooled	≥65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split systems and single package	11.5 EER 12.0 IEER	ARI 340/360
		All other	Split systems and single package	11.3 EER 11.8 IEER	
	≥135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	Split systems and single package	11.5 EER 12.0 IEER	
		All other	Split systems and single package	11.3 EER 11.8 IEER	
	≥240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)	Split systems and single package	10.0 EER 10.5 IEER	
		All other	Split systems and single package	9.8 EER 10.3 IEER	
	≥760,000 Btu/h	Electric resistance (or none)	Split systems and single package	9.7 EER 10.2 IEER	
		All other	Split systems and single package	9.5 EER 10.0 IEER	
Air conditioners, water and evaporatively cooled	<65,000 Btu/h	All	Split systems and single package	14.0 EER 14.3 IEER	ARI 210/240
	≥65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split systems and single package	14.0 EER 14.3 IEER	ARI 340/360
		All other	Split systems and single package	13.8 EER 14.1 IEER	
	≥135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	Split systems and single package	14.0 EER 14.3 IEER	
		All other	Split systems and single package	13.8 EER 14.1 IEER	
	≥240,000 Btu/h	Electric resistance (or none)	Split systems and single package	14.0 EER 14.0 IEER	
		All other	Split systems and single package	13.8 EER 13.8 IEER	
Condensing units, air-cooled	≥135,000 Btu/h			Not applicable match with indoor coil	ARI 365
Condensing, water or evaporatively cooled	≥135,000 Btu/h			Not applicable match with indoor coil	

a. Section 11 contains a complete specification of the referenced test procedures, including year version of the test procedure.

TABLE C-2 (Supersedes Table 6.8.1B in ANSI/ASHRAE/IESNA Standard 90.1) Electrically-Operated Unitary and Applied Heat Pumps Minimum Efficiency Requirements (I-P)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure[a]
Air conditioners, air-cooled (cooling mode)	<65,000 Btu/h	All	Split systems	14.0 SEER 12.0 EER	ARI 210/240
			Single packaged	14.0 SEER 11.6 EER	
Through-the-wall, air-cooled (cooling mode)	<30,000 Btu/h	All	Split systems	12.0 SEER	
			Single packaged	12.0 SEER	
Small-duct high velocity, air-cooled (cooling mode)	<65,000 Btu/h	All	Split systems	10.0 SEER	
Air conditioners, air-cooled (cooling mode)	≥65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split systems and single package	11.3 EER 11.8 IEER	ARI 340/360
		All other	Split systems and single package	11.1EER 11.6 IEER	
	≥135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	Split systems and single package	11.3 EER 11.8 IEER	
		All other	Split systems and single package	11.1EER 11.6 IEER	
	≥240,000 Btu/h	Electric resistance (or none)	Split systems and single package	9.8 EER 9.8 IEER	
		All other	Split systems and single package	9.6 EER 9.6 IEER	
Water-source (cooling mode)	<17,000 Btu/h	All	86°F entering water	14.0 EER	ISO-13256-1
	≥17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	14.0 EER	
	>65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	14.0 EER	
Groundwater-source (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.2 EER	
		All	77°F entering water	13.4 EER	
Air conditioners, air-cooled (heating mode)	<65,000 Btu/h	All	Split systems	8.5 HSPF	ARI210/240
			Single packaged	8.0 HSPF	
Through-the-wall, air-cooled (heating mode)	<30,000 Btu/h	All	Split systems	7.4 HSPF	
			Single packaged	7.4 HSPF	
Small-duct high velocity, air-cooled (heating mode)	<65,000 Btu/h	All	Split systems	6.8 HSPF	
Air-cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)		47°F DB/43°F WB *Outdoor air*	3.3 COP	ARI 340/360
			17°F DB/15°F WB *Outdoor air*	2.2 COP	
	≥135,000 Btu/h (cooling capacity)		47°F DB/43°F WB *Outdoor air*	3.2 COP	
			17°F DB/15°F WB *Outdoor air*	2.0 COP	
Water-source (heating mode)	< 135,000 Btu/h (cooling capacity)		68°F entering water	4.2 COP	ISO-13256-1
Groundwater-source (heating mode)	< 135,000 Btu/h (cooling capacity)		50°F entering water	3.6 COP	
			32°F entering fluid	3.1 COP	

a. Section 11 contains a complete specification of the referenced test procedures, including year version of the test procedure.

TABLE C-3 (Supersedes Table 6.8.1C in ANSI/ASHRAE/IESNA Standard 90.1) Water Chilling Packages—Minimum Efficiency Requirements[a] (I-P)

Equipment Type	Size Category	Units	Minimum Efficiency[c] (I-P)				Test Procedure[b]
			Path A		Path B[d]		
			Full Load	IPLV	Full Load	IPLV	
Air-cooled chillers with condenser, electrically operated	<150 tons	EER	10.000	12.500	NA	NA	ARI 550/590
	≥150 tons	EER	10.000	12.750	NA	NA	
Air-cooled without condenser, electrical operated	All capacities	EER	Condenserless units shall be rated with matched condensers				ARI 550/590
Water-cooled, electrically operated, positive displacement (reciprocating)	All capacities	kw/ton	Reciprocating units required to comply with water cooled positive displacement requirements				ARI 550/590
Water-cooled electrically operated, positive displacement	<75 tons	kw/ton	0.780	0.630	0.800	0.600	ARI 550/590
	≥75 tons and <150 tons	kw/ton	0.775	0.615	0.790	0.586	
	≥150 tons and <300 tons	kw/ton	0.680	0.580	0.718	0.540	
	≥300 tons	kw/ton	0.620	0.540	0.639	0.490	
Water-cooled electrically operated, centrifugal[a]	<150 tons	kw/ton	0.634	0.596	0.639	0.450	ARI 550/590
	≥150 tons and <300 tons	kw/ton	0.634	0.596	0.639	0.450	
	≥300 tons and <600 tons	kw/ton	0.576	0.549	0.600	0.400	
	≥600 tons	kw/ton	0.570	0.539	0.590	0.400	
Air-cooled absorption single effect[g]	All capacities	COP	0.600	NR[f]	NA[e]	NA[e]	ARI 560
Water-cooled absorption single effect[g]	All capacities	COP	0.700	NR[f]	NA[e]	NA[e]	
Absorption double effect indirect-fired	All capacities	COP	1.000	1.050	NA[e]	NA[e]	
Absorption double effect direct fired	All capacities	COP	1.000	1.000	NA[e]	NA[e]	

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is <40°F
b Section 11 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure
c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However both the full load and IPLV must be met to fulfill the requirements of Path A and Path B
d. Path B is intended for applications with significant operating time at part load. All Path B machines shall be equipped with demand limiting capable controls
e. NA means that this requirement is not applicable and can not be used for compliance
f. NR means that for this category there are no minimum requirements
g. Only allowed to be used in heat recovery applications
h. Packages that are not designed for operation at ARI Standard 550/590 test conditions (and, thus, cannot be tested to meet the requirements of Table C-3) of 44°F leaving chilled-water temperature and 85°F entering condenser-water temperature with 3 gpm/ton condenser-water flow shall have maximum full-load kW/ton and *NPLV* ratings adjusted using the following equation:

Adjusted maximum full load kW/ton rating = (full load kW/ton from Table C-3) / K_{adj}

Adjusted maximum NPLV rating = (IPLV from Table C-3) / K_{adj}

where
K_{adj} = $6.174722 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$
X = DT_{std} + LIFT (°F)
DT_{std} = (24 + (full load kW/ton from Table C-3) · 6.83) / flow (°F)
Flow = condenser-water flow (gpm) / cooling full load capacity (tons)
LIFT = CEWT – CLWT (°F)
CEWT = full load entering condenser-water temperature (°F)
CLWT = full load leaving chilled-water temperature (°F)

The adjusted full load and *NPLV* values are only applicable over the following full-load design ranges:
- minimum leaving chilled-water temperature: 38°F
- maximum condenser entering water temperature: 102°F
- condenser-water flow: 1 to 6 gpm/ton
- $X \geq 39$°F and ≤60°F

**TABLE C-4 (Supersedes Table 6.8.1D in ANSI/ASHRAE/IESNA Standard 90.1)
Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Packaged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps—Minimum Efficiency Requirements (I-P)**

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
PTAC (cooling mode) new construction	<7,000 Btu/h	95°F DB *Outdoor air*	11.9 EER	ARI 310/380
	≥7,000 Btu/h and <10,000 Btu/h	95°F DB *Outdoor air*	11.3 EER	
	≥ 10,000 Btu/h and <13,000 Btu/h	95°F DB *Outdoor air*	10.7 EER	
	≥13,000 Btu/h	95°F DB *Outdoor air*	9.5 EER	
PTAC (cooling mode) replacement[b]	<7,000 Btu/h	95°F DB *Outdoor air*	11.9 EER	ARI 310/380
	≥7,000 Btu/h and <10,000 Btu/h	95°F DB *Outdoor air*	11.3 EER	
	≥10,000 Btu/h and <13,000 Btu/h	95°F DB *Outdoor air*	10.7 EER	
	≥13,000 Btu/h	95°F DB *Outdoor air*	9.5 EER	
PTHP (cooling mode) new construction	<7,000 Btu/h	95°F DB *Outdoor air*	11.7 EER	ARI 310/380
	≥7,000 Btu/h and <10,000 Btu/h	95°F DB *Outdoor air*	11.1 EER	
	≥10,000 Btu/h and <13,000 Btu/h	95°F DB *Outdoor air*	10.5 EER	
	≥13,000 Btu/h	95°F DB *Outdoor air*	9.3 EER	
PTHP (heating mode) new construction	All capacities	95°F DB *Outdoor air*	2.8 COP	ARI 310/380
PTHP (cooling mode) replacement[b]	<7,000 Btu/h	95°F DB *Outdoor air*	11.7 EER	ARI 310/380
	≥7,000 Btu/h and <10,000 Btu/h	95°F DB *Outdoor air*	11.1 EER	
	≥10,000 Btu/h and < 13,000 Btu/h	95°F DB *Outdoor air*	10.5 EER	
	≥13,000 Btu/h	95°F DB *Outdoor air*	9.3 EER	
PTHP (heating mode) replacement[b]	All capacities	95°F DB *Outdoor air*	2.8 COP	ARI 310/380

a. Section 11 contains a complete specification of the referenced test procedures, including year version of the test procedure.
b. Replacement units shall be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 in. high and less than 42 in. wide.

TABLE C-5 (Supersedes Table 6.8.1D in ANSI/ASHRAE/IESNA Standard 90.1)
Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Pacakged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps—Minimum Efficiency Requirements (I-P)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
SPVAC (cooling mode)	<65,000 Btu/h	95°F DB/75°F WB *Outdoor air*	10.0 EER 13.5 IPLV	ARI 390
	≥65,000 Btu/h and <135,000 Btu/h	95°F DB/75°F WB *Outdoor air*	11.5 EER	
	≥135,000 Btu/h and <240,000 Btu/h	95°F DB/75°F WB *Outdoor air*	11.5 EER	
SPVHP (cooling mode)	<65,000 Btu/h	95°F DB/75°F WB *Outdoor air*	10.0 EER 13.5 IPLV	
	≥65,000 Btu/h and <135,000 Btu/h	95°F DB/75°F WB *Outdoor air*	11.5 EER	
	≥135,000 Btu/h and <240,000 Btu/h	95°F DB/75°F WB *Outdoor air*	11.5 EER	
SPVHP (heating mode)	<65,000 Btu/h	47°F DB/43°F WB *Outdoor air*	3.0 COP	
	≥65,000 Btu/h and <135,000 Btu/h	47°F DB/43°F WB *Outdoor air*	3.0 COP	
	≥135,000 Btu/h and <240,000 Btu/h	47°F DB/43°F WB *Outdoor air*	2.9 COP	
Room air conditioners, with louvered sides	<6000 Btu/h		10.7 SEER	ANSI/ AHAM RAC-1
	≥6000 Btu/h and <8000 Btu/h		10.7 EER	
	≥8000 Btu/h and <14,000 Btu/h		10.8 EER	
	≥14000 Btu/h and <20,000 Btu/h		10.7 EER	
	≥20,000 Btu/h		9.3 EER	
Room air conditioners, without louvered sides	<8000 Btu/h		9.9 EER	
	≥8000 Btu/h and <20,000 Btu/h		9.3 EER	
	≥20,000 Btu/h		9.3 EER	
Room air conditioner heat pump with louvered sides	<20,000 Btu/h		9.9 EER	
	≥20,000 Btu/h		9.3 EER	
Room air conditioner heat pump without louvered sides	<14,000 Btu/h		9.3 EER	
	≥14,000 Btu/h		8.8 EER	
Room air conditioner, casement only	All capacities		9.6 EER	
Room air conditioner, casement-slider	All capacities		10.4 EER	

a. Section 11 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

TABLE C-6 (Supersedes Table 6.8.1E in ANSI/ASHRAE/IESNA Standard 90.1) Warm Air Furnace and Combustion Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces, and Unit Heaters (I-P)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Test Procedure[b]	Minimum Efficiency[a]
Warm air furnace, gas-fired (weatherized)	<225,000 Btu/h	Maximum capacity[d]	DOE 10 CFR Part 430 or ANSI Z21.47	78% AFUE or 80% E_t[c,e]
	>225,000 Btu/h	Maximum capacity[d]	ANSI Z21.47	80% E_c[c,e]
Warm air furnace, gas-fired (non-weatherized)	<225,000 Btu/h	Maximum capacity[d]	DOE 10 CFR Part 430 or ANSI Z21.47	90% AFUE or 92% E_t[c,e]
	>225,000 Btu/h	Maximum capacity[d]	ANSI Z21.47	92% E_c[c,e]
Warm air furnace, oil-fired (weatherized)	<225,000 Btu/h	Maximum capacity[d]	DOE 10 CFR Part 430 or UL 727	78% AFUE or 80% E_t[c,e]
	>225,000 Btu/h	Maximum capacity[d]	UL 727	81% E_t[e]
Warm air furnace, oil-fired (non-weatherized)	<225,000 Btu/h	Maximum capacity[d]	DOE 10 CFR Part 430 or UL 727	85% AFUE or 87%% E_t[c,e]
	>225,000 Btu/h	Maximum capacity[d]	UL 727	87% E_t[e]
Warm air duct furnaces, gas-fired (weatherized)	All capacities	Maximum capacity[d]	ANSI Z83.9	80% E_c[f]
Warm air duct furnaces, gas-fired (non-weatherized)	All capacities	Maximum capacity[d]	ANSI Z83.9	90% E_c[f]
Warm air unit heaters, gas fired (non-weatherized)	All capacities	Maximum capacity[d]	ANSI Z83.8	90% E_c[f,g]
Warm air unit heaters, oil-fired (non-weatherized)	All capacities	Maximum capacity[d]	UL 731	90% E_c[f,g]

a E_t = thermal efficiency. See test procedure for detailed discussions
b Section 11 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c Combustion units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h) is allowed to comply with either rating
d Minimum and maximum ratings as provided for and allowed by the unit's controls
e Units shall 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 flue damper. A vent damper is an acceptable alternative to the flue damper for those furnaces where combustion air is drawn from the *conditioned space*.
f E_c = combustion efficiency (100% less flue losses) See test procedures for detailed discussion
g As of August 8, 2008, according to the Energy Policy Act of 2005, units shall also include an interrupted or intermittent ignition devices (IID) and have either power venting or automatic flue dampers. A vent damper is an acceptable alternative to a flue damper for those unit heaters where combustion air is drawn from the *conditioned space*.

TABLE C-7 (Supersedes Table 6.8.1F in ANSI/ASHRAE/IESNA Standard 90.1)
Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements (I-P)

Equipment Type[a]	Subcategory or Rating Condition	Size Category (Input)	Efficiency[b,c]	Test Procedure
Boilers, hot water	Gas-fired	<300,000 Btu/h	89 % AFUE[f]	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	89% E_t[f]	10 CFR Part 431
		>2,500,000 Btu/h[a]	91% E_c[f]	
	Oil-fired[e]	<300,000 Btu/h	89 % AFUE[f]	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	89% E_t[f]	10 CFR Part 431
		>2,500,000 Btu/h[a]	91% E_c[f]	
Boilers, steam	Gas-fired	<300,000 Btu/h	75% AFUE	10 CFR Part 430
	Gas-fired all, except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	79% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	79% E_t	
	Gas-fired natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	77% E_t	
		>2,500,000 Btu/h[a]	77% E_t	
	Oil-fired[e]	<300,000 Btu/h	80% E_t	10 CFR Part 430
		≥300,000 Btu/h and ≤2,5000,000 Btu/h[d]	81% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	81% E_t	

a These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.
b E_c = thermal 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 Systems shall be designed with lower operating return hot water temperatures (<130°F) and use hot water reset to take advantage of the much higher efficiencies of condensing boilers

TABLE C-8 (Supersedes Table 6.8.1G in ANSI/ASHRAE/IESNA Standard 90.1) Performance Requirements for Heat Rejection Equipment (I-P)

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Rating Standard	Rating Conditions	Performance Required[a,b]
Open-loop propeller or axial fan cooling towers[a]	All	CTI ATC-105 and CTI STD-201	95°F entering water 85°F leaving water 75°F wb entering air	>40 gpm/hp
Closed-loop propeller or axial fan cooling towers[b]	All	CTI ATC-105 and CTI STD-201	102°F entering water 90°F leaving water 75°F wb entering air	>15 gpm/hp
Open-loop centrifugal fan cooling towers [a]	All	CTI ATC-105 and CTI STD-201	95°F entering water 85°F leaving water 75°F wb entering air	>22 gpm/hp
Closed-loop centrifugal fan cooling towers[b]	All	CTI ATC-105 and CTI STD-201	102°F entering water 90°F leaving water 75°F wb entering air	>8 gpm/hp
Air-cooled condensers	All	ARI 460		Not applicable, air-cooled condenser shall be matched to the HVAC system and rated per Table C-3

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 this table divided by the fan nameplate rated 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 this table divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.

TABLE C-9 (Supersedes Table 6.8.2A in ANSI/ASHRAE/IESNA Standard 90.1) Minimum Duct Insulation R-Value[a] Cooling and Heating Only Supply Ducts and Return Ducts (I-P)

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with *Roof* Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Heating Ducts Only							
1, 2	None	None	None	None	None	None	None
3	R-6	None	None	None	R-6	None	None
4	R.6	None	None	None	R-6	None	None
5	R-8	R-6	None	None	R-6	None	R-6
6	R-8	R-8	R-6	None	R-6	None	R-6
7	R-10	R-8	R-8	None	R-6	None	R-6
8	R-10	R-10	R-8	None	R-8	None	R-8
Cooling Only Ducts							
1	R-6	R-8	R-10	R-6	R-6	None	R-6
2	R-6	R-8	R-10	R-6	R-6	None	R-6
3	R-6	R-8	R-8	R-6	R-3.5	None	None
4	R-3.5	R-6	R-8	R-3.5	R-3.5	None	None
5, 6	R-3.5	R-3.5	R-6	R-3.5	R-3.5	None	None
7, 8	R-1.9	R-3.5	R-3.5	R-3.5	R-3.5	None	None
Return Ducts							
1 to 8	R-6	R-6	R-6	None	None	None	None

a Insulation R-values, measured in $(h \cdot ft^2 \cdot °F)/Btu$, 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 exterior *walls* are used as plenum *walls*, *wall* insulation shall be as required by the most restrictive condition of this table or Section 7.4.2. 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 crawl spaces, both ventilated and nonventilated.
c Includes return air plenums with or without exposed *roofs* above.

TABLE C-10 (Supersedes Table 6.8.2B in ANSI/ASHRAE/IESNA Standard 90.1) Minimum Duct Insulation R-Value[a], Combined Heating and Cooling Supply Ducts and Return Ducts (I-P)

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic w/ *Roof* Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Supply Ducts							
1	R-8	R-8	R-10	R-6	R-6	None	R-6
2	R-8	R-8	R-8	R-6	R-8	None	R-6
3	R-8	R-8	R-8	R-6	R-8	None	R-6
4	R-8	R-8	R-8	R-6	R-8	None	R-6
5	R-8	R-8	R-8	R-3.5	R-8	None	R-6
6	R-10	R-8	R-8	R-3.5	R-8	None	R-6
7	R-10	R-8	R-8	R-3.5	R-8	None	R-6
8	R-10	R11	R11	R-3.5	R-8	None	R-8
Return Ducts							
1 to 8	R-6	R-6	R-6	None	None	None	None

a Insulation R-values, measured in (h·ft^2·°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 exterior *walls* are used as plenum *walls*, *wall* insulation shall be as required by the most restrictive condition of this table or Section 7.4.2. 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 crawl spaces, both ventilated and non-ventilated.
c Includes return air plenums with or without exposed *roofs* above.

TABLE C-11 (Supersedes Table 6.8.3 in ANSI/ASHRAE/IESNA Standard 90.1) Minimum Pipe Insulation Thickness[a] (I-P)

Fluid Design Operating Temp. Range (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
	Conductivity Btu·in./(h·ft^2·°F)	Mean Rating Temp. °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
Heating Systems (Steam, Steam Condensate, and Hot Water)[b,c]							
>350	0.32-0.34	250	3.0	3.5	3.5	4.5	4.5
251-350	0.29-0.32	200	2.0	3.0	3.5	3.5	3.5
201-250	0.27-0.30	150	2.0	2.0	2.5	2.5	2.5
141-200	0.25-0.29	125	1.5	1.5	1.5	2.0	2.0
105-140	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
Domestic and Service Hot Water Systems							
105+	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
Cooling Systems (Chilled Water, Brine, and Refrigerant)[d]							
40-60	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5
<40	0.22-0.28	100	1.0	1.5	1.5	1.5	2.0

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·ft^2·°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 Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within 4 ft of the coil and the pipe size is 1 in. or less.
d 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.

TABLE C-12 (Supersedes Table 7.8 in ANSI/ASHRAE/IESNA Standard 90.1)
Performance Requirements for Water Heating Equipment (I-P)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required [a]	Test Procedure [b]
Electric water heaters	12 kW	Resistance ≥ 20 gal	EF ≥ 0.97 − 0.00132V	DOE 10 CFR Part 430
	>12 kW	Resistance ≥ 20 gal	SL ≤ 20 + 35 $\sqrt{V}$, Btu/h	ANSI Z21.10.3
	All sizes	Heat Pump	EF ≥ 2.0	DOE 10 CFR Part 430
Gas storage water heaters	≤75,000 Btu/h	≥20 gal	EF ≥ 0.67	DOE 10 CFR Part 430
	>75,000 Btu/h	<4000 (Btu/h)/gal	E_t ≥ 80% and SL ≤ (Q/800 + 110 $\sqrt{V}$), Btu/h	ANSI Z21.10.3
Gas instantaneous water heaters	>50,000 Btu/h and <200,000 Btu/h	≥4000 (Btu/h)/gal and <2 gal	EF ≥ 0.82	DOE 10 CFR Part 430
	≥200,000 Btu/h[c]	≥4000 (Btu/h)/gal and <10 gal	E_t ≥ 80%	ANSI Z21.10.3
	≥200,000 Btu/h	4000 (Btu/h)/gal and ≥10 gal	E_t ≥ 80% and SL ≤ (Q/800 + 110 $\sqrt{V}$), Btu/h	
Oil storage water heaters	≤105,000 Btu/h	≥20 gal	EF ≥ 0.59-0.0019V	DOE 10 CFR Part 430
	>105,000 Btu/h	<4000 (Btu/h)/gal	E_t ≥ 78% and SL ≤ (Q/800 + 110 $\sqrt{V}$), Btu/h	ANSI Z21.10.3
Oil instantaneous water heaters	≤210,000 Btu/h	≥4000 (Btu/h)/gal and < 2 gal	EF ≥ 0.59-0.0019V	DOE 10 CFR Part 430
	>210,000 Btu/h	≥4000 (Btu/h)/gal and <10 gal	E_t ≥ 80%	ANSI Z21.10.3
	>210,000 Btu/h	≥4000 (Btu/h)/gal and ≥10 gal	E_t ≥ 78% and SL ≤ (Q/800 + 110 $\sqrt{V}$), Btu/h	
Hot-water supply boilers, gas and oil	300,000 Btu/h and <12,500,000 Btu/h	≥4000 (Btu/h)/gal and <10 gal	E_t ≥ 80%	ANSI Z21.10.3
Hot-water supply boilers, gas		≥4000 (Btu/h)/gal and ≥10 gal	E_t ≥ 80% and SL ≤ (Q/800 + 110 $\sqrt{V}$), Btu/h	
Hot-water supply boilers, oil		≥4000 (Btu/h)/gal and ≥10 gal	E_t ≥ 78% and SL ≤ (Q/800 + 110 $\sqrt{V}$), Btu/h	
Pool heaters oil and gas	All sizes		E_t ≥ 78%	ASHRAE 146
Heat pump pool heaters	All sizes		≥4.0 COP	ASHRAE 146
Unfired storage tanks	All sizes		≥R-12.5	(none)

a Energy factor (EF) and thermal efficiency (Et) are minimum requirements, while standby loss (SL) is maximum Btu/h based on a 70°F temperature difference between stored water and ambient requirements. In the EF equation, V is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and Q is the nameplate input rate in Btu/h.
b Section 11 contains a complete specification, including the year version, of the referenced test procedure.
c Instantaneous water heaters with input rates below 200,000 Btu/h shall comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher."

TABLE C-13 Minimum Nominal Efficiency for General Purpose Design A and Design B Motors[a] (I-P)

	Minimum Nominal Full-Load Efficiency (%)					
	Open Motors			Enclosed Motors		
Number of Poles ==>	**2**	**4**	**6**	**2**	**4**	**6**
Synchronous Speed (RPM) ==>	**3600**	**1800**	**1200**	**3600**	**1800**	**1200**
Motor Horsepower						
1	77.0	85.5	82.5	77.0	85.5	82.5
1.5	84.0	86.5	86.5	84.0	86.5	87.5
2	85.5	86.5	87.5	85.5	86.5	88.5
3	85.5	89.5	88.5	86.5	89.5	89.5
5	86.5	89.5	89.5	88.5	89.5	89.5
7.5	88.5	91.0	90.2	89.5	91.7	91.0
10	89.5	91.7	91.7	90.2	91.7	91.0
15	90.2	93.0	91.7	91.0	92.4	91.7
20	91.0	93.0	92.4	91.0	93.0	91.7
25	91.7	93.6	93.0	91.7	93.6	93.0
30	91.7	94.1	93.6	91.7	93.6	93.0
40	92.4	94.1	94.1	92.4	94.1	94.1
50	93.0	94.5	94.1	93.0	94.5	94.1
60	93.6	95.0	94.5	93.6	95.0	94.5
75	93.6	95.0	94.5	93.6	95.4	94.5
100	93.6	95.4	95.0	94.1	95.4	95.0
125	94.1	95.4	95.0	95.0	95.4	95.0
150	94.1	95.8	95.4	95.0	95.8	95.8
200	95.0	95.8	95.4	95.4	96.2	95.8
250	95.0	95.8	95.4	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	95.8	96.2	96.2	95.8	96.2	95.8
500	95.8	96.2	96.2	95.8	96.2	95.8

a. Nominal efficiencies shall be established in accordance with NEMA Standard MG1. Design A and Design B are National Electric Manufacturers Association (NEMA) design class designations for fixed frequency small and medium AC squirrel-cage induction motors.

TABLE C-14 Commercial Refrigerator and Freezers (I-P)

Equipment Type	Application	Energy Use Limit (kW/h per day)
Refrigerators with solid doors	Holding temperature	0.10 V + 2.04
Refrigerators with transparent doors		0.12 V + 3.34
Freezers with solid doors		0.40 V + 1.38
Freezers with transparent doors		0.75 V + 4.10
Refrigerators/freezers with solid doors		The greater of 0.12 V + 3.34 or 0.70
Commercial refrigerators	Pulldown	0.126 V + 3.51

V means the chiller or frozen compartment volume (ft^3) as defined in the Association of Home Appliance Manufacturers Standard HRF1-1979

TABLE C-15 Commercial Clothes Washers (I-P)

Product	MER	WF
All commercial clothes washers	1.72	8

MER = Modified Energy Factor, a combination of Energy Factor and MEF=Modified Energy Factor, a combination of Energy Factor and Remaining Moisture Content. MEF measures energy consumption of the total laundry cycle (washing and drying). It indicates how many cubic feet of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency.

TABLE C-1 (Supersedes Table 6.8.1A in ANSI/ASHRAE/IESNA Standard 90.1)
Electrical Operated Unitary Air Conditioners and Condensing Units (SI)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure[a]
Air conditioners, air-cooled	<19 kW	All	Split systems	4.10 SCOP 3.52 COP	ARI 210/240
			Single packaged	4.10 SCOP 3.52 COP	
Through-the-wall, air-cooled	<9 kW	All	Split systems	3.52 SCOP	
			Single packaged	3.52 SCOP	
Small-duct high velocity, air-cooled	<19kW	All	Split systems	2.93 SCOP	
Air conditioners, air-cooled	≥19 kW and < 40 kW	Electric resistance (or none)	Split systems and single package	3.37 COP 3.52 ICOP	ARI 340/360
		All other	Split systems and single package	3.31 COP 3.46 ICOP	
	≥40 kW and < 70 kW	Electric resistance (or none)	Split systems and single package	3.37 COP 3.52 ICOP	
		All other	Split systems and single package	3.31 COP 3.46 ICOP	
	≥70 kW and < 223 kW	Electric resistance (or none)	Split systems and single package	2.93 COP 3.08 ICOP	
		All other	Split systems and single package	2.87 COP 3.02 ICOP	
	≥223 kW	Electric resistance (or none)	Split systems and single package	2.84 COP 2.99 ICOP	
		All other	Split systems and single package	2.78 COP 2.93 ICOP	
Air conditioners, water and evaporatively cooled	<19kW	All	Split systems and single package	4.10 COP 4.19 ICOP	ARI 210/240
	≥19 kW and < 40 kW	Electric resistance (or none)	Split systems and single package	4.10 COP 4.19 ICOP	ARI 340/360
		All other	Split systems and single package	4.04 COP 4.13 ICOP	
	≥40 kW and < 70 kW	Electric resistance (or none)	Split systems and single package	4.10 COP 4.19 ICOP	
		All other	Split systems and single package	3.81 COP 4.13 ICOP	
	≥70 kW	Electric resistance (or none)	Split systems and single package	4.10 COP 4.10 ICOP	
		All other	Split systems and single package	3.81 COP 3.81 ICOP	
Condensing units, air-cooled	≥ 40 kW			Not applicable match with indoor coil	ARI 365
Condensing, water or evaporatively cooled	≥ 40 kW			Not applicable match with indoor coil	

a. Section 11 contains a complete specification of the referenced test procedures, including year version of the test procedure.

TABLE C-2 (Supersedes Table 6.8.1B in ANSI/ASHRAE/IESNA Standard 90.1)
Electrically Operated Unitary and Applied Heat Pumps Minimum Efficiency Requirements (SI)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency	Test Procedure[a]
Air conditioners, air-cooled (cooling mode)	<19 kW	All	Split systems	4.10 $SCOP_C$ 3.52 COP_C	ARI 210/240
			Single packaged	4.10 $SCOP_C$ 3.40 COP_C	
Through-the-wall, air-cooled (cooling mode)	<9 kW	All	Split systems	3.52 $SCOP_C$	
			Single packaged	3.52 $SCOP_C$	
Small-duct high velocity, air-cooled (cooling mode)	<19 kW	All	Split systems	2.93 $SCOP_C$	
Air conditioners, air-cooled (cooling mode)	≥19 kW and < 40 kW	Electric resistance (or none)	Split systems and single package	3.31 COP_C 3.46 $ICOP_C$	ARI 340/360
		All other	Split systems and single package	3.25 COP_C 3.40 $ICOP_C$	
	≥40 kW and < 70 kW	Electric resistance (or none)	Split systems and single package	3.31 COP_C 3.46 $ICOP_C$	
		All other	Split systems and single package	3.25 COP_C 3.40 $ICOP_C$	
	≥70 kW	Electric resistance (or none)	Split systems and single package	2.87 COP_C 2.87 $ICOP_C$	
		All other	Split systems and single package	2.81 COP_C 2.81 $ICOP_C$	
Water-source (cooling mode)	<5 kW	All	30°C entering water	4.10 COP_C	ISO-13256-1
	≥5 kW and < 19 kW	All	30°C entering water	4.10 COP_C	
	>19 kW and < 40 kW	All	30°C entering water	4.10 COP_C	
Groundwater-source (cooling mode)	< 40 kW	All	15°C entering water	4.75 COP_C	
		All	25°C entering water	13.4 COP_C	

a. Section 11 contains a complete specification of the referenced test procedures, including year version of the test procedure.

TABLE C-3 (Supersedes Table 6.8.1C in ANSI/ASHRAE/IESNA Standard 90.1) Water Chilling Packages—Minimum Efficiency Requirements[a] (SI)

Equipment Type	Size Category	Units	Minimum Efficiency[c]				Test Procedure[b]
			Path A		Path B[d]		
			Full Load	IPLV	Full Load	IPLV	
Air-cooled chillers with condenser, electrically operated	<528 kW	COP	2.931	3.664	NA	NA	ARI 550/590
	≥528 kW	COP	2.931	3.737	NA	NA	
Air-cooled without condenser, electrical operated	All capacities	COP	Condenserless units shall be rated with matched condensers				ARI 550/590
Water-cooled, electrically operated, positive displacement (reciprocating)	All capacities	COP	Reciprocating units required to comply with water cooled positive displacement requirements				ARI 550/590
Water-cooled electrically operated, positive displacement	<264 kW	COP	4.509	5.583	4.396	5.862	ARI 550/590
	≥264 kW and < 528 kW	COP	4.538	5.719	4.452	6.002	
	≥ 528 kW and < 1055 kW	COP	5.172	6.064	4.898	6.513	
	≥1055 kW	COP	5.673	6.513	5.504	7.178	
Water-cooled electrically operated, centrifugal	<528 kW	COP	5.547	5.901	5.504	7.816	ARI 550/590
	≥ 528 kW and < 1055 kW	COP	5.547	5.901	5.504	7.816	
	≥ 1055 kW and <2110 kW	COP	6.106	6.406	5.862	8.792	
	≥ 2110 kW	COP	6.170	6.525	5.961	8.792	
Air-cooled absorption single effect[g]	All capacities	COP	0.600	NR[f]	NA[e]	NA[e]	ARI 560
Water-cooled absorption single effect[g]	All capacities	COP	0.700	NR[f]	NA[e]	NA[e]	
Absorption double effect indirect-fired	All capacities	COP	1.000	1.050	NA[e]	NA[e]	
Absorption double effect direct fired	All capacities	COP	1.000	1.000	NA[e]	NA[e]	

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is <2.4 C
b Section 11 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure
c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However both the full load and IPLV must be met to fulfill the requirements of Path A or Path B
d. Path B is intended for applications with significant operating time at part load. All path B machines shall be equipped with demand limiting capable controls
e. NA means that this requirement is not applicable and can not be used for compliance
f. NR means that for this category there are no minimum requirements
g. Only allowed to be used in heat recovery applications
h. Packages that are not designed for operation at ARI Standard 550/590 test conditions (and, thus, cannot be tested to meet the requirements of Table C-3) of 6.7°C leaving chilled-water temperature and 29.4°C entering condenser-water temperature with 0.054 L/s·kW condenser-water flow shall have maximum full-load kW/ton and *NPLV* ratings adjusted using the following equation:

Adjusted minimum full load COP rating = (full load COP from Table C-3) · K_{adj}

Adjusted maximum NPLV rating = (IPLV from Table C-3) · K_{adj}

where
K_{adj} = $6.174722 - 0.5466024(X) + 0.020394698(X)^2 - 0.000266989(X)^3$
X = DT_{std} + LIFT (°C)
DT_{std} = (0.267114 + 0.267088/(full load COP from Table C-3)) / Flow (°C)
Flow = condenser-water flow (L/s) / cooling full load capacity (kW)
LIFT = CEWT – CLWT (°C)
CEWT = full load entering condenser-water temperature (°C)
CLWT = full load leaving chilled-water temperature (°C)

The adjusted full load and *NPLV* values are only applicable over the following full-load design ranges:
- minimum leaving chilled-water temperature: 3.3°C
- maximum condenser entering water temperature: 39°C
- condenser-water flow: 0.036 to 0.0721 L/s·kW
- $X \geq 21.7$°C and ≤33.3°C

**TABLE C-4 (Supersedes Table 6.8.1D in ANSI/ASHRAE/IESNA Standard 90.1)
Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Packaged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps, Room Air Conditioners and Room Air Conditioners Heat Pumps—Minimum Efficiency Requirements (SI)**

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
PTAC (cooling mode) new construction	<2.0 kW	35 C DB *Outdoor air*	3.49 COP_C	ARI 310/380
	≥ 2.0 kW and <2.9 kW	35 C DB *Outdoor air*	3.31 COP_C	
	≥ 2.9 kW and < 3.8 kW	35 C DB *Outdoor air*	3.14 COP_C	
	≥ 3.8 kW	35 C DB *Outdoor air*	3.48 COP_C	
PTAC (cooling mode) replacement[b]	<2.0 kW	35 C DB *Outdoor air*	3.49 COP_C	ARI 310/380
	≥ 2.0 kW and <2.9 kW	35 C DB *Outdoor air*	3.31 COP_C	
	≥ 2.9 kW and < 3.8 kW	35 C DB *Outdoor air*	3.14 COP_C	
	≥ 3.8 kW	35 C DB *Outdoor air*	3.48 COP_C	
PTHP (cooling mode) new construction	<2.0 kW	35 C DB *Outdoor air*	3.48 COP_C	ARI 310/380
	≥ 2.0 kW and <2.9 kW	35 C DB *Outdoor air*	3.48 COP_C	
	≥ 2.9 kW and < 3.8 kW	35 C DB *Outdoor air*	3.48 COP_C	
	≥ 3.8 kW	35 C DB *Outdoor air*	3.48 COP_C	
PTHP (heating mode) new construction	All capacities	35 C DB *Outdoor air*	2.8 COP_H	ARI 310/380
PTHP (cooling mode) replacement[b]	<2.0 kW	35 C DB *Outdoor air*	3.43 COP_C	ARI 310/380
	≥ 2.0 kW and <2.9 kW	35 C DB *Outdoor air*	3.25 COP_C	
	≥ 2.9 kW and < 3.8 kW	35 C DB *Outdoor air*	3.08 COP_C	
	≥ 3.8 kW	35 C DB *Outdoor air*	2.73 COP_C	
PTHP (heating mode) replacement[b]	All capacities	35 C DB *Outdoor air*	2.8 COP_H	ARI 310/380

a. Section 11 contains a complete specification of the referenced test procedures, including year version of the test procedure.
b. Replacement units shall be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 in. high and less than 42 in. wide.

**TABLE C-5 (Supersedes Table 6.8.1D in ANSI/ASHRAE/IESNA Standard 90.1)
Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single Packaged Vertical Air Conditioners, Single Packaged Vertical Heat Pumps, Room Air Conditioners and Room Air Conditioners Heat Pumps—Minimum Efficiency Requirements (SI)**

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
SPVAC (cooling mode)	<19 kW	35 C DB/23.9 C WB *Outdoor air*	2.93 COP_c	ARI 390
	≥ 19 kW and < 40 kW Btu/h	35 C DB/23.9 C WB *Outdoor air*	3.37 COP_C	
	≥ 40kW and < 70 kW	35 C DB/23.9 C WB *Outdoor air*	3.37 COP_C	
SPVHP (cooling mode)	<19 kW	35 C DB/23.9 C WB *Outdoor air*	2.93 COP_c	
	≥ 19 kW and < 40 kW Btu/h	35 C DB/23.9 C WB *Outdoor air*	3.37 COP_C	
	≥ 40kW and < 70 kW	35 C DB/23.9 C WB *Outdoor air*	3.37 COP_C	
SPVHP (heating mode)	<19 kW	8.3 CF DB/6.1 C WB *Outdoor air*	3.0 COP_H	
	≥ 19 kW and < 40 kW Btu/h	8.3 CF DB/6.1 C WB *Outdoor air*	3.0 COP_H	
	≥ 40kW and < 70 kW	8.3 CF DB/6.1 C WB *Outdoor air*	2.9 COP_H	
Room air conditioners, with louvered sides	<1.8 kW		3.14 $SCOP_C$	ANSI/ AHAM RAC-1
	≥1.8 kW and < 2.3 kW		3.14 COP_C	
	≥2.3 kW and <4.1 kW		3.17 COP_C	
	≥4.1 kW and < 5.9 kW		3.14 COP_C	
	≥5.9 kW		2.73 COP_C	
Room air conditioners, without louvered sides	<2.3 kW		2.90 COP_C	
	≥2.3 kW and < 5.9 kW		2.73 COP_C	
	≥5.9 kW		2.73 COP_C	
Room air conditioner heat pump with louvered sides	<5.9 kW		2.90 COP_C	
	≥5.9 kW		2.73 COP_C	
Room air conditioner heat pump without louvered sides	<4.1 kW		2.73 COP_C	
	≥4.1 kW		2.58 COP_C	
Room air conditioner, casement only	All Capacities		2.81 COP_C	
Room air conditioner, casement-slider	All Capacities		3.05 COP_C	

a. Section 11 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

TABLE C-6 (Supersedes Table 6.8.1E in ANSI/ASHRAE/IESNA Standard 90.1) Warm Air Furnace and Combustion Warm Air Furnaces/Air Conditioning Units, Warm Air Duct Furnaces and Unit Heaters (SI)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Test Procedure[b]	Minimum Efficiency[a]
Warm air furnace, gas-fired (weatherized)	<65.9 kW	Maximum capacity[d]	DOE 10 CFR Part 430 or ANSI Z21.47	78% AFUE or 80% E_t[c,e]
	>65.9 kW	Maximum capacity[d]	ANSI Z21.47	80% E_c[c,e]
Warm air furnace, gas-fired- (non-weathersized)	<65.9 kW	Maximum capacity[d]	DOE 10 CFR Part 430 or ANSI Z21.47	90% AFUE or 92% E_t[c,e]
	>65.9 kW	Maximum capacity[d]	ANSI Z21.47	92% E E_c[c,e]
Warm air furnace, oil-fired (weatherized)	<65.9 kW	Maximum capacity[d]	DOE 10 CFR Part 430 or UL 727	78% AFUE or 80% E_t[c,e]
	>65.9 kW	Maximum capacity[d]	UL 727	81% E_t[e]
Warm air furnace, oil-fired (non-weathersized)	<65.9 kW	Maximum capacity[d]	DOE 10 CFR Part 430 or UL 727	85% AFUE or 87%% E_t[c,e]
	>65.9 kW	Maximum capacity[d]	UL 727	87% E_t[e]
Warm air duct furnaces, gas-fired (weatherized)	All capacities	Maximum capacity[d]	ANSI Z83.9	80% E_c[f]
Warm air duct furnaces, gas-fired (non-weathersized)	All capacities	Maximum capacity[d]	ANSI Z83.9	90% E_c[f]
Warm air unit heaters, gas-fired (non-weathersized)	All capacities	Maximum capacity[d]	ANSI Z83.8	90% E_c[f,g]
Warm air unit heaters, oil-fired (non-weathersized)	All capacities	Maximum capacity[d]	UL 731	90% E_c[f,g]

a. E_t = thermal efficiency. See test procedure for detailed discussions.
b. Section 11 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c. Combustion units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 19.0 kW) may comply with either rating.
d. Minimum and maximum ratings as provided for and allowed by the unit's controls.
e. Units shall 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 flue damper. A vent damper is an acceptable alternative to the fuel damper for those furnaces where combustion air is drawn from the *conditioned space*.
f. E_c = combustion efficiency (100% less flue losses) See test procedures for detailed discussion.
g. As of August 8, 2008, according to the Energy Policy Act of 2005, units shall also include an interrupted or intermittent ignition devices (IID) and have either power venting or automatic flue dampers. A vent damper is an acceptable alternative to a flue damper for those unit heaters where combustion air is drawn from the *conditioned space*.

TABLE C-7 (Supersedes Table 6.8.1F in ANSI/ASHRAE/IESNA Standard 90.1) Gas and Oil Fired Boilers—Minimum Efficiency Requirements (SI)

Equipment Type[a]	Subcategory or Rating Condition	Size Category (Input)	Efficiency[b,c]	Test Procedure[g]
Boilers, hot water	Gas-fired	<87.9 kW	89 % AFUE[f]	10 CFR Part 430
		≥87.9 kW and <732.7 kW[d]	89% E_t[f]	10 CFR Part 431
		≥732.7 kW[a]	91% E_c[f]	
	Oil-fired[e]	<87.9 kW	89 % AFUE[f]	10 CFR Part 430
		≥87.9 kW and <732.7 kW[d]	89% E_t[f]	10 CFR Part 431
		≥732.7 kW[a]	91% E_c[f]	
Boilers, steam	Gas-fired	<87.9 kW	75% AFUE	10 CFR Part 430
	Gas-fired all, except natural draft	≥87.9 kW and <732.7 kW[d]	79% E_t	10 CFR Part 431
		≥732.7 kW[a]	79% E_t	
	Gas-fired natural draft	≥87.9 kW and <732.7 kW[d]	77% E_t	
		≥732.7 kW[a]	77% E_t	
	Oil-fired[e]	<87.9 kW	80% E_t	10 CFR Part 430
		≥87.9 kW and <732.7 kW[d]	81% E_t	10 CFR Part 431
		≥732.7 kW[a]	81% E_t	

a. These requirements apply to boilers with rated input of 2,344 kW 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 = thermal 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. Systems shall be designed with lower operating return hot water temperatures (<55 C) and use hot water reset to take advantage of the higher efficiencies of condensing boilers.
g. Section 11 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

TABLE C-8 (Supersedes Table 6.8.1G in ANSI/ASHRAE/IESNA Standard 90.1) Performance Requirements for Heat Rejection Equipment (SI)

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Rating Standard	Rating Conditions	Performance Required[a,b]
Open-loop propeller or axial fan cooling towers[a]	All	CTI ATC-105 and CTI STD-201	35°C entering water 29.4°C leaving water 23.9°C wb entering air	>3.38 L/s kW
Closed-loop propeller or axial fan cooling towers[b]	All	CTI ATC-105 and CTI STD-201	38.9°C entering water 32.2°C leaving water 23.9°C wb entering air	>1.27 L/s kW
Open-loop centrifugal fan cooling towers[a]	All	CTI ATC-105 and CTI STD-201	35°C entering water 29.4°C leaving water 23.9°C wb entering air	>1.86 L/s kW
Closed-loop centrifugal fan cooling towers[b]	All	CTI ATC-105 and CTI STD-201	38.9°C entering water 32.2°C leaving water 23.9°C wb entering air	>0.68 L/s kW
Air-cooled condensers	All	ARI 460		Not applicable, air cooled condenser shall be matched to the HVAC system and rated per Table C-3

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 this table divided by the fan nameplate rated 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 this table divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.

TABLE C-9 (Supersedes Table 6.8.2A in ANSI/ASHRAE/IESNA Standard 90.1) Minimum Duct Insulation R-Value[a] Cooling and Heating Only Supply Ducts and Return Ducts (SI)

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with Roof Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Heating Ducts Only							
1, 2	None	None	None	None	None	None	None
3	R-1.06	None	None	None	R-1.06	None	None
4	R-1.06	None	None	None	R-1.06	None	None
5	R-1.41	R-1.06	None	None	R 1.06	None	R-1.06
6	R-1.41	R-1.41	R-1.06	None	R 1.06	None	R-1.06
7	R-1.76	R-1.41	R-1.41	None	R-1.06	None	R-1.06
8	R-1.76	R-10	R-1.41	None	R-1.41	None	R-1.41
Cooling Only Ducts							
1	R-1.06	R-1.41	R-10	R-1.06	R-1.06	None	R-1.06
2	R-1.06	R-1.41	R-10	R-1.06	R-1.06	None	R-1.06
3	R-1.06	R-1.41	R-1.41	R-1.06	R-0.62	None	None
4	R-0.62	R-1.06	R-1.41	R-0.62	R-0.62	None	None
5, 6	R-0.62	R-0.62	R-1.06	R-0.62	R-0.62	None	None
7, 8	R-1.9	R-0.62	R-0.62	R-0.62	R-0.62	None	None
Return Ducts							
1 to 8	R-1.06	R-1.06	R-1.06	None	None	None	None

a Insulation R-values, measured in m2 k/kW, 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 exterior *walls* are used as plenum *walls*, *wall* insulation shall be as required by the most restrictive condition of this table or Section 7.4.2. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 23.8 C at the installed thickness.
b Includes crawl spaces, both ventilated and non-ventilated.
c Includes return air plenums with or without exposed *roofs* above.

TABLE C-10 (Supersedes Table 6.8.2B in ANSI/ASHRAE/IESNA Standard 90.1) Minimum Duct Insulation R-Value[a], Combined Heating and Cooling Supply Ducts and Return Ducts (SI)

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic w/ *Roof* Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Supply Ducts							
1	R-1.41	R-1.41	R-1.76	R-1.06	R-1.06	None	R-1.06
2	R-1.41	R-1.41	R-1.41	R-1.06	R-1.41	None	R-1.06
3	R-1.41	R-1.41	R-1.41	R-1.06	R-1.41	None	R-1.06
4	R-1.41	R-1.41	R-1.41	R-1.06	R-1.41	None	R-1.06
5	R-1.41	R-1.41	R-1.41	R-0.62	R-1.41	None	R-1.06
6	R-1.76	R-1.41	R-1.41	R-0.62	R-1.41	None	R-1.06
7	R-1.76	R-1.41	R-1.41	R-0.62	R-1.41	None	R-1.06
8	R-1.76	R-1.94	R-1.94	R-0.62	R-1.41	None	R-1.41
Return Ducts							
1 to 8	R-1.06	R-1.06	R-1.06	None	None	None	None

a Insulation R-values, measured in m2 k/kW, 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 exterior *walls* are used as plenum *walls*, *wall* insulation shall be as required by the most restrictive condition of this table or Section 7.4.2. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 23.8 C at the installed thickness."
b Includes crawl spaces, both ventilated and non-ventilated.
c Includes return air plenums with or without exposed *roofs* above.

TABLE C-11 (Supersedes Table 6.8.3 in ANSI/ASHRAE/IESNA Standard 90.1) Minimum Pipe Insulation Thickness[a] (SI)

Fluid Design Operating Temp. Range (°C)	Insulation Conductivity		Nominal Pipe or Tube Size (mm)				
	Conductivity kW/(h·m^2 °K)	Mean Rating Temp. °C	<25	25 to < 38	38 to < 102	102 to <203	≥203
Heating Systems (Steam, Steam Condensate, and Hot Water)[b,c]							
>176.7	1.82-1.93	121.1	76	89	89	114	114
121.7-176.7	1.65-1.82	200	51	76	89	89	89
93.9-121.1	1.53-1.70	150	51	51	63	63	63
60.6-93.3	1.42-1.65	125	38	38	38	51	51
40.6-60.0	1.25-1.59	100	25	25	38	38	38
Domestic and Service Hot Water Systems							
40.6+	1.25-1.59	100	25	25	38	38	38
Cooling Systems (Chilled Water, Brine, and Refrigerant)d							
4.4-15.6	1.25-1.59	100	25	25	38	38	38
<4.4	1.25-1.59	100	25	38	38	38	51

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 (mm), r = actual outside radius of pipe (mm), 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 (kW/(h-m2 K); 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 Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within 1.2 m of the coil and the pipe size is 25 mm or less."
d 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.

TABLE C-12 (Supersedes Table 7.8 in ANSI/ASHRAE/IESNA Standard 90.1)
Performance Requirements for Water Heating Equipment (SI)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required [a]	Test Procedure [b]
Electric water heaters	12 kW	Resistance > 75.7L	EF ≥ 0.97-0.00132V	DOE 10 CFR Part 430
	>12 kW	Resistance > 75.7L	SL ≤ 20 + 35 $\sqrt{V}$, W	ANSI Z21.10.3
	All	Heat Pump	EF ≥ 2.0	DOE 10 CFR Part 430
Gas storage water heaters	<22.98 kW	Resistance > 75.7L	EF ≥ 0.67	DOE 10 CFR Part 430
	>22.98 kW	<309.75 W/L	E_t ≥ 80% and SL ≤ (Q/800 + 110 $\sqrt{V}$), W	ANSI Z21.10.3
Gas instantaneous water heaters	>14.66 kW and <58.62 kW	>309.75 W/L and <7 L	EF ≥ 0.82	DOE 10 CFR Part 430
	>58.62 kW[c]	>309.75 W/L and <37.5 L	E_t ≥ 80%	ANSI Z21.10.3
	>58.62 kW	>309.75 W/L and <37.5 L	E_t ≥ 80% and SL ≤ (Q/800 + 110 $\sqrt{V}$), W	
Oil storage water heaters	<30.78 kW	Resistance >75.7L	EF ≥ 0.59 – 0.0019V	DOE 10 CFR Part 430
	>30.78 kW	<309.75 W/L	E_t ≥ 78% and SL ≤ (Q/800 + 110 $\sqrt{V}$), W	ANSI Z21.10.3
Oil instantaneous water heaters	<61.55 kW	≥309.75 W/L and < 7.56 L	EF ≥ 0.59 – 0.0019V	DOE 10 CFR Part 430
	>61.55 kW	≥309.75 W/L and < 37.5 L	E_t ≥ 80%	ANSI Z21.10.3
	>61.55 kW	≥309.75 W/L and ≥37.5 L	E_t ≥ 78% and SL ≤ (Q/800 + 110 $\sqrt{V}$) , W	
Hot-water supply boilers, gas and oil	61.55 kW and <3663.8 kW	≥309.75 W/L and < 37.5 L	E_t ≥ 80%	ANSI Z21.10.3
Hot-water supply boilers, gas		≥309.75 W/L and ≥37.5 L	E_t ≥ 80% and SL ≤ (Q/800 + 110 $\sqrt{V}$), W	
Hot-water supply boilers, oil		≥309.75 W/L and ≥37.5 L	E_t ≥ 78% and SL ≤ (Q/800 + 110 $\sqrt{V}$), W	
Pool heaters oil and gas	All		E_t ≥ 78%	ASHRAE 146
Heat pump pool heaters	All		≥4.0 COP	ASHRAE 146
Unfired storage tanks	All		≥R-12.5	(none)

a Energy factor (EF) and thermal efficiency (Et) are minimum requirements, while standby loss (SL) is maximum W based on a 21.1 C temperature difference between stored water and ambient requirements. In the EF equation, V is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and Q is the nameplate input rate in kW

b Section 11 contains a complete specification, including the year version, of the referenced test procedure.

c Instantaneous water heaters with input rates below 58.62 kW shall comply with these requirements if the water heater is designed to heat water to temperatures 82.2°C or higher."

TABLE C-13 Minimum Nominal Efficiency for General Purpose Design A and Design B Motors[a] (SI)

	Minimum Nominal Full-Load Efficiency (%)[a]					
	Open Motors			Enclosed Motors		
Number of Poles ==>	**2**	**4**	**6**	**2**	**4**	**6**
Synchronous Speed (RPM) ==>	**3600**	**1800**	**1200**	**3600**	**1800**	**1200**
Motor Size (kW)						
0.7	77.0	85.5	82.5	77.0	85.5	82.5
1.1	84.0	86.5	86.5	84.0	86.5	87.5
1.5	85.5	86.5	87.5	85.5	86.5	88.5
2.2	85.5	89.5	88.5	86.5	89.5	89.5
3.7	86.5	89.5	89.5	88.5	89.5	89.5
5.6	88.5	91.0	90.2	89.5	91.7	91.0
7.5	89.5	91.7	91.7	90.2	91.7	91.0
11.2	90.2	93.0	91.7	91.0	92.4	91.7
14.9	91.0	93.0	92.4	91.0	93.0	91.7
18.7	91.7	93.6	93.0	91.7	93.6	93.0
22.4	91.7	94.1	93.6	91.7	93.6	93.0
29.8	92.4	94.1	94.1	92.4	94.1	94.1
37.3	93.0	94.5	94.1	93.0	94.5	94.1
44.8	93.6	95.0	94.5	93.6	95.0	94.5
56.0	93.6	95.0	94.5	93.6	95.4	94.5
74.6	93.6	95.4	95.0	94.1	95.4	95.0
93.3	94.1	95.4	95.0	95.0	95.4	95.0
111.9	94.1	95.8	95.4	95.0	95.8	95.8
149.2	95.0	95.8	95.4	95.4	96.2	95.8
186.5	95.0	95.8	95.4	95.8	96.2	95.8
223.8	95.4	95.8	95.4	95.8	96.2	95.8
261.1	95.4	95.8	95.4	95.8	96.2	95.8
298.4	95.8	95.8	95.8	95.8	96.2	95.8
335.7	95.8	96.2	96.2	95.8	96.2	95.8
373.0	95.8	96.2	96.2	95.8	96.2	95.8

a Nominal efficiencies shall be established in accordance with NEMA Standard MG1. Design A and Design B are National Electric Manufacturers Association (NEMA) design class designations for fixed frequency small and medium AC squirrel-cage induction motors.

TABLE C-14 Commercial Refrigerator & Freezers (SI)

Equipment Type	Application	Energy Use Limit (kW/h per day)
Refrigerators with solid doors	Holding temperature	2.831 V + 57.75
Refrigerators with transparent doors		3.40 V + 94.55
Freezers with solid doors		11.32 V + 39.07
Freezers with transparent doors		21.23 V + 116.07
Refrigerators/freezers with solid doors		the greater of 3.40 V + 94.55 or 19.82
Commercial Refrigerators	Pulldown	1.26 V + 99.37

V means the chiller or frozen compartment volume (Liters) as defined in the Association of Home Appliance Manufacturers Standard HRF1-1979

TABLE C-15 Commercial Clothes Washers (SI)

Product	MER	WF
All commercial clothes washers	48.7	30.3

MER = Modified Energy Factor, a combination of Energy Factor and MEF=Modified Energy Factor, a combination of Energy Factor and Remaining Moisture Content. MEF measures energy consumption of the total laundry cycle (washing and drying). It indicates how many liters of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX D PERFORMANCE OPTION FOR ENERGY EFFICIENCY

Note: Appendix D is essentially identical to Appendix G in ANSI/ASHRAE/IESNA Standard 90.1; however, there are some differences. Thus, care should be given to ensure that the correct standard and proper appendix is being used.

D1. GENERAL

D1.1 Performance Option Scope. This building performance option is a modification of the Energy Cost Budget (ECB) Method in Section 11 of ANSI/ASHRAE/IESNA Standard 90.1 and Appendix G of ANSI/ASHRAE/IESNA Standard 90.1. This appendix offers an alternative to Section 7.4 for compliance with ANSI/ASHRAE/USGBC/IESNA Standard 189.1. Also, it is provided for those wishing to use the methodology developed for this standard to quantify performance that substantially exceeds the requirements of ANSI/ASHRAE/USGBC/IESNA Standard 189.1. It may be useful for evaluating the performance of all proposed designs, including alterations and additions to existing buildings, except designs with no mechanical systems.

D1.2 Performance Option. This performance option requires conformance with the following provisions:

a. All requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 of ANSI/ASHRAE/IESNA Standard 90.1 and Section 7.3 are complied with. These sections contain the mandatory provisions of the standard, and are prerequisites.
b. The proposed design shall only vary from requirements in Section 7.4 where those variations have been accurately and completely modeled. Where variations are not specifically analyzed (e.g., the requirements in Section 7.4.3.11 for pipe insulation), the proposed design shall comply with those requirements.
c. The improved performance of the proposed building design is calculated in accordance with provisions of this appendix using the following formula:

Example: Percentage improvement = 100 × (Baseline building performance − Proposed building performance) / Baseline building performance

Notes:

1. Both the proposed building performance and the baseline building performance shall include all end-use load components, such as receptacle and process loads.
2. Neither the proposed building performance nor the baseline building performance are predictions of actual energy consumption or costs for the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this procedure, changes in energy rates between design of the building and occupancy, and the precision of the calculation tool.

D1.3 Trade-Off Limits. When the proposed modifications apply to less than the whole building, only parameters related to the systems to be modified shall be allowed to vary. Parameters relating to unmodified existing conditions or to future building components shall be identical for determining both the baseline building performance and the proposed building performance. Future building components shall comply with the prescriptive requirements of Sections 5.5, 6.5, 7.5, 9.5, and 9.6 of ANSI/ASHRAE/IESNA Standard 90.1 and Section 7.4.

D1.4 Documentation Requirements. Simulated performance shall be documented, and documentation shall be submitted to the *AHJ*. The information submitted shall include the following:

a. Calculated values for the baseline building performance, the proposed building performance, and the percentage improvement.
b. A list of the energy-related features that are included in the design and on which the performance is based. This list shall document all energy features that differ between the models used in the baseline building performance and proposed building performance calculations.
c. Input and output report(s) from the simulation program or compliance software, including a breakdown of energy usage by at least the following components: interior lighting, façade lighting, parking lighting, space heating, space cooling, interior fans, parking garage fans, pumps, *service water heating*, office equipment, elevators and escalators, refrigeration, commercial cooking, and energy production by *on-site renewable energy systems*. 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 baseline building design.
d. An explanation of any error messages noted in the simulation program output.

D2. SIMULATION GENERAL REQUIREMENTS

D2.1 Performance Calculations. The proposed building performance and baseline building performance shall be calculated using the following:

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

D2.2 Simulation Program. The simulation program shall be a computer-based program for the analysis of energy consumption in buildings. 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 D2.5 may be used.

D2.2.1 The simulation program shall be approved by the *AHJ* and shall, at a minimum, have the ability to explicitly model all of the following:

a. 8760 hours per year
b. Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, 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 cooling equipment
g. Air-side economizers with integrated control
h. Inputs from *on-site renewable energy systems* (the renewable energy modeling program that is used must at a minimum be able to calculate monthly results)
i. Baseline building design characteristics specified in Section D3.

D2.2.2 The simulation program shall have the ability to either directly determine the proposed building performance and baseline building performance or produce hourly reports of energy use by an energy source suitable for determining the proposed building performance and baseline building performance using a separate calculation engine.

D2.2.3 The simulation program shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with *generally accepted engineering standards* and handbooks for both the proposed design and baseline building design.

D2.2.4 The simulation program shall be tested according to ANSI/ASHRAE Standard 140, and the results shall be furnished by the software provider.

D2.3 Climate Data. The simulation program shall perform the simulation using hourly values of climate data, such as temperature and humidity from representative climate data, for the *site* in which the proposed design is to be located. For cities or urban regions with several climate data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction *site*. The selected weather data shall be approved by the *AHJ*.

D2.4 Energy Rates. Annual energy costs shall be determined using either actual rates for purchased energy or published state EIA Average Energy Prices for commercial building customers, but rates from different sources may not be mixed in the same project.

Informative Note: The above provision allows users to gain credit for features that yield load management benefits. Where such features are not present, users can simply use state average unit prices from EIA.

Exception: On-site renewable energy sources or *site*-recovered energy shall not be considered to be purchased energy and shall not be assigned an energy cost in the baseline building performance or in the proposed building performance. Where on-site renewable or site-recovered sources are used as the primary energy source in the proposed building, the portion of the baseline building performance that is not provided by an *on-site renewable energy system* shall be based on the energy source used as the backup energy source or on the use of electricity if no backup energy source has been specified.

D2.5 Exceptional Calculation Methods. Where no simulation program is available that adequately models a design, material, or device, the *AHJ* may approve an exceptional calculation method to demonstrate above-standard performance using this method. Applications for approval of an exceptional method shall include documentation of the calculations performed and theoretical and/or empirical information supporting the accuracy of the method.

D3. CALCULATION OF THE PROPOSED AND BASELINE BUILDING PERFORMANCE

D3.1 Building Performance Calculations. The simulation model for calculating the proposed and baseline building performance shall be developed in accordance with the requirements in Table D3.1.

D3.1.1 Baseline HVAC System Type and Description. HVAC systems in the baseline building design shall be based on usage, number of floors, conditioned floor area, and heating source, as specified in Table D3.1.1A, and shall conform with the system descriptions in Table D3.1.1B. For systems 1, 2, 3, and 4, 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 can be grouped for modeling purposes.

Exceptions:

1. Use additional system type(s) for non-predominant conditions (i.e., *residential*/*nonresidential* or heating source) if those conditions apply to more than 20,000 ft^2 (2000 m^2) of conditioned floor area.
2. If the baseline HVAC system type is 5, 6, 7, or 8, use separate single-zone systems conforming with the requirements of System 3 or System 4 (depending on building heating source) for any spaces that have occupancy or process loads or schedules that differ significantly from the rest of the building. Peak thermal loads that differ by 10 (Btu/h)/ft^2 (30 W/m^2) or more from the average of other spaces served by 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, computer server rooms, natatoriums, and continually-occupied security areas.
3. If the baseline HVAC system type is 5, 6, 7, or 8, use separate single-zone systems conforming with the requirements of System 3 or System 4 (depending on building heat source) for any zones having special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates.

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

No.	Proposed Building Performance	Baseline Building Performance
1.	**Design Model**	
	a. The simulation model of the proposed design shall be consistent with the design documents, including proper accounting of *fenestration* and opaque envelope types and areas; interior lighting power and controls; HVAC system types, sizes, and controls; and *service water heating* systems and controls. All end-use load components within and associated with the building shall be modeled, including, but not limited to, exhaust fans, parking garage ventilation fans, snow-melt and freeze-protection equipment, facade lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration, and cooking. Where the simulation program does not specifically model the functionality of the installed system, spreadsheets or other documentation of the assumptions shall be used to generate the power demand and operating schedule of the systems.	The baseline building design shall be modeled with the same number of floors and identical conditioned floor area as the proposed design.
	b. All *conditioned spaces* in the proposed design shall be simulated as being both heated and cooled even if no heating or cooling system is to be installed, and temperature and humidity control set-points and schedules shall be the same for proposed and baseline building designs.	
	c. When the performance option is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the proposed design exactly as they are defined in the baseline building design. Where the space classification for a space is not known, the space shall be categorized as an office space.	
2.	**Additions and Alterations**	
	It is acceptable to predict performance using building models that exclude parts of the existing building provided that all of the following conditions are met: a. Work to be performed in excluded parts of the building shall comply with the requirements of 7.3 and 7.4. b. Excluded parts of the building are served by HVAC systems that are entirely separate from those serving parts of the building that are included in the building model. c. Design space temperature and HVAC system operating set-points and schedules on either side of the boundary between included and excluded parts of the building are essentially the same. d. If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the building are on the same utility meter, the rate shall reflect the utility block or rate for the building plus the addition.	Same as Proposed Design
3.	**Space Use Classification**	
	Usage shall be specified using the building type or space type lighting classifications in accordance with Section 9.5.1 or 9.6.1 of ANSI/ASHRAE/IESNA Standard 90.1. The user shall specify the space use classifications using either the building type or space type categories but shall not combine the two types of categories. More than one building type category may be used in a building if it is a mixed-use facility. If space type categories are used, the user may simplify the placement of the various space types within the building model, provided that building-total areas for each space type are accurate.	Same as Proposed Design

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

4.	**Schedules**	
	Schedules capable of modeling hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and HVAC system operation shall be used. The schedules shall be typical of the proposed building type as determined by the designer and approved by the *AHJ*. **HVAC Fan Schedules**. Schedules for HVAC fans shall run continuously whenever spaces are occupied and shall be cycled on and off to meet heating and cooling loads during unoccupied hours. **Exceptions to HVAC Fan Schedules:** 1. Where no heating and/or cooling system is to be installed and a heating or cooling system is being simulated only to comply with the requirements described in this table, heating and/or cooling system fans shall not be simulated as running continuously during occupied hours but shall be cycled on and off to meet heating and cooling loads during all hours. 2. HVAC fans shall remain on during occupied and unoccupied hours in spaces that have health and safety mandated minimum ventilation requirements during unoccupied hours.	Same as Proposed Design. **Exception:** Schedules may be allowed to differ between proposed design and baseline building design when necessary to model non-standard efficiency measures for those cases where the measures exceed the requirements in this standard, provided that the revised schedules have the approval of the *AHJ*. Measures that may warrant use of different schedules include, but are not limited to, lighting controls in addition to those required by 7.4.6, natural ventilation in addition to the *outdoor air* quantities required by 8.3.1, *DCV* in addition to that required by 7.4.3, and measures that reduce *service water heating* loads in addition to that required by 6.3.2, 6.4.2, 7.4.4, and 7.4.7.

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

5. Building Envelope	
All components of the *building envelope* in the proposed design shall be modeled as shown on architectural drawings or as built for existing *building envelopes*. **Exceptions:** The following building elements are permitted to differ from architectural drawings. 1. All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate floor stabs, concrete floor beams over parking garages) shall be separately modeled using either of the following techniques: a. Separate model of each of these assemblies within the energy simulation model. b. Separate calculation of the U-factor for each of these assemblies. The U-factors of these assemblies are then averaged with larger adjacent surfaces using an area-weighted average method. This average U-factor is modeled within the energy simulation model. Any other envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior *walls*) need not be separately described provided that it is similar to an assembly being modeled. If not separately described, the area of an envelope assembly shall be added to the area of an assembly of that same type with the same orientation and thermal properties. 2. Exterior surfaces whose azimuth orientation and tilt differ by less than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers. 3. For exterior *roofs*, the *roof* surface shall be modeled with a reflectance of 0.45 if the reflectance of the proposed design *roof* is greater than 0.70 and its emittance is greater than 0.75. Reflectance values shall be based on testing in accordance with ASTM C1549, or ASTM E1918, and emittance values shall be based on testing in accordance with ASTM C1371 or ASTM E408, and *SRI* shall be based on ASTM E1980 calculated at medium wind speed. All other *roof* surfaces shall be modeled with a reflectance of 0.30. Manual *fenestration* shading devices such as blinds or shades shall not be modeled. Automatically controlled *fenestration* shades or blinds may be modeled. Permanent shading devices such as fins, overhangs, and light shelves may be modeled.	Equivalent dimensions shall be assumed for each exterior envelope component type as in the proposed design; i.e., the total gross area of exterior *walls* shall be the same in the proposed and baseline building designs. The same shall be true for the areas of *roofs*, floors, and doors, and the exposed perimeters of concrete slabs on grade shall also be the same in the proposed and baseline building designs. The following additional requirements shall apply to the modeling of the baseline building design: a. **Orientation.** The baseline building performance shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, 270 degrees, then averaging the results. The building shall be modeled so that it does not shade itself. b. **Opaque assemblies.** Opaque assemblies used for new buildings or additions shall conform with the following common, lightweight assembly types and shall match the appropriate assembly maximum U-factors in Tables A-1 through A-8: • *Roofs* – Insulation entirely above deck • Above-grade *walls*– Steel-framed • Floors – Steel-joist • Opaque door types shall match the proposed design and conform to the U-factor requirements from the same tables. • Slab-on-grade floors shall match the F-factor for unheated slabs from the same tables. Opaque assemblies used for alterations shall conform with Section 5.1.3 of ANSI/ASHRAE/IESNA Standard 90.1 as modified by 7.3 and 7.4. c. **Vertical Fenestration.** *Vertical fenestration areas* for new buildings and additions shall equal that in the proposed design or 40% of gross above-grade *wall area*, whichever is smaller, and shall be distributed uniformly in horizontal bands across the four orientations. *Fenestration* U-factors shall match the appropriate requirements in Tables A-1 through A-8 for the applicable *vertical fenestration* framing system type. *Fenestration SHGC* shall match the appropriate requirements in Tables A-1 through A-8 using the value for $SHGC_{all}$ provided that the *vertical fenestration* in the proposed building complies with 7.4.2.9. If not, then the *SHGC* for west-facing and east-facing *fenestration* in the baseline building shall be uniformly reduced until the *vertical fenestration* in the baseline building complies with 7.4.2.9. Using the *vertical fenestration area* specified above, the *vertical fenestration* visible light transmittance shall be determined so that the *vertical fenestration* complies with the effective aperture requirements in 8.4.1. All *vertical fenestration* shall be modeled as fixed and shall be assumed to be flush with the exterior *wall*, and with shading by a permanent projection complying with 7.4.2.5. Manual window shading devices such as blinds or shades shall not be modeled. The *fenestration areas* for envelope alterations shall reflect the limitations on area, U-factor, and *SHGC* as described in Section 5.1.3 of ANSI/ASHRAE/IESNA Standard 90.1 as modified by 7.3 and 7.4. d. **Skylights and Glazed Smoke Vents.** *Skylight* area shall be equal to that in the proposed building design or 5% of the *gross roof area* that is part of the *building envelope*, whichever is smaller, but not less than that required in 8.3.4. If the *skylight* area of the proposed building design is greater than 5% of the *gross roof area*, baseline *skylight* area shall be decreased by an identical percentage in all *roof* components in which *skylights* are located to reach the 5% *skylight*-to-roof ratio. *Skylight* orientation and tilt shall be the same as in the proposed building design. *Skylight* U-factor and *SHGC* properties shall match the appropriate requirements in Tables A-1 through A-8 and shall comply with the requirements in 8.3.4.2. e. **Roof albedo.** Those *roof* surfaces subject to 5.3.2.3 shall be modeled with a reflectivity of 0.45. All other *roof* surfaces shall be modeled with a reflectivity of 0.30. f. **Existing Buildings.** For existing *building envelopes*, the baseline building design shall reflect existing conditions prior to any revisions that are part of the scope of work being evaluated.

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

6.	**Lighting**	
	Lighting power in the proposed design shall be determined as follows: a. Where a complete lighting system exists, the actual lighting power shall be used in the model. b. Where a lighting system has been designed, lighting power shall be determined in accordance with Sections 9.1.3 and 9.1.4 of ANSI/ASHRAE/IESNA Standard 90.1. c. Where lighting neither exists nor is specified, lighting power shall be determined in accordance with the Building Area Method for the appropriate building type. d. Lighting system power shall include all lighting system components shown or provided for on the plans (including lamps and ballasts and task and furniture-mounted fixtures). **Exception to 6d.:** For multifamily living units, hotel/motel guest rooms, and other spaces in which lighting systems are connected via receptacles and are not shown or provided for on building plans, assume identical lighting power for the proposed and baseline building designs in the simulations. e. Lighting power for parking garages and building facades shall be modeled. f. Credit may be taken for the use of automatic controls for daylight utilization in excess of that required by 7.4.6, 8.3.7, and 8.4.1 but only if their operation is either modeled directly in the building simulation or modeled in the building simulation through schedule adjustments determined by a separate daylighting analysis approved by the *AHJ*. For automatic lighting controls in addition to those required for minimum code compliance under Section 9.4.1 of ANSI/ASHRAE/IESNA Standard 90.1 and 7.4.6, 8.3.7, and 8.4.1, credit may be taken for automatically controlled systems by reducing the connected lighting power by the applicable percentages listed in Table D3.2. Alternatively, credit may be taken for these devices by modifying the lighting schedules used for the proposed design, provided that credible technical documentation for the modifications are provided to the *AHJ*.	Lighting power in the baseline building design shall be determined using the same categorization procedure (building area or space function) and categories as the proposed design with lighting power set equal to the maximum allowed for the corresponding method and category in Section 9.2 of ANSI/ASHRAE/IESNA Standard 90.1 and 7.4.6. Automatic lighting controls shall be modeled in accordance with Section 9.4.1 of ANSI/ASHRAE/IESNA Standard 90.1 and 7.4.3.12 and 7.4.6. No additional automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in the baseline building design, as the lighting schedules used are understood to reflect the mandatory and prescriptive control requirements in this standard.
7.	**Thermal Blocks – HVAC Zones Designed**	
	Where HVAC zones are defined on HVAC design drawings, each HVAC zone shall be modeled as a separate thermal block. **Exception:** Different HVAC zones may be combined to create a single thermal block or identical thermal blocks to which multipliers are applied, provided that all of the following conditions are met: 1. The space use classification is the same throughout the thermal block. 2. All HVAC zones in the thermal block that are adjacent to glazed exterior *walls* face the same orientation or their orientations vary by less than 45 degrees. All of the zones are served by the same HVAC system or by the same kind of HVAC system.	Same as Proposed Design.

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

8.	**Thermal Blocks – HVAC Zones Not Designed**	
	Where the HVAC zones and systems have not yet been designed, *thermal blocks* shall be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following: a. Separate *thermal blocks* shall be assumed for interior and perimeter spaces. Interior spaces shall be those located greater than 15 ft (4.5 m) from an exterior *wall*. Perimeter spaces shall be those located within 15 ft (4.5 m) of an exterior *wall*. b. Separate *thermal blocks* shall be assumed for spaces adjacent to glazed exterior *walls*; a separate zone shall be provided for each orientation, except that orientations that differ by less than 45 degrees may be considered to be the same orientation. Each zone shall include all floor area that is 15 ft (4.5 m) or less from a glazed perimeter *wall*, except that floor area within 15 ft (4.5 m) of glazed perimeter *walls* having more than one orientation shall be divided proportionately between zones. c. Separate *thermal blocks* shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features. Separate *thermal blocks* shall be assumed for spaces having exterior ceiling or *roof* assemblies from zones that do not share these features.	Same as Proposed Design.
9.	**Thermal Blocks - Multifamily Residential Buildings**	
	Residential spaces shall be modeled using at least one thermal block per living unit, except that those units facing the same orientations may be combined into one thermal block. Corner units and units with *roof* or floor loads shall only be combined with units sharing these features.	Same as Proposed Design.
10.	**HVAC Systems**	
	The HVAC system type and all related performance parameters in the proposed design, such as equipment capacities and efficiencies, shall be determined as follows: a. Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. b. Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the standard rating conditions specified in 7.4.3.1 and Normative Appendix C if required by the simulation model. c. Where no heating system exists or no heating system has been specified, the heating system classification shall be assumed to be electric, and the system characteristics shall be identical to the system modeled in the baseline building design. Where no cooling system exists or no cooling system has been specified, the cooling system shall be identical to the system modeled in the baseline building design.	The HVAC system(s) in the baseline building design shall be of the type and description specified in D3.1.1, shall comply with the general HVAC system requirements specified in D3.1.2, shall comply with any system-specific requirements in D3.1.3 that are applicable to the baseline HVAC system type(s), and shall comply with 7.3 and 7.4.3.

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

11.	**Service Hot Water Systems**	
	The service hot water 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 hot water system exists, the proposed design shall reflect the actual system type using actual component capacities and efficiencies. b. Where a service hot water system has been specified, the service hot water model shall be consistent with design documents. c. Where no service hot water system exists or has been specified but the building will have service hot water loads, a service hot water system shall be modeled that matches the system in the baseline building design and serves the same hot water loads. For buildings that will have no service hot water loads, no service hot water system shall be modeled.	The service hot water system in the baseline building design shall use the same energy source as the corresponding system in the proposed design and shall conform with the following conditions: a. Where a complete service hot water system exists, the baseline building design shall reflect the actual system type using actual component capacities and efficiencies. b. Where a new service hot water system has been specified, the system shall be sized according to the provisions of Section 7.4.1 of ANSI/ASHRAE/IESNA Standard 90.1 and the equipment shall match the minimum efficiency requirements in 7.4.4 and the heat recovery requirements in 7.4.7.2 and 7.4.7.3. Where the energy source is electricity, the heating method shall be electrical resistance. c. Where no service hot water system exists or has been specified but the building will have service hot water loads, a service water system(s) using electrical-resistance heat and matching minimum efficiency requirements of 7.4.4 and the heat recovery requirements in 7.4.7.2 and 7.4.7.3 shall be assumed and modeled identically in the proposed and baseline building designs. d. For buildings that will have no service hot water loads, no service hot water heating shall be modeled. e. Where a combined system has been specified to meet both space heating and *service water heating* loads, the baseline building system shall use separate systems complying with the minimum efficiency requirements applicable to each system individually. f. For large, 24-hour-per-day facilities that comply with the prescriptive criteria for use of condenser heat recovery systems described in Section 6.5.6.2 of ANSI/ASHRAE/IESNA Standard 90.1, a system complying with the requirements of that section shall be included in the baseline building design regardless of the exceptions to 6.5.6.2. **Exception to 11f.:** If a condenser heat recovery system complying with the requirements described in Section 6.5.6.2 of ANSI/ASHRAE/IESNA Standard 90.1 cannot be modeled, the requirement for including such a system in the actual building shall be met as a prescriptive requirement in accordance with 6.5.6.2, and no heat-recovery system shall be included in the proposed or baseline building designs. g. Service hot-water energy consumption shall be calculated explicitly based upon the volume of service hot water required and the entering makeup water and the leaving service hot-water temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements. h. Where recirculation pumps are used to ensure prompt availability of service hot water at the end use, the energy consumption of such pumps shall be calculated explicitly. i. Service water loads and usage shall be the same for both the baseline building design and the proposed design and shall be documented by the calculation procedures described in Section 7.4.1 of ANSI/ASHRAE/IESNA Standard 90.1. **Exceptions to 11i.:** 1. Service hot-water usage can be demonstrated to be reduced by documented water conservation measures that reduce the physical volume of service water required in excess of that required by 6.3.2 and 6.4.2. Examples include even more efficient low-flow shower heads. Such reduction shall be demonstrated by calculations. 2. Service hot-water energy consumption can be demonstrated to be reduced by reducing the required temperature of service mixed water, by increasing the temperature, or by increasing the temperature of the entering makeup water. Examples include alternative sanitizing technologies for dishwashing and heat recovery to entering makeup water in excess of that required by 6.3.2, 6.4.2, and 7.4.7. Such reduction shall be demonstrated by calculations.

TABLE D3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

12.	**Receptacle and other Loads**	
	Receptacle and process loads, such as those for office and other equipment, shall be estimated based on the building type or space type category and shall be assumed to be identical in the proposed and baseline building designs, except as specifically authorized by the *AHJ*. These loads shall be included in simulations of the building and shall be included when calculating the baseline building performance and proposed building performance.	Other systems, such as motors covered by Section 10 of ANSI/ASHRAE/IESNA Standard 90.1 and 7.4.7, and miscellaneous loads shall be modeled as identical to those in the proposed design. Where there are specific efficiency requirements in Section 10 of ANSI/ASHRAE/IESNA Standard 90.1 and in 6.3.2, 6.4.2, and 7.4.7, these systems or components shall be modeled as having the lowest efficiency allowed by those requirements. Where no efficiency requirements exist, power and energy rating or capacity of the equipment shall be identical between the baseline building and the proposed design with the following exception: variations of the power requirements, schedules, or control sequences of the equipment modeled in the baseline building from those in the proposed design may be allowed by the *AHJ* based upon documentation that the equipment installed in the proposed design represents a significant verifiable departure from documented conventional practice. The burden of this documentation is to demonstrate that accepted conventional practice would result in baseline building equipment different from that installed in the proposed design. Occupancy and occupancy schedules may not be changed.
13.	**Modeling Limitations to the Simulation Program**	
	If the simulation program cannot model a component or system included in the proposed design explicitly, substitute a thermodynamically similar component model that can approximate the expected performance of the component that cannot be modeled explicitly.	Same as Proposed Design.

3. For laboratory spaces with a minimum of 5000 cfm (2500 L/s) of exhaust, use system type 5 or 7 that reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

D3.1.1.1 Purchased Heat. For systems using purchased hot water or steam, hot water or steam costs shall be based on actual utility rates, and on-site boilers shall not be modeled in the baseline building design.

D3.1.1.2 Purchased Chilled Water. For systems using purchased chilled water, the cooling source shall be modeled as purchased chilled water in both the proposed and baseline building designs. 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.

D3.1.1.3 Baseline HVAC System Requirements for Systems Utilizing Purchased Chilled Water and/or Purchased Heat. If the proposed building design uses purchased chilled water and/or purchased heat, the following modifications to the Baseline HVAC System Types in Table D3.1.1B shall be used.

D3.1.1.3.1 Purchased Heat Only. If the proposed building design uses purchased heat, but does not use purchased chilled water, then Table D3.1.1A and Table D3.1.1B shall be used to select the Baseline HVAC System Type, with the modifications listed below:

Purchased heat shall be substituted for the Heating Type in Table D3.1.1B. The same heating source shall be used in the proposed and baseline building design.

D3.1.1.3.2 Purchased Chilled Water Only. If the proposed building design uses purchased chilled water, but does not use purchased heat, then Table D3.1.1A and Table D3.1.1B shall be used to select the Baseline HVAC System Type, with the modifications listed below:

a. Purchased chilled water shall be substituted for the Cooling Types in Table D3.1.1B.
b. System 1 and 2 shall be constant volume fan-coil units with fossil fuel boiler(s).
c. System 3 and 4 shall be constant volume single-zone air handlers with fossil fuel furnace(s).
d. System 7 shall be used in place of System 5.
e. System 8 shall be used in place of System 6.

D3.1.1.3.3 Purchased Chilled Water and Purchased Heat. If the proposed building design uses purchased chilled water and purchased heat, then Table D3.1.1A and Table D3.1.1.B 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 D3.1.1B.
b. System 1 shall be constant volume fan-coil units.
c. System 3 shall be constant volume single-zone air handlers.
d. System 7 shall be used in place of System 5.

D3.1.1.3.4 On-Site Distribution Pumps. All on-site distribution pumps shall be modeled in both the baseline and proposed designs.

D3.1.2 General Baseline HVAC System Requirements. HVAC systems in the baseline building design shall conform to the general provisions in this section.

D3.1.2.1 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 Section 7.4.3.1. Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.

TABLE D3.1.1A Baseline HVAC System Types

Building Type	Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat	Electric and Other
Residential	System 1 – PTAC	System 2 - PTHP
Nonresidential and three floors or less and < 25,000 ft^2 (2500 m^2)	System 3 – PSZ-AC	System 4 – PSZ-HP
Nonresidential and four or five floors and < 25,000 ft^2 (2500 m^2) or five floors or less and 25,000 ft^2 to 150,000 ft^2 (2500 m^2 to 15,000 m^2)	System 5 - Packaged *VAV* w/ reheat	System 6 - Packaged *VAV* w/ PFP boxes
Nonresidential and more than five floors or >150,000 ft^2 (15,000 m^2)	System 7 - *VAV* w/reheat	System 8 - *VAV* w/PFP boxes

Notes:

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*.

Where no heating system is to be provided or no heating energy source is specified, use the "Electric and Other" heating source classification.

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.

For laboratory spaces with a minimum of 5000 cfm (2,500 L/s) of exhaust, use system type 5 or 7 and reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.

TABLE D3.1.1B Baseline System Descriptions

System No.	System Type	Fan Control	Cooling Type	Heating Type
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* w/ reheat	Packaged rooftop *VAV* with reheat	*VAV*	Direct expansion	Hot water fossil fuel boiler
6. Packaged *VAV* w/PFP boxes	Packaged rooftop *VAV* with reheat	*VAV*	Direct expansion	Electric resistance
7. *VAV* w/reheat	Packaged rooftop *VAV* with reheat	*VAV*	Chilled water	Hot water fossil fuel boiler
8. *VAV* w/PFP boxes	*VAV* with reheat	*VAV*	Chilled water	Electric resistance

Note: Reheat shall not exceed that specified in Section 7.4.3(g).
For purchased chilled water and purchased heat see Section D3.1.1.3.

D3.1.2.2 Equipment Capacities. The equipment capacities for the baseline building design shall be based on sizing runs for each orientation (per Table D3.1 No. 5a) 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. Unmet load hours for the proposed design or baseline building designs shall not exceed 300 (of the 8760 hours simulated), and unmet load hours for the proposed design shall not exceed the number of unmet load hours for the baseline building design by more than 50. If unmet load hours in the proposed design exceed the unmet load hours in the baseline building by more than 50, simulated capacities in the baseline building shall be decreased incrementally and the building resimulated until the unmet load hours are within 50 of the unmet load hours of the proposed design. If unmet load hours for the proposed design or baseline building design exceed 300, simulated capacities shall be increased incrementally, and the building with unmet loads resimulated until unmet load hours are reduced to 300 or less. Alternatively, unmet load hours exceeding these limits may be accepted at the discretion of the *AHJ* provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

D3.1.2.2.1 Sizing Runs. Weather conditions used in sizing runs to determine baseline equipment capacities may be based either on hourly historical weather files containing typical peak conditions or on design days developed using 99.6% heating design temperatures and 1% dry-bulb and 1% wet-bulb cooling design temperatures.

D3.1.2.3 Preheat Coils. If the HVAC system in the proposed design has a preheat coil and a preheat coil can be modeled in the baseline system, the baseline system shall be modeled with a preheat coil controlled in the same manner as the proposed design.

D3.1.2.4 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. If the supply fan is modeled as cycling and fan energy is included in the energy-efficiency rating of the equipment, fan energy shall not be modeled explicitly. 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.

D3.1.2.5 Ventilation. Minimum *outdoor air* ventilation rates shall be the same for the proposed and baseline building designs and shall comply with Section 8.3.1.1.

Exception: When modeling *DCV* in the proposed design when its use is not required by Section 7.4.3.2.

D3.1.2.6 Economizers. *Outdoor air* economizers shall be included on all baseline HVAC systems unless the individual unit size does not exceed the capacity specified in Section 7.4.3.4 and Table 7.4.3.4.A, and the total capacity of all systems without economizers in the *building project* does not exceed that specified in footnote a to Table 7.4.3.4.A. If an economizer is not required by Section 7.4.3.4.1 and Table 7.4.3.4.A, including footnote a, *outdoor air* economizers shall not be included in baseline HVAC Systems 1 and 2. If an economizer is not required by Section 7.4.3.4.2 and Table 7.4.3.4.A, including footnote a, *outdoor air* economizers shall be included in baseline HVAC Systems 3 through 8 based on climate as specified in Table D3.1.2.6.

Exceptions: Economizers shall not be included for systems complying with one or more of the exceptions listed below.

1. Systems that include gas-phase air cleaning to comply with the requirements of Section 6.1.2 of ANSI/ASHRAE Standard 62.1. This exception shall be used only if the system in the proposed design does not match 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.

D3.1.2.7 Economizer High-Limit Shutoff. The high-limit shutoff shall be differential enthalpy or differential dry-bulb as defined in Table 7.4.3.4.A.

D3.1.2.8 Design Air Flow Rates. System design supply air flow rates for the baseline building design shall be based on a supply-air-to-room-air temperature difference of 20°F (11°C). 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.

D3.1.2.9 Fan Power. Electrical power for supply, return, exhaust, and relief fans (excluding power to fan-powered *VAV* boxes) shall be calculated using the following formulas:

I-P units

For Systems 1 and 2,

$$P_{fan} = CFM_S \cdot 0.27$$

For Systems 3 through 8,

$$P_{fan} = bhp \times 746 / \textit{fan motor efficiency}$$

where

P_{fan} = electric power to fan motor (watts) and

bhp = brake horsepower of baseline fan motor from Table D3.1.2.9.

TABLE D3.1.2.6 Climate Conditions under which Economizers are Included for Baseline Systems 3 through 8

Climate Zone	Conditions
1A, 1B, 2A	N.R.
Others	Economizer included

N.R. means that there is no conditioned building floor area for which economizers are included for the type of zone and climate.

TABLE D3.1.2.9 Baseline Fan Power Limitation (I-P)

Baseline Fan Power Limitation	
Constant Volume Systems 3– 4	**Variable Volume Systems 5 – 8**
$bhp = \text{CFM}_s \cdot 0.000846 + A$	$bhp = \text{CFM}_s \cdot 0.00117 + A$

Where *A* is calculated according to Section 6.5.3.1.1 of ANSI/ASHRAE/IESNA Standard 90.1 using the pressure drop adjustment from the proposed building design and the design flow rate of the baseline building system. Do not include pressure drop adjustments for evaporative coolers or heat recovery devices that are not required in the baseline building system by Section D3.1.2.10.

TABLE D3.1.2.9 Baseline Fan Power Limitation (SI)

Baseline Fan Power Limitation	
Constant Volume Systems 3 – 4	**Variable Volume Systems 5 – 8**
Input kW$i = L/S_S \cdot 0.00135 + A$	Input kW$i = L/S_S \cdot 0.00189 + A$

Where *A* is calculated according to Section 6.5.3.1.1 of ANSI/ASHRAE/IESNA Standard 90.1 using the pressure drop adjustment from the proposed building design and the design flow rate of the baseline building system. Do not include pressure drop adjustments for evaporative coolers or heat recovery devices that are not required in the baseline building system by Section D3.1.2.10.

fan motor efficiency = the efficiency from Table C-13 for the next motor size greater than the bhp using the enclosed motor at 1800 rpm.

CFM_S = the baseline system maximum design supply fan airflow rate in cfm

where *A* is calculated according to Section 6.5.3.1.1 of ANSI/ASHRAE/IESNA Standard 90.1 using the pressure drop adjustment from the proposed building design and the design flow rate of the baseline building system. Do not include pressure drop adjustments for evaporative coolers or heat recovery devices that are not required in the baseline building system by Section D3.1.2.10.

SI units

For Systems 1 and 2,

$$P_{fan} = L/S_S \cdot 0.127$$

For Systems 3 through 8,

$$P_{fan} = \text{input kW}i \text{ x } 1000 \times \textit{fan motor efficiency}$$

where

P_{fan} = electric power to combined fan motor (watts) and

Input kW*i* = input kW of baseline combined fan input from Table D3.1.2.9.

fan motor efficiency = the efficiency from Table C-13 for the next motor size greater than the input kW using the enclosed motor at 1800 rpm.

L/S_S = the baseline system maximum design supply fan airflow rate in L/s.

D3.1.2.10 Exhaust Air Energy Recovery. Where required by 7.4.3.8, individual fan systems shall have energy recovery with at least 60% recovery effectiveness. Sixty percent energy recovery effectiveness shall mean a change in the enthalpy of the *outdoor air* supply equal to 60% 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.

Exceptions: 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 (16°C).
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. Heating operation for systems in *climate zones* 1 through 3.
4. Cooling operation for systems in *climate zones* 3C, 4C, 5B, 5C, 6B, 7, and 8.
5. Where the largest exhaust source is less than 75% of the design *outdoor air* flow. This exception shall only be used if exhaust air energy recovery is not used in the proposed design.
6. 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.
7. Systems serving laboratories with exhaust rates of 5000 cfm (2500 L/s) or greater.

D3.1.3 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.

D3.1.3.1 Heat Pumps (Systems 2 and 4). Electric air-source heat pumps shall be modeled with electric auxiliary heat. The systems shall be controlled with multi-stage space thermostats 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 (4°C).

D3.1.3.2 Type and Number of Boilers (Systems 1, 5, and 7). The boiler plant shall use the same fuel as the proposed design and shall be natural draft, except as noted under Section D3.1.1.1. 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 ft^2 (1500 m^2) or less and as having two equally sized boilers for *plants* serving more than 15,000 ft^2 (1500 m^2). Boilers shall be staged as required by the load.

D3.1.3.3 Hot-Water Supply Temperature (Systems 1, 5, and 7). Hot-water design supply temperature shall be modeled as 180°F (82°C) and design return temperature as 130°F (54°C).

D3.1.3.4 Hot-Water Supply Temperature Reset (Systems 1, 5, and 7). Hot-water supply temperature shall be reset based on outdoor dry-bulb temperature using the following schedule: 180°F at 20°F (82°C at −7°C) and below, 150°F at 50°F (66°C at 10°C) and above, and ramped linearly between 180°F and 150°F (82°C and 66°C) at temperatures between 20°F and 50°F (−7°C and 10°C).

D3.1.3.5 Hot-Water Pumps. The baseline building design hot-water pump power shall be 19 W/gpm (300 kW/1000 L/s). The pumping system shall be modeled as primary-only with continuous variable flow. Hot-water systems serving 120,000 ft^2 (12,000 m^2) or more shall be modeled with variable-speed drives, and systems serving less than 120,000 ft^2 (12,000 m^2) shall be modeled as riding the pump curve.

Exception: The pump power for systems using purchased heat shall be 14 W/gpm (0.9 W/lps).

D3.1.3.6 Piping Losses. Piping losses shall not be modeled in either the proposed or baseline building designs for hot water, chilled water, or steam piping.

D3.1.3.7 Type and Number of Chillers (Systems 7 and 8). Electric chillers shall be used in the baseline building design regardless of the cooling energy source, e.g., direct-fired absorption, absorption from purchased steam, or purchased chilled water. The baseline building design's chiller plant shall be modeled with chillers having the number and

TABLE D3.1.3.7 Type and Number of Chillers

Building Peak Cooling Load	Number and Type of Chiller(s)
≤ 300 tons (1050 kW)	1 water-chilled screw chiller
> 300 tons (1050 kW), < 600 tons (2100 kW)	2 water-chilled screw chillers sized equally
≥ 600 tons (2100 kW)	Two centrifugal chillers minimum with chillers added so that no chiller is larger than 800 tons(2800 kW), all sized equally

type as indicated in Table D3.1.3.7 as a function of building peak cooling load.

Exception: Systems using purchased chilled water shall be modeled in accordance with Section D3.1.1.3.

D3.1.3.8 Chilled-Water Design Supply Temperature (Systems 7 and 8). Chilled-water design supply temperature shall be modeled at 44°F (7°C) and return water temperature at 56°F (13°C).

D3.1.3.9 Chilled-Water Supply Temperature Reset (Systems 7 and 8). Chilled-water supply temperature shall be reset based on outdoor dry-bulb temperature using the following schedule: 44°F at 80°F (7°C at 27°C) and above, 54°F at 60°F (12°C at 16°C) and below, and ramped linearly between 44°F and 54°F (7°C and°12 C) at temperatures between 80°F and 60°F (27°C and 16°C).

D3.1.3.10 Chilled-Water Pumps. The baseline building design pump power shall be 22 W/gpm (350 kW/1000 L/s). Chilled-water systems with a cooling capacity of 300 tons (1050 kW) or more shall be modeled as primary/secondary systems with variable-speed drives on the secondary pumping loop. Chilled water pumps in systems serving less than 300 tons (1050 kW) cooling capacity shall be modeled as primary/secondary systems with secondary pump riding the pump curve.

Exception: The pump power for systems using chilled water shall be 16 W/gpm

D3.1.3.11 Heat Rejection (Systems 7 and 8). The heat rejection device shall be an axial fan cooling tower with two-speed fans. Condenser water design supply temperature shall be 85°F (29°C) or 10°F (6°C) approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F (6°C). The tower shall be controlled to maintain a 70°F (21°C) leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The baseline building design condenser water pump power shall be 19 W/gpm (300 kW/1000 L/s). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

D3.1.3.12 Supply Air Temperature Reset (Systems 5 through 8). The air temperature for cooling shall be reset higher by 5°F (3°C) temperature difference under the minimum cooling load conditions.

D3.1.3.13 VAV Minimum Flow Setpoints (Systems 5 and 7). Minimum volume setpoints for *VAV* reheat boxes shall be 0.4 cfm/ft^2 (2 L/s·m^2) of floor area served. Reheat shall not exceed that specified in Section 7.4.3.5.

TABLE D3.1.3.15 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 (L/s)/design cfm (L/s)).

D3.1.3.14 Fan Power (Systems 6 and 8). 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 (0.7 W/L/s) fan power. Minimum volume setpoints for fan-powered boxes shall be equal to 30% of peak design flow rate or the rate required to comply with the minimum *outdoor air* ventilation requirement, whichever is larger. The supply air temperature setpoint shall be constant at the design condition.

D3.1.3.15 VAV Fan Part-Load Performance (Systems 5 through 8). *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 D3.1.3.15.

TABLE D3.2 Power Adjustment Percentages for Automatic Lighting Controls

Automatic Control Devices(s)	Non-24-hr and ≤ 5000ft^2 (500 m^2)	All Other
(1) Programmable timing control	10%	0%
(2) Occupancy sensor (where not required by 7.4.6.2 or 7.4.6.3)	15%	10%
(3) Occupancy sensor and programmable timing control (where not required by 7.4.6.2 or 7.4.6.3)	15%	10%

Note: The 5000 ft^2 (500 m^2) condition pertains to the total conditioned floor area of the building.

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX E
IAQ LIMIT REQUIREMENTS FOR OFFICE FURNITURE SYSTEMS AND SEATING

E1. IAQ LIMIT REQUIREMENTS

Installed office furniture system workstations and seating units shall comply with both the requirements of Sections E1.1 and E1.2.

E1.1 At least 95% of the total number of installed office furniture system workstations and at least 95% of the total number of seating units installed shall have emissions concentrations or factors in compliance with the following criteria as defined in ANSI/BIFMA Standard X7.1 at 168 hours.

E1.2 At least 50% of the total number of installed office furniture system workstations and at least 50% of the total number of seating units installed shall not exceed the individual volatile organic chemical (VOC) concentration limits listed in Table E1.3 at 336 hours (14 days) or sooner when determined in accordance with the ANSI/BIFMA Standard M7.1.

When the emission factor at 336 hours is determined using the power-law defined in ANSI/BIFMA Standard M7.1 (Sections 10.4 and 10.5), emission factors with $-0.20 < b < 0.20$ shall be reported as constant.

Small chamber testing of component pieces of workstations per the ANSI/BIFMA Standard M7.1 shall be allowed, provided that there is third-party oversight in selecting representative components and in applying the calculations in ANSI/BIFMA Standard M7.1 to estimate the emission factor of a product.

TABLE E1.1 Workstation Systems and Seating Office Emissions Concentration Limits

Chemical Contaminant	Workstation Emission Limits	Seating Emission Limits
$TVOC_{toluene}$	≤0.5 mg/m^3	≤0.25 mg/m^3
Formaldehyde	≤50 ppb	≤25 ppb
Total aldehydes	≤100 ppb	≤50 ppb
4-Phenylcyclohexene	≤0.0065 mg/m^3	≤ 0.00325 mg/m^3

TABLE E1.2 Individual Furniture Components Maximum Emission Factors

	ANSI/BIFMA M7.1 Open Plan Workstation	ANSI/BIFMA M7.1 Private Office Workstation
Formaldehyde, ug/m^2·h	42.3	85.1
TVOC, ug/m^2·h	345	694
Total aldehyde, umol/m^2·h	2.8	5.7
4-Phenylcyclohexene, ug/m^2·h	4.5	9.0

TABLE E1.3 Individual Volatile Organic Chemical (VOC) Concentration Limits

				Workstation	Seating	Individual Components	
Compound Name	**CASRN**	**MW**	**CREL**	**Maximum Allowable Conc., µg/m^3**	**Maximum Allowable Conc., µg/m^3**	**Open Plan Maximum Allowable Emission Factor, µg/m^2·h**	**Private Office Maximum Allowable Emission Factor, µg/m^2·h**
Ethylbenzene	100-41-4	106.2	Y	1000	500	689	1392
Styrene	100-42-5	104.2	Y	450	225	310	627
p-Xylene	106-42-3	106.2	Y	350	175	241	487
1,4-Dichlorobenzene	106-46-7	147	Y	400	200	276	557
Epichlorohydrin	106-89-8	92.52	Y	1.5	0.75	1.0	2.1
Ethylene Glycol	107-21-1	62.1	Y	200	100	138	278
1-Methoxy-2-propanol (Propylene glycol monomethyl ether)	107-98-2	90.12	Y	3500	1750	2413	4874
Vinyl Acetate	108-05-4	86.1	Y	100	50	68.9	139
m-Xylene	108-38-3	106.2	Y	350	175	241	487
Toluene	108-88-3	92.1	Y	150	75	103	209
Chlorobenzene	108-90-7	112.56	Y	500	250	345	696
Phenol	108-95-2	94.1	Y	100	50	68.9	139
2-Methoxyethanol	109-86-4	76.1	Y	30	15	21	42
Ethylene glycol monomethyl ether acetate	110-49-6	118.13	Y	45	22.5	31	63
n-Hexane	110-54-3	86.2	Y	3500	1750	2413	4874
2-Ethoxyethanol	110-80-5	90.1	Y	35	17.5	24	49
2-Ethoxyethyl acetate	111-15-9	132.2	Y	150	75	103	209
1,4-Dioxane	123-91-1	88.1	Y	1500	750	1034	2089
Tetrachloroethylene	127-18-4	165.8	Y	17.5	8.75	12.1	24.4
Formaldehyde	50-00-0	30.1	Y	16.5	8.25	11	23
Isopropanol	67-63-0	60.1	Y	3500	1750	2413	4874
Chloroform	67-66-3	119.4	Y	150	75	103	209
N,N-Dimethyl Formamide	68-12-2	73.09	Y	40	20	28	56
Benzene	71-43-2	78.1	Y	30	15	21	42
1,1,1-Trichloroethane	71-55-6	133.4	Y	500	250	345	696
Acetaldehyde	75-07-0	44.1	Y	9	4.5	6	13
Methylene Chloride	75-09-2	84.9	Y	200	100	138	278
Carbon Disulfide	75-15-0	76.14	Y	400	200	276	557
Trichloroethylene	79-01-6	131.4	Y	300	150	207	418
1-Methyl-2-Pyrrolidinone	872-50-4	99.13	N	160	80	110	223
Naphthalene	91-20-3	128.2	Y	4.5	2.25	3	6
o-Xylene	95-47-6	106.2	Y	350	175	241	487

(This is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX F
BUILDING CONCENTRATIONS

F1. BUILDING CONCENTRATIONS

Building concentrations shall be estimated based on the following parameters and criteria:

a. Laboratory-measured VOC emission factors and actual surface area of all materials as described in (b) below.
b. At minimum, those materials listed in Section 8.5.2 (a) through (g) to be installed shall be modeled.
c. The actual building parameters for volume, average weekly minimum ventilation rate, and ventilated volume fraction for the building being modeled shall be used.
d. Standard building scenarios or modeling from similar buildings shall not be allowed.
e. Average weekly minimum air change rates shall be calculated based on the *minimum outdoor airflow rates* and hours of operation for the specific building being modeled.
f. Steady-state conditions with respect to emission rates and building ventilation may be assumed.
g. Zero *outdoor air* concentrations, perfect mixing within the building, and no net losses of VOCs from air due to other effects such as irreversible or net sorption on surfaces (i.e., net sink effects) and chemical reactions may be assumed.
h. All assumptions shall be clearly stated in the design documents.
i. The estimated building concentration, C_{Bi} (μg/m^3), of each target VOC shall be calculated using Equation 2 of the CA/DHS/EHLB/R-174, as shown below. Estimated building concentrations of individual target VOCs with multiple sources shall be added to establish a single total estimated building concentration for individual target VOCs.

$$C_{Bi} = (EF_{Ai} \times A_B) / (V_B \times a_B \times 0.9)$$

where

EF_{Ai} = area specific emission rate or emission factor at 96 hours after placing a test specimen in the chamber (14 days total exposure time), μg/m^2·h

A_B = exposed surface area of the installed material in the building, m^2

V_B = building volume, m^3

a_B = average weekly minimum air change rate, 1/h

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INFORMATIVE APPENDIX G
INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of this standard and to acknowledge source documents when appropriate. Section numbers indicate where the reference occurs in this document.

Reference	Title	Section
American Institute of Architects (AIA) 1735 New York Avenue NW Washington, DC 20006 United States 1-800-AIA-3837 or 202-626-7300; www.aia.org		
AIA National/AIA California Council	Integrated Project Delivery: A Guide, v. 1 - 2007	Appendix H
American Institute of Steel Construction One East Wacker Drive - Suite 700 Chicago, Illinois 60601 United States 1-312-670-2400; www.aisc.org		
Brochure	Steel Takes LEED® With Recycled Content	9.4.1.1
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 1791 Tullie Circle NE Atlanta, GA 30329 United States 1-404-636-8400; www.ashrae.org		
ASHRAE Guideline 0-2005	The Commissioning Process	10.3.1.1
ASHRAE Guideline 1-2007	HVAC&R Technical Requirements to Support the Commissioning Process	10.3.1.1
ASHRAE Guideline 4-1994	Preparation of Operating and Maintenance Documentation for Building Systems	10.3.1.1
ASHRAE Standard 62.1-2007 with Appendix B	Ventilation for Acceptable Indoor Air Quality	Table 10.3.1.4
ASHRAE Handbook	Fundamentals – 2005	Appendix D
ASHRAE Handbook	HVAC Applications – 2007	Appendix H

American Society for Testing and Materials International **100 Barr Harbor Dr.** **West Conshohocken, PA 19428-2959** **United States** **1-610-832-9585; www.astm.org**		
ASTM D6329-98	Standard Guide for Developing Methodology for Evaluating the Ability of Indoor Materials to Support Microbial Growth Using Static Environmental Chambers	8.4.2
State of California, Department of General Services, Procurement Division, **Ziggurat Building** **707 Third Street** **West Sacramento, CA 95605-2811** **1-916-376-5000**		
RFP DGS-56275	Section 5.7: Indoor Air Quality Requirements for Open Office Panel Systems,	Appendix E
California Environmental Protection Agency, **Office of Environmental Health Hazard Assessment** **Post Office Box 4010** **Sacramento, CA 95812-4010** **1-916-324-7572 ; http://www.oehha.ca.gov/**		
http://www.oehha.org/air/allrels.html	Air Toxics Hot Spots Program Risk Assessment Guidelines. Technical Support Document for the Derivation of Noncancer Reference Exposure Levels	8.4.2, 8.5.2, Appendix E
Canadian Standards Association (CSA) **5060 Spectrum Way, Suite 100** **Mississauga, Ontario, L4W 5N6** **Canada** **1-800-463-6727 and 1-416-747-4000; www.csa.ca**		
CSA S478-95 (R2001)	Guideline on Durability for Buildings	9.4.2.1.3.1, 10.3.4
Carpet and Rug Institute **730 College Drive** **Dalton, Georgia 30720** **United States** **1-706-278-3176; www.carpet-rug.org**		
		8.4.2.3
Cool Roof Rating Council **1610 Harrison Street** **Oakland, California 94612** **United States** **1-510-482-4421; www.coolroofs.org**		
CCRC-1-2007	Cool Roof Council Product Rating Program	5.3.2.4

Forest Stewardship Council (FSC) **1155 30th Street NW, Suite 300** **Washington, DC 20007** **United States** **1-202-342-0413; www.fsc.org**		
		9.4.1.3.1
GREENGUARD Environmental Institute **2211 Newmarket Parkway, #110** **Marietta, GA 30067** **1-678-444-4055** **www.greenguard.org**		
		8.42, 8.52
Institute of Transportation Engineers **1099 14th Street NW, Suite 300 West** **Washington, DC 20005-3438** **United States** **1-202-289-0222; www.ite.org**		
3rd Edition, 2004	Parking Generation	10.3.6
Market Transformation to Sustainability (MTS) **1511 Wisconsin Avenue, N.W.** **Washington, D.C. 20007** **United States** **1-202-338-3131; www.sustainableproducts.com**		
MTS 1.0 WSIP Guide – 2007	Whole Systems Integrated Process Guide for Sustainable Buildings and Communities	Appendix H
National Institute of Building Sciences **1090 Vermont Avenue, NW, Suite 700** **Washington, DC 20005-4905** **1-202-289-7800; www.nibs.org**		
NIBS Guideline 3-2005	Exterior Enclosure Technical Requirements for the Commissioning Process	10.3.1.1
National Renewable Energy Laboratory **1617 Cole Blvd.** **Golden, CO 80401-3393** **1-303-275-3000; www.nrel.gov**		
NREL/TP-550-38617	Source Energy and Emissions Factors for Energy Use in Buildings	Table 7.5.3.1

Resilient Floor Covering Institute **115 Broad Street, Suite 201** **LaGrange, GA 30240** **United States** **1-706-882-3833** **www.rfci.com**		
		8.4.2.3
Sheet Metal and Air Conditioning Contractors National Association (SMACNA) **4201 Lafayette Center Drive** **Chantilly, VA 20151** **Unites States** **1-703-803-2980**		
ANSI/SMACNA 008-2008	IAQ Guidelines for Occupied Buildings under Construction	10.3.6
Steel Recycling Institute **680 Andersen Drive** **Pittsburgh, PA 15220** **United States** **1-412-922-2772; www.recycle-steel.org**		
Brochure	Steel Takes LEED® With Recycled Content	9.4.1.1
Sustainable Forestry Initiative, Inc. (SFI) **1600 Wilson Blvd, Suite 810** **Arlington, VA 22209** **United States** **1-703-875-9500; www.sfiprogram.org**		
		9.4.1.3.1
U.S. Department of Health and Human Services **Agency for Toxic Substances and Disease Registry (ATSDR)** **4770 Buford Hwy NE** **Atlanta, GA 30341** **1-800-232-4636; http://www.atsdr.cdc.gov/**		
http://www.atsdr.cdc.gov/mrls/	Minimal Risk Levels (MRLs)	Table 10.3.1.4
United States Environmental Protection Agency (USEPA) **1200 Pennsylvania Ave NW** **Washington, DC 20460** **United States** **1-888-782-7937 and 1- 202-775-6650; www.energystar.gov**		
	Portfolio Manager	10.3.3.3.1

United States Department of Energy (USDOE) **Washington, DC 20585** **United States** **1-202-586-5000; www.energyplus.gov**		
	EnergyPlus (or predecessors BLAST or DOE-2)	Appendix D
United States General Services Administration (USGSA) **1800 F Street, NW** **Washington, DC 20405** **1-800-488-3111 and 1-202-501-1100; www.gsa.gov**		
U.S. GSA – 2005	The Building Commissioning Guide	10.3.1

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INFORMATIVE APPENDIX H
INTEGRATED DESIGN

H1. INTEGRATED DESIGN PROCESS/ INTEGRATED PROJECT DELIVERY

Integrated design, and related concepts such as *integrated project delivery* and integrative design, requires early stakeholder collaboration to enable stronger, more balanced design solutions in all aspects of a project through the sharing of knowledge and expertise among project team members. This *integrated design process* is in contrast to traditional methods, where there is a limited utilization of the skills and knowledge of all stakeholders in the development of design solutions. An *integrated design process* enables the construction of high-performance green buildings that consume fewer resources and achieve better comfort and functionality. A goal of integrated processes is to better enable the construction of high-performance green buildings that consume fewer resources and achieve better comfort and functionality, as well as increased predictability of project outcomes early on.

Integrated design facilitates higher building performance by bringing major issues and key participants into the project early in the design process. For the most part, the opportunities for creatively addressing solutions occur very early in the design process. The complex interactions of sophisticated building systems require early coordination in order to maximize effectiveness and output of such systems. Early team building and goal setting may also reduce total project costs. This collaborative process can inform building form, envelope, and mechanical, electrical, plumbing and other systems. The later in the design process that systems are introduced to the project, the more expensive the implementation of such systems will be. Use of building information technologies can also be a valuable asset in increasing predictability of outcomes earlier in the project and is recommended for all integrated teams.

An iterative design process is intended to take full advantage of the collective knowledge and skills of the design team. A linear process approaches each problem sequentially. In contrast, an integrated process approaches each problem with input from the different viewpoints of the participants and the issues they represent, circling back after each design decision to collectively evaluate the impact on all stakeholders. This process acknowledges the complex interdependency of all building systems and their relationship to resource consumption and occupant well being.

There are several existing, and currently evolving, models for collaboration which can be considered: for example, the *ASHRAE Handbook—HVAC Applications*, Chapter 57; the MTS 1.0 WSIP Guide, *Whole Systems Integrated Process Guide for Sustainable Buildings and Communities*; and *Integrated Project Delivery: A Guide*, by the AIA and AIA California Council.

Project specific integrated design and/or *integrated project delivery* processes should be determined with full participation of the stakeholder team. What works for one project may not prove the best approach for the next. Additionally, the team should collectively identify the performance standards and the associated metrics by which the project success will be judged. Design charrettes of varying duration may be an effective tool to consider, though ultimately it is the responsibility of the stakeholder team to determine the process that will best fit any specific problem or project.

H1.1 Design Charrette. The following outlines one type of design charrette process that has resulted in successful integrated design.

At the initial stages of building design, a charrette process can be initiated and the members of the process should include all the stakeholders.

H1.1.1 Charrette Process. Experienced personnel representing each specialty should participate in the charrette process. A discussion of all the systems and all the items that affect the *integrated design* should be discussed. Stakeholders should be able to decide and vote on the best integrated system.

The integrative team process should entail the following steps of design optimization:

a. The original goals and budget of the project should be revisited to see whether the overall intentions of the project are intact.
b. The project should be compared against this standard or at least one existing green rating system.
c. Each of the building and *site* components should be scrutinized to help ensure natural systems for energy conservation, lighting, ventilation, and passive heating and cooling are maximized before mechanical systems are engaged.
d. The appropriateness and integration logic of the building's primary systems should be confirmed.
e. The impact of the design on the *site* and its larger context should be evaluated, including the environmental impact on a life-cycle cost basis.
f. Building information modeling (BIM) software, design tools, and the experience of the design team should be used if practical to help optimize the design.
g. All members of the design team should be included when making design decisions.
h. Commissioning and consideration of future operation and maintenance (O&M) requirements should be included within the design optimization process.

H1.1.2 Design Charrette Matrix. At the end of the charrette process, a matrix for each proposed building scheme can be developed and evaluated to summarize the impact on the *site*, water, energy, materials, and indoor environmental quality and to help lead to a decision as to the best integrated system. The matrix contains cells indicating the high-performance value, grading a particular building system to its appropriate high-performance criteria. Each high-performance value is qualitatively rated from 1 to 10, with 1 being the lowest (minimal energy savings, low air quality, low water efficiency, high cost) and 10 being the highest (high energy savings, high air quality, high water efficiency, low cost). The average of the high-performance values for each building system is the aggregate index. Selection of the best system should be based upon a comparison of these aggregate indices for each matrix.

Figure H1.2 Sample Charrette Design Matrices

Scheme #1—with Atrium, maximum exposure on the south, three-story office building.

Building System	High Performance Criteria						
	Site	IAQ	IEQ	Energy	Comm. M&V	Initial Cost	O & M
Arch	8	7	6	1	6	1	6
HVAC	–	5	6	2	6	2	7
Plumbing	N/A	–	–	–	–	2	7
Structural	–	–	–	–	–	2	
Aggregate index	8	6	6	1.5	6	2	6.8

Result:
Least numbers under energy and cost column defines consumption of substantial energy with high initial cost.

Scheme #2—without Atrium, three-story, minimum exposure on the south and west side

Building System	High Performance Criteria						
	Site	IAQ	IEQ	Energy	Comm. M&V	Initial Cost	O & M
Arch	6	7	7	7	7	7	6
HVAC	N/A	5	7	7	7	7	7
Plumbing	N/A	–	–	–	7	7	7
Structural	–	–	–	–	–		
Aggregate index	6	6	7	7	7	7	6.8

Result:
High numbers on all columns indicate the building is conceived optimally.

NOTICE

INSTRUCTIONS FOR SUBMITTING A PROPOSED CHANGE TO THIS STANDARD UNDER CONTINUOUS MAINTENANCE

This standard is maintained under continuous maintenance procedures by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. SSPC consideration will be given to proposed changes within 13 months of receipt by the manager of standards (MOS).

Proposed changes must be submitted to the MOS in the latest published format available from the MOS. However, the MOS may accept proposed changes in an earlier published format if the MOS concludes that the differences are immaterial to the proposed change submittal. If the MOS concludes that a current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

ELECTRONIC PREPARATION/SUBMISSION OF FORM FOR PROPOSING CHANGES

An electronic version of each change, which must comply with the instructions in the Notice and the Form, is the preferred form of submittal to ASHRAE Headquarters at the address shown below. The electronic format facilitates both paper-based and computer-based processing. Submittal in paper form is acceptable. The following instructions apply to change proposals submitted in electronic form.

Use the appropriate file format for your word processor and save the file in either a recent version of Microsoft Word (preferred) or another commonly used word-processing program. Please save each change proposal file with a different name (for example, “prop01.doc,” “prop02.doc,” etc.). If supplemental background documents to support changes submitted are included, it is preferred that they also be in electronic form as word-processed or scanned documents.

ASHRAE will accept the following as equivalent to the signature required on the change submittal form to convey nonexclusive copyright:

Files attached to an e-mail:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg).
Files on a CD:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg) or a letter with submitter’s signature accompanying the CD or sent by facsimile (single letter may cover all of proponent’s proposed changes).

Submit an e-mail or a CD containing the change proposal files to:
Manager of Standards
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
E-mail: change.proposal@ashrae.org
(Alternatively, mail paper versions to ASHRAE address or fax to 404-321-5478.)

The form and instructions for electronic submittal may be obtained from the Standards section of ASHRAE’s Home Page, www.ashrae.org, or by contacting a Standards Secretary, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
Phone: 404-636-8400. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

FORM FOR SUBMITTAL OF PROPOSED CHANGE TO AN ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

NOTE: Use a separate form for each comment. Submittals (Microsoft Word preferred) may be attached to e-mail (preferred), submitted on a CD, or submitted in paper by mail or fax to ASHRAE, Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: change.proposal@ashrae.org. Fax: +1-404/321-5478.

1. Submitter:

Affiliation:

Address: City: State: Zip: Country:

Telephone: Fax: E-Mail:

I hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Submitter's signature: _____ Date: _____

All electronic submittals must have the following statement completed:

I *(insert name)* _____, through this electronic signature, hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

2. Number and year of standard:

3. Page number and clause (section), subclause, or paragraph number:

4. I propose to: *(check one)*

[ ] Change to read as follows
[ ] Add new text as follows
[ ] Delete and substitute as follows
[ ] Delete without substitution

Use underscores to show material to be added (<u>added</u>) and strike through material to be deleted (~~deleted~~). Use additional pages if needed.

5. Proposed change:

6. Reason and substantiation:

7. Will the proposed change increase the cost of engineering or construction? If yes, provide a brief explanation as to why the increase is justified.

[ ] Check if additional pages are attached. Number of additional pages: _____

[ ] Check if attachments or referenced materials cited in this proposal accompany this proposed change. Please verify that all attachments and references are relevant, current, and clearly labeled to avoid processing and review delays. *Please list your attachments here:*

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.

IMPORTANT NOTICES ABOUT THIS STANDARD

To ensure that you have all of the approved addenda, errata, and interpretations for this standard, visit www.ashrae.org/standards to download them free of charge.

Addenda, errata, and interpretations for ASHRAE standards and guidelines will no longer be distributed with copies of the standards and guidelines. ASHRAE provides these addenda, errata, and interpretations only in electronic form in order to promote more sustainable use of resources.

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