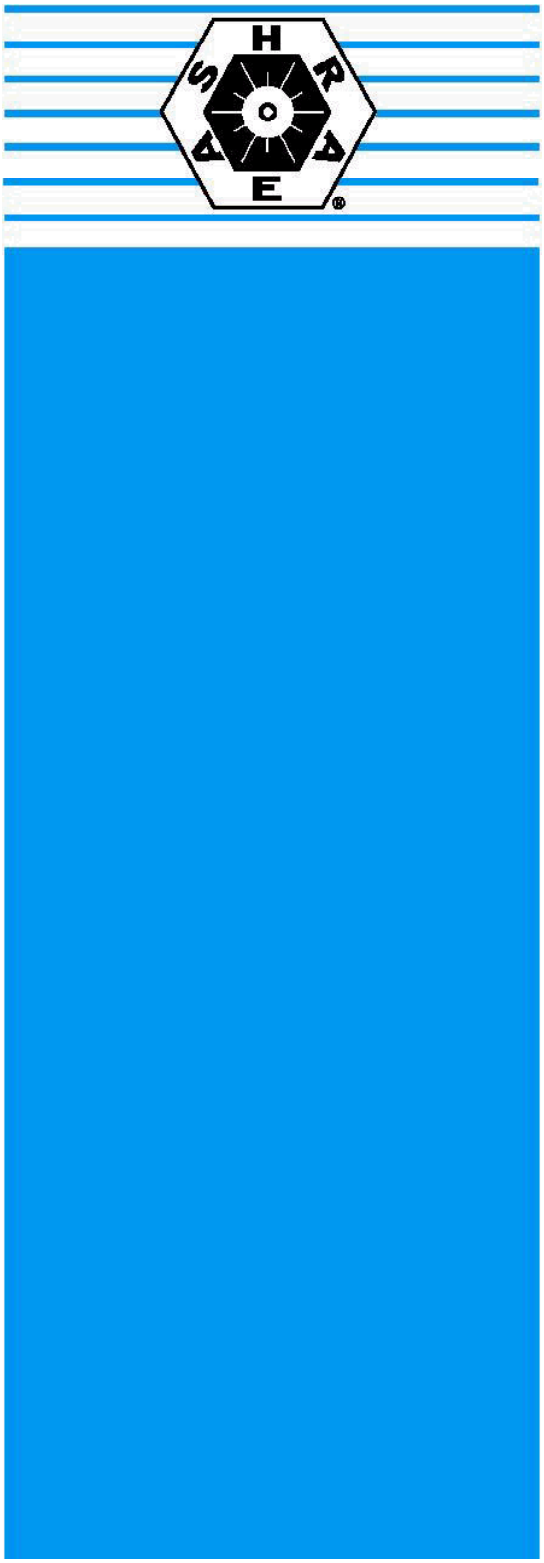

BSR/ASHRAE//USGBC/IESNA Standard 189P

Public Review Draft

ASHRAE® Standard

Proposed Standard 189, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*

First Public Review (May 2007)
(Complete Draft for Full Review)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed addendum, use the comment form and instructions provided with this draft. The draft is subject to modification until it is approved for publication by the ASHRAE Board of Directors and ANSI. Until this time, the current edition of the standard remains in effect. The current edition of any standard may be purchased from the ASHRAE Bookstore @ http://www/ashrae.org or by calling 404-636-8400 or 1-800-527-4723 (for orders in the U.S. or Canada).

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AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
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CONTENTS
ASHRAE/USGBC/IESNA Standard 189, Standard for High-Performance Green Buildings Except Low-Rise Residential Buildings

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This is the first edition of ASHRAE/USGBC/IESNA Standard 189. This is a standard for high-performance green buildings. It is not a rating system, though it could be incorporated as the baseline in a green building rating system. It addresses sustainable sites, water use efficiency, energy efficiency, the building's impact on the atmosphere, materials and resources, and indoor environmental quality (IEQ). These five key subject areas, as well as construction and 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 can not 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 based on equivalence to the Prescriptive Option.

x.6 Submittals: This subsection lists information needed to show compliance with the Mandatory Provisions, and Prescriptive and Performance Options.

This standard is meant to be used in conjunction with ASHRAE/IESNA Standard 90.1-2007, and ASHRAE Standards 62.1-2007 and 55-2004. Where a requirement is contained herein, this requirement supersedes the requirements in those standards. For all other criteria, the project is to comply with the requirements in those standards.

Following approval, this standard is expected to be placed on continuous maintenance, permitting the standard to be updated through the publication of approved addenda to the standard. The standard is expected to be republished in its entirety every third year. All approved addenda and errata will be included in the new edition.

1. PURPOSE

The purpose of this standard is to provide minimum requirements for the design 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 new buildings and major renovation projects (new portions of buildings and their systems): a building or group of buildings, including on-site energy conversion or electric-generating facilities, which utilize a single submittal for a construction permit or which are within the boundary of a contiguous area under single ownership.

(b) Address sustainable sites, water use efficiency, energy efficiency, the building's impact on the atmosphere, materials and resources, and indoor environmental quality (IEQ).

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 do not use either electricity or fossil fuel.

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. 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

adapted plants: see *plants, adapted.*

agricultural land: land that is, or has been within the last 10 years, 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.*

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

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

basis of design (BOD): the documentation by the design team of the primary thought processes and assumptions behind design decisions that are made to comply with the owner's project requirements. The BOD describes the assumptions used for sizing and selection of systems (i.e. codes, standards, operating conditions, design conditions, weather data, interior environmental criteria, other pertinent design assumptions, etc.). (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 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 commissioning: the systematic process of assuring by verification and documentation, from the design phase to a minimum of one year after construction, that all facility systems perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs, including preparation of operation personnel.

building entrance: see ASHRAE/IESNA Standard 90.1.

building envelope: see ASHRAE/IESNA Standard 90.1.

building project: a building or group of buildings and site, including on-site energy conversion or electric-generating facilities, which utilize a single submittal for a construction permit or which are within the boundary of a contiguous area under single ownership.

candela: a unit of measurement, weighted by wavelength based on the human eye sensitivity, for the luminous intensity emitted by a lighting source in a particular direction in lumens per steradian.

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, 23 for methane (CH_4), and 296 for nitrous oxide (N_2O).

classroom: a space primarily used for scheduled instructional activities.

clerestory: see ASHRAE/IESNA Standard 90.1.

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

commissioning agent (CxA): the qualified person, company or agency that plans, coordinates and oversees the entire commissioning process. The commissioning agent makes final recommendations to the owner regarding functional performance of the commissioned building systems. This individual is the party the commissioning coordinator or supervisor reports to and may be an employee or consultant of the owner, contractor, construction manager, or architect/engineer. The commissioning agent is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The commissioning agent may assist with problem-solving or resolving nonconformance or deficiencies, but responsibility resides with the general contractor and design professionals.

commissioning coordinator: the party in direct charge of the day-to-day site commissioning activities: prepares test procedures; directly oversees site commissioning work executed by themselves, the contractor, or consultants; documents the commissioning work; and generates first-hand commissioning reports. The commissioning coordinator may work directly for the owner, contractor, architect/engineer, or construction manager. The commissioning coordinator reports to the commissioning authority.

commissioning plan: the document prepared for each project that describes all aspects of the commissioning process including schedules, responsibilities, documentation requirements, the construction pre-functional checklist and communication structures.

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 ASHRAE/IESNA Standard 90.1.

construction pre-functional checklist: a checklist to ensure that the specified equipment has been provided, is properly installed and initially started and checked out adequately in preparation for full operation and functional testing.

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

cutoff: see *IESNA luminaire classification, cutoff*.

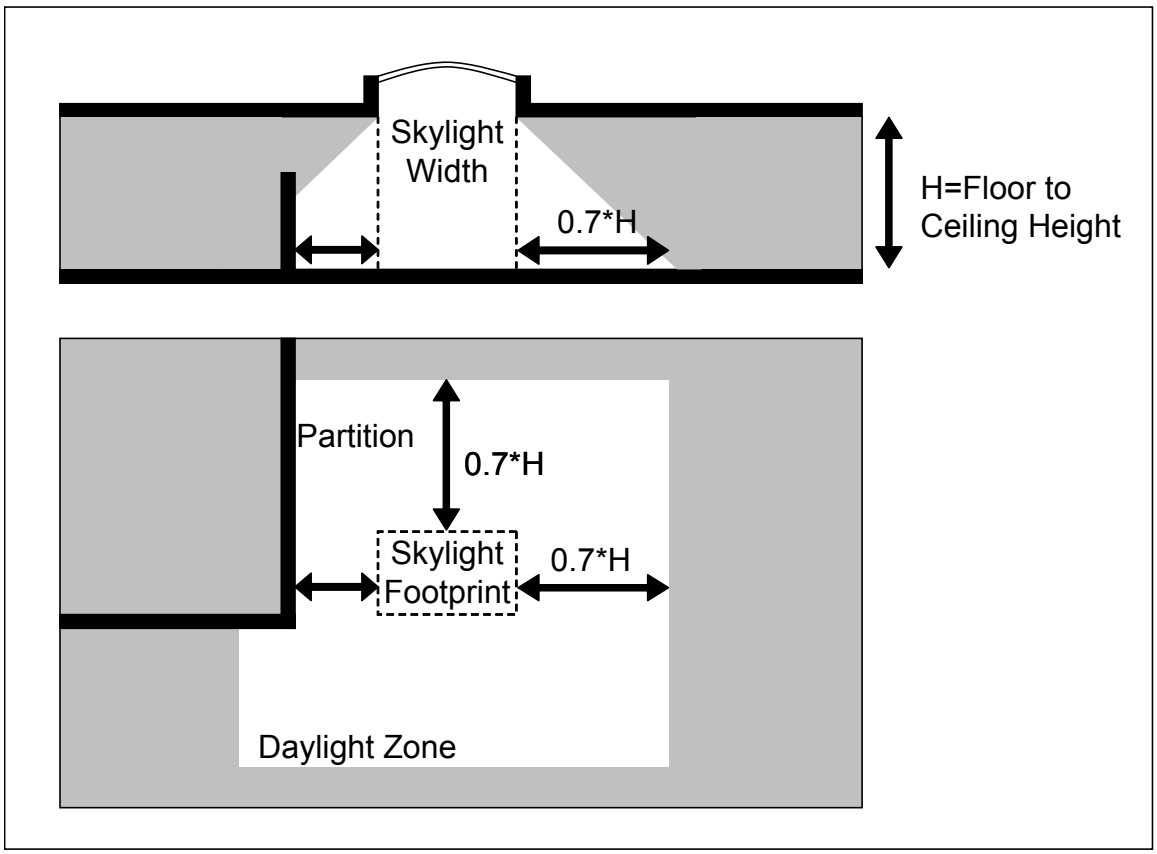
daylight zone:

(a) adjacent to vertical fenestration: the area illuminated by vertical glazing calculated as the daylit depth multiplied by the daylit width, where the daylit depth is 4.5 m (15 ft), or the distance on the floor, perpendicular to the glazing, to the nearest 1500 mm (60 in.) or higher permanent partition, whichever is less; and the daylit width is the width of the window plus, on each side, either 0.6 m (2 ft), the distance to a permanent partition, or one half the distance to the closest skylight or vertical fenestration, whichever is least. (See *skylight, roof monitor, clerestory, tubular daylighting device,* and *vertical fenestration*.)

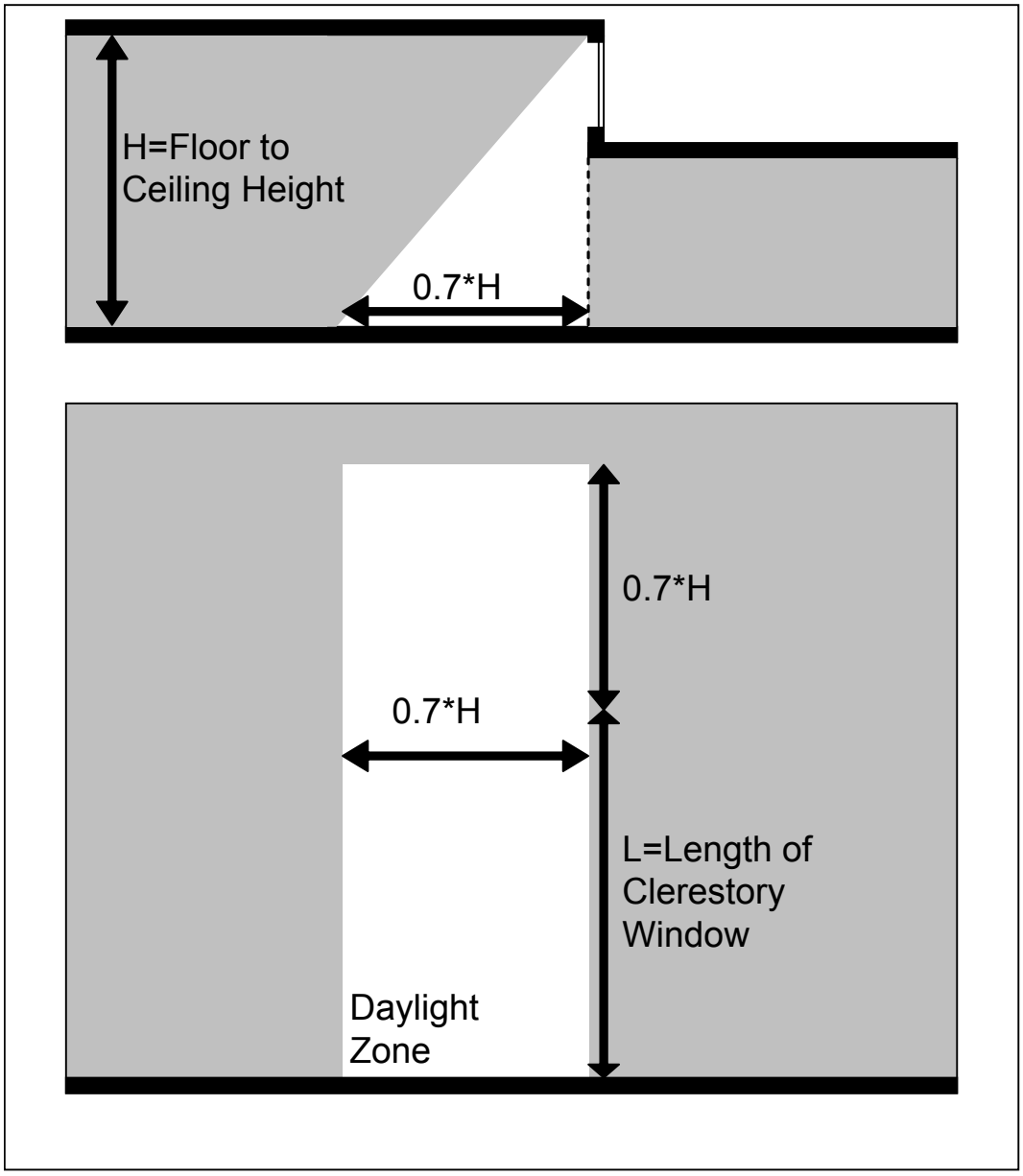
(b) under skylights and tubular daylighting devices: the area illuminated by skylights calculated by adding the rough opening of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 1500 mm (60 in.) 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 roof monitor: 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 1500 mm (60 in.) 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*.)

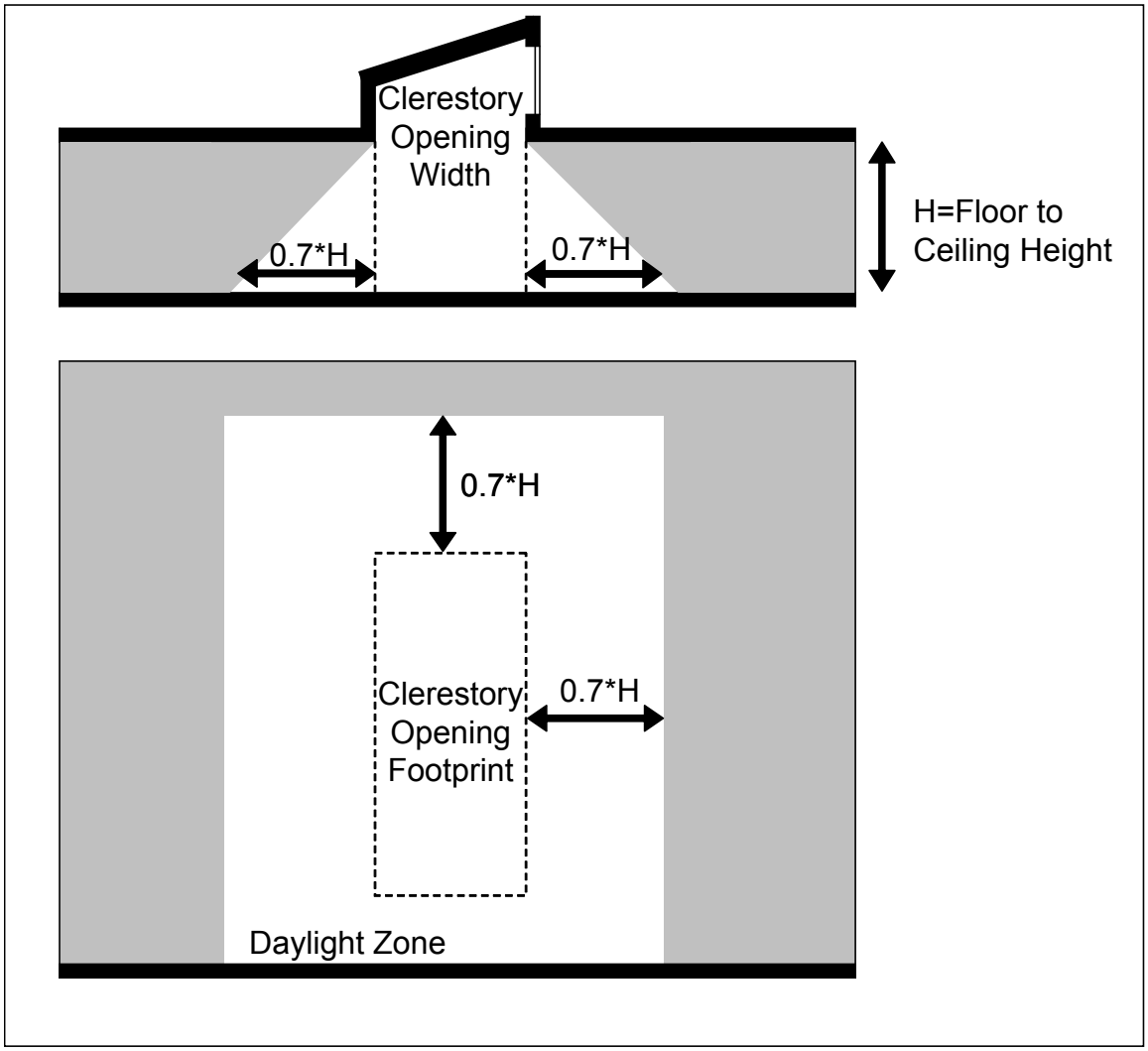
(d) under clerestory: the area illuminated by vertical fenestration in a clerestory calculated as the daylit depth multiplied by the daylit width, where the daylit depth is the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 1500 mm (60 in.) or higher permanent partition, or 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 height, the distance to the nearest 1500 mm (60 in.) 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*.)



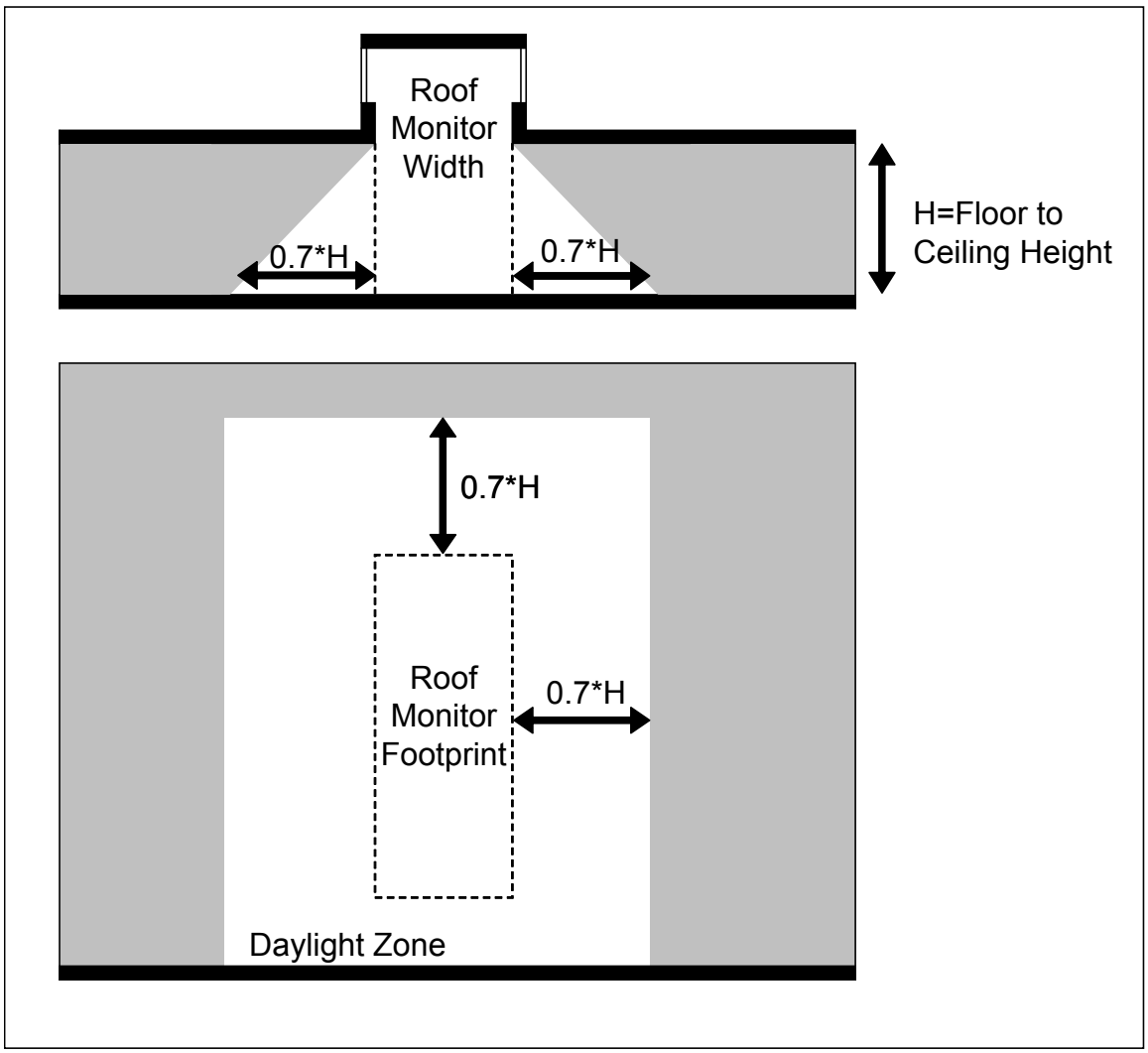
Daylight Zone Under Skylights



Daylight Zone Under Clerestory



Daylight Zone Under Clerestory Roof Monitor



Daylight Zone Under Roof Monitor

densely occupied space: those spaces with a design occupant density greater than or equal to 15 people per 100 m^2 (1000 ft^2).

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 area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

dwelling unit: see 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 ASHRAE/IESNA Standard 90.1, Section 5.8.2.6. (See *fenestration area*, *gross wall area*, and *vertical fenestration*.)

electrical service load: the specified rating, in kW, of the main electrical service.

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.

fenestration: see ASHRAE/IESNA Standard 90.1.

fenestration area: see ASHRAE/IESNA Standard 90.1.

***fish and wildlife habitat conservation area*:** an area necessary for maintaining species in suitable habitat within their natural geographic distribution so that isolated subpopulations are not created. These areas include:

(a) areas with which state or federally designated endangered, threatened, and sensitive species have a primary association;

(b) naturally occurring ponds under 8 ha (20 acres) and their submerged aquatic beds that provide fish or wildlife habitat, including those artificial ponds intentionally created from dry areas in order to mitigate impacts to ponds;

(c) waters of the state, including lakes, rivers, ponds, streams, and inland waters;

(d) lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity;

(e) state natural area preserves and natural resource conservation areas; and

(f) land essential for preserving connections between habitat blocks and open spaces.

forest land: all designated state and national forests, land that is, or has been within the last 10 years, primarily devoted to growing trees for long-term commercial timber production, or land that can be economically and practically managed for such production and that has long-term commercial significance.

full cutoff: see *IESNA luminaire classification, full cutoff*.

functional testing: testing that evaluates the dynamic function and operation of equipment and systems using direct observation or other monitoring methods. Functional testing is the assessment of the system's (rather than the component's) ability to perform within the parameters established within the owner's project requirements. (See *owner's project requirements*.)

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

***greenfield site*:** a site of which 30% or less has been previously developed with impervious surfaces.

***greyfield site**:* a site of which more than 30% is already developed with impervious

surfaces.

gross roof area: see ASHRAE/IESNA Standard 90.1.

gross wall area: see 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 which increases environmental performance and economic value over time, safeguards the health of occupants, and enhances satisfaction and productivity of workers through integration of environmentally-preferable building materials, and water-efficient and energy-efficient systems.

hydrozone: to divide the landscape irrigation system according to each zone's water needs based on plant materials, soil and other factors.

IESNA luminaire classification:

(a) cutoff: a luminaire that has a light distribution in which the candela per 1000 lamp lumens does not numerically exceed 25 (2.5%) at or above an angle of 90° above nadir, and 100 (10%) at or above a vertical angle of 80° above nadir.

(b) full cutoff: a luminaire that has a light distribution in which zero candela intensity occurs at or above an angle of 90° above nadir, and, the candela per 1000 lamp lumens does not numerically exceed 100 (10%) at or above a vertical angle of 80° above nadir.

light rail: a streetcar-type vehicle operated on city streets, semi-exclusive rights-of-way, or exclusive rights-of-way. Service may be provided by step-entry vehicles or by level boarding.

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: a design process utilizing early and complete 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 and the architect is not the sole party primarily responsible for design.

life cycle assessment (LCA): an accounting and evaluation of the environmental aspects and potential impacts of a building throughout its life—from raw material acquisition through manufacturing, construction, use, operation, demolition, and disposal. The purpose is to identify opportunities to improve the environmental performance of buildings throughout their life cycles.

lighting power allowance: see ASHRAE/IESNA Standard 90.1.

load factor: the building's average electric usage from the grid divided by its peak electric usage, calculated based on daily, monthly or yearly data.

native plants: see *plants, native.*

non-densely occupied space: a space that is not a densely occupied space. (See *densely occupied space*.)

nonresidential: see ASHRAE/IESNA Standard 90.1.

on-site renewable energy power system: includes photovoltaic, solar thermal, and wind systems used to generate power and located on the building site. On-site renewable energy power systems shall not include natural daylighting, passive solar gain through fenestration, nocturnal cooling, lake or pond thermal differences, geothermal heat pumps, or any energy or power from natural gas, oil, coal, wood, liquefied petroleum gas, steam and any utility-supplied electricity.

once-through cooling: the practice of using potable water to cool a condenser or other item of process or building equipment and then discarding of the water to a sanitation drain. Once-through cooling also includes the use of potable water to temper hot water or steam before sending it to a sanitation drain.

owner's project requirements (OPR): the documentation that provides the owner's vision for the planned facility, functional performance requirements and expectations for how it will be used and operated.

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: concrete or masonry 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 (or introduced) 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 in which they inhabit. Collectively they are one of the great threats to biodiversity and ecosystem stability.

(c) native (or indigenous) 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 (also known as open-grid pavers): concrete or masonry units where a minimum 40% of the surface area is covered with holes or openings which are filled with sand, gravel, or 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 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 and the 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 ASHRAE/IESNA Standard 90.1.

roof: see ASHRAE/IESNA Standard 90.1.

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

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

semiheated space: see ASHRAE/IESNA Standard 90.1.

service water heating: see ASHRAE/IESNA Standard 90.1.

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

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

skylight: see 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.

solar energy system: any device or combination of devices or elements which rely upon direct sunlight as an energy source, including but not limited to any substance or device which 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 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.

toplighting: daylighting provided by fenestration mounted above the ceiling plane, including skylights, tubular daylighting devices, and vertical fenestration in roof monitors; 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 and roots.

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

variable air volume: see ASHRAE/IESNA Standard 90.1.

vertical fenestration: see ASHRAE/IESNA Standard 90.1.

wall: see ASHRAE/IESNA Standard 90.1.

wall area, gross: see 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, 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 & commercial: the quantity of water in L (gal) used to wash each m^3 (ft^3) of machine capacity.

(b) residential dishwasher: the quantity of water use in L (gal) per full machine wash and rinse cycle.

***wetlands*:** those areas, designated in accordance with the United States Army Corps of Engineers' *Wetland Delineation Manual*, that are inundated or saturated by surface or ground water 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.

3.3 Abbreviations and Acronyms

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASTM	American Society for Testing and Materials
BOD	basis of design
Btu	British thermal unit
CBECS	Commercial Building Energy Consumption Survey
CDHS	California Department of Health Services
CEC	California Energy Commission
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

cm	centimeter
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CSA	Canadian Standards Association
CxA	commissioning agent
DX	direct expansion
EA_{vf}	effective aperture for vertical fenestration
EPAct	U.S. Energy Policy Act
ESC	erosion and sedimentation control
ETo	evapotranspiration
ETS	environmental tobacco smoke
fc	footcandle
FF&E	fit-out furniture and equipment
FSC	Forest Stewardship Council
ft	foot
gal	gallon
gpm	gallons per minute
GWP	global warming potential
GWP_r	global warming potential of refrigerant
h	hour
ha	hectare
HCFC	hydrochlorofluorocarbon
HVAC	heating, ventilation, and air-conditioning
HVAC&R	heating, ventilation, air-conditioning, and refrigeration
I-P	inch-pound
IA	Irrigation Association
IAQ	indoor air quality
IEQ	indoor environmental quality
IESNA	Illuminating Engineering Society of North America
in.	inch
kg	kilogram

km	kilometer
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
L	liter
L_r	refrigerant leakage rate
lb	pound
LCA	life cycle assessment
LCGWP	lifecycle direct global warming potential
LCODP	lifecycle ozone depletion potential
LID	low impact development
LPD	lighting power density
m	meter
M&V	measurement and verification
mcg (μg)	microgram
MDF	medium density fiberboard
MERV	minimum efficiency reporting value
mi	mile
min	minute
mm	millimeter
M_r	end-of-life refrigerant loss
NAECA	National Appliance Energy Conservation Act
NC	noise criterion
O&M	operation and maintenance
ODP_r	ozone deletion potential of refrigerant
OPR	owner's project requirements
Pa	Pascal
PEFC	Programme for the Endorsement of Forest Certification
PF	projection factor
ppb	parts per billion
ppm	parts per million

Q_{total}	total cooling capacity of all HVAC or refrigeration
Q_{unit}	cooling capacity of an individual HVAC or refrigeration unit
R_c	refrigerant charge
s	second
SCAQMD	South Coast Air Quality Management District
SCS	Scientific Certification Systems
SFI	Sustainable Forestry Initiative
SHGC	solar heat gain coefficient
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SOV	single occupancy vehicle
SRI	solar reflectance index
STC	sound transmission class
TMP	transportation management plan
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
USGPO	United States Government Printing Office
USGSA	United States General Services Administration
VAV	variable air volume
VOC	volatile organic compound
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 Documentation. Documentation shall comply with Submittals (x.6).

4.1.2 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.

4.1.3 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.

4.2 Integrated Design. While it is not required, it is recommended that the design team use an *integrated design* process for the *building project*. (Informative note: A recommended procedure for *integrated design* is included in Informative Appendix G.)

5. SUSTAINABLE SITES

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. All of the provisions of Section 5 are Mandatory Provisions. Documentation shall comply with 5.6, Submittals.

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 800 m (1/2 mi) of *residential* land that is developed, or is under construction, at an average density of 4 units per ha (10 units per acre) net unless that *site* is *agricultural land* or *forest land*. Proximity is determined by drawing a circle with an 800 m (1/2 mi) radius around the center of the proposed *site*.

(e) on a *greenfield site* that is within 800 m (1/2 mi) of a minimum of 10 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) bank; 2) place of worship; 3) convenience grocery; 4) day care; 5) cleaners; 6) fire station; 7) beauty; 8) hardware; 9) laundry; 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. Proximity is determined by drawing a circle with an 800 m (1/2 mi) radius around the center of the proposed *site*.

(f) on a *greenfield site* that is either within 800 m (1/2 mi) of an existing, or planned and funded, commuter rail, *light rail* or subway station or within 400 m (1/4 mi) of one or more stops for two or more campus or public bus lines useable by building occupants unless that *site* is *agricultural land* or *forest land*. Proximity is determined by drawing a circle with an 800 m (1/2 mi) 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 Sites. There shall be no *site* disturbance or development of the following:

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

(b) within 90 m (300 ft) 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 50 m (150 ft) 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 exclusively designed for walking is allowed within 4.5 m (15 ft) of a *fish and wildlife habitat conservation area* or *wetland*.

5.3.2 Site Development. *Building projects* shall comply with 5.3.2.1 and 5.3.2.2.

5.3.2.1: Effective Pervious Area for All Sites: A minimum of 40% of the entire *site* shall:

(a) be vegetated with a minimum depth of growing medium of 300 mm (12 in.) Such vegetated areas include bioretention facilities, raingardens, 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) have a green roof with a minimum depth of growing medium of 75 mm (3 in.),

(c) have *porous pavers (open grid pavers)*, or

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

Exceptions to 5.3.2.1:

(a) The effective pervious surface is allowed to be reduced to a minimum of 20% of the entire *site* if 10% of the annual rainfall for the entire *development footprint* is captured on *site* and reused for site water use or building water use.

(b) The effective pervious surface is not required if 50% of the annual rainfall for the entire *development footprint* is captured on site and reused for site water use or building water use.

(c) Locations with less than 250 mm (10 in.) of rain per year.

5.3.2.2 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, raingardens, 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*.

5.3.3 Mitigation of Heat Island Effect. The *solar reflectance index (SRI)* is calculated according to ASTM E1980 using solar reflectance as measured according to ASTM E1918 or ASTM C1549 and emittance as measured according to ASTM E408 or ASTM C1371.

5.3.3.1 Site Hardscape. Projects shall provide any combination of the following strategies for a minimum of 50% of the *site hardscape* (which includes roads, sidewalks, courtyards, and parking lots but not the constructed building surfaces nor portion of the *site hardscape* covered by photovoltaic panels generating electricity or other *solar energy systems* used for space heating or water heating):

(a) *bio-diverse plantings* of *native plants* and *adapted plants* (trees and vegetation) planted to provide shade within 5 years of occupancy. The effective shade coverage shall be the arithmetic mean of the shade coverage calculated at 10 am, noon, and 3pm on the summer solstice.

(b) paving materials with a minimum *SRI* of 29.

(c) *porous pavers (open-grid pavers)* .

(d) shading through the use of structures, as long as the top surface of the shading structure complies with the provisions of 5.3.3.3.

(e) parking under a building, as long as the roof of the building complies with the provisions of 5.3.3.3.

Exception to 5.3.3.1: *Building projects* in *climate zones* 6, 7 and 8.

5.3.3.2 Walls and Air Conditioner Condenser Units. This section applies to above-grade building *walls*, retaining walls, and the top horizontal surface of ground-level air conditioner condenser units. Compliance with this section is allowed to be achieved through the use of shade-providing plants, man-made structures, existing buildings, hillsides, permanent building projections, or a combination of these, using the following criteria:

(a) vegetation (including trees) shall be *bio-diverse plantings* of *native plants* and *adapted plants* and appropriately sized, selected, planted and maintained so that they do not interfere with overhead power lines or underground water and sewer lines. Trees shall be placed a minimum of 1.5 m (5 ft) from the building, retaining wall, or condenser unit, but within 15 m (50 ft).

(b) shade shall be provided on 30% of the east and west above-grade *walls* and retaining walls and 10% of the south above-grade *walls* and retaining walls, from grade level to a height of 6 m (20 ft) above-grade, within 5 years of occupancy. Shade coverage shall be calculated at 10 am for the east *walls* and 3 pm for the west *walls* on the summer solstice. Shade coverage shall be the arithmetic mean of the value at 10 am

and 3 pm for the south *walls* on the summer solstice.

(c) shade shall be provided on 75% of the horizontal surface area of air conditioner condenser units located on the ground. Shade coverage shall be calculated at 3 pm on the summer solstice, within 5 years of occupancy. Vegetation or man-made structures shall not be planted or placed so close that the full-grown plants or the man-made structure will obstruct the flow of air around the unit.

Exceptions to 5.3.3.2:

(a) The requirements for this section are complied with if 75% or more of the opaque *wall* surfaces on the east, south, and west have a minimum *SRI* of 29. Each *wall* is allowed to be considered separately for this exception.

(b) East *wall* shading is not required for buildings located in *climate zones* 5, 6, 7 and 8. South and west *wall* shading is not required for buildings located in *climate zones* 7 and 8.

(c) Air conditioner condenser unit shading is not required for *climate zones* 6, 7 and 8.

5.3.3.3 Roofs. This section applies to the building and covered parking roof surfaces. A minimum of 75% of the entire roof surface not used for roof penetrations, *renewable energy power systems* (e.g. photovoltaics or solar thermal collectors), harvesting systems for rainwater to be used on-site, or green roofing systems shall be covered with products that meet one or more of the following:

(a) have a minimum *SRI* of 78 for a low-sloped roof (a slope less than or equal to 2:12) and a minimum *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 to 5.3.3.3:

(a) *Building projects* in *climate zones* 7 and 8.

(b) *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 7.5.2, are both less for the proposed roof than with a roof material complying with the requirements of section 5.3.3.3(a).

(c) Roofs used to shade or cover parking and roofs over semi-heated spaces provided that they have a minimum *SRI* of 29.

5.3.4 Reduction of Light Pollution

5.3.4.1 Luminaire Cutoff Requirements. All outdoor luminaires for lighting *hardscape* areas including parking lots, *building entrances*, sales and non-sales canopies, and all outdoor sales areas shall comply with the criteria in Table 5.3.4.1.

Exceptions to 5.3.4.1:

(a) Temporary outdoor lighting.

(b) Lighting used in or around swimming pools, water features, or other locations subject to Article 680 of the National Electrical Code.

Table 5.3.4.1
Outdoor Lighting Trespass Limits

Luminaire Lamp Rating	IESNA Luminaire Classification
>150 watts	*Cutoff*
>400 watts	*Full Cutoff*

5.3.4.2 Outdoor Lighting Trespass Limits. Outdoor lighting shall be designed so that all *site* and building-mounted luminaires produce a maximum initial illuminance no greater than indicated in Table 5.3.4.2.

Exception to 5.3.4.2: Illuminance generated from a single luminaire placed at the intersection of a private vehicular driveway and public roadway accessing the *site*, is allowed to be excluded from the restrictions of Table 5.3.4.2 provided that the luminaire has a *full cutoff* classification as defined in IESNA.

Table 5.3.4.2
Outdoor Lighting Trespass Limits[1]

	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Horizontal and vertical illuminance at boundary in lux (fc)	0.1 (0.01)	1.0 (0.10)	2.0 (0.20)	6.0 (0.60)
Horizontal and vertical illuminance beyond boundary in lux (fc)	0.1 at 3 m (0.01 at 10 ft)	0.1 at 3 m (0.01 at 10 ft)	0.1 at 4.5 m (0.01 at 15 ft)	0.1 at 4.5 m (0.01 at 15 ft)
Max. percentage of initial designed fixture lumens emitted 90 degrees or higher	0%	2%	5%	10%

[1] Lighting Zone 1: *Designated park land* and *forest land*.
Lighting Zone 2: Rural areas, as defined by the 2000 U.S. Census.
Lighting Zone 3: Urban areas, as defined by the 2000 U.S. Census.
Lighting Zone 4: Special districts as defined by local jurisdiction for high intensity nighttime use.

5.4 Prescriptive Option. There are no prescriptive criteria.

5.5 Performance Option. There are no performance criteria.

5.6 Submittals. Submittals are necessary to demonstrate compliance with some of the sections in Chapter 5. Those submittals are as follows:

5.6.1 Site Selection Documentation. Demonstration of compliance with 5.3.1 shall include the following:

(a) For 5.3.1.1, provide a vicinity map and *site* plan highlighting the nature of *site* and details necessary to demonstrate that the *site* is an allowable *site*.

1. If the *site* is being characterized as a *brownfield site*, provide an ASTM E1903 Phase II Environmental Site Assessment or information demonstrating that the *site* has been classified as a *brownfield site* by a local, state, or federal government agency.
2. If the *site* is being characterized as a *greyfield site*, provide a *site* plan showing the current development on the *site* with calculations included on the plan demonstrating that more than 30% of the *site* has been developed with impervious surface.
3. If the *site* is allowable under section 5.3.1.1(d), (e), or (f), provide a vicinity map that identifies either the development density or the ten basic services or the requisite transportation services that are within 800 m (1/2 mi) of the *site*.
4. If the *site* is allowable under any section except 5.3.1.1(g) or (h), provide signed affidavit by the representative of the developer asserting that the land is not *agricultural* or *forest* land.
5. If the *site* is allowable under 5.3.1.1(i), provide federal, state or local documentation that demonstrates that the *site* is within *designated park land*.

(b) For 5.3.1.2,

1. For a previously undeveloped *site*, provide a topographic drawing prepared specifically for the proposal depicting the elevation of the project *site* and demonstrating that the project *site* elevation is a minimum of 1.5 m (5 ft) above the elevation of the 100 year flood plain as defined by the USFEMA.
2. If there is any potential for the presence of a *fish and wildlife habitat conservation area* within 90 m (300 ft) of the proposal, then provide a *site* plan depicting the boundary of the *fish and wildlife habitat conservation area* as well as the buffer area of 90 m (300 ft) within which there will be no *site* disturbance or development. If there will be *site* disturbance or development that involves plantings or habitat enhancement of the functions and values of the area, provide a *site* plan and report prepared by a certified biologist depicting the enhancement and planting plan and providing a summary of how this enhancement and/or planting will benefit the area.
3. If there is any potential for the presence of a *wetland* within 50 m (150 ft) of the

proposal, then provide a *site* plan depicting the boundary of the *wetland* as well as the buffer area of 50 m (150 ft) within which there will be no *site* disturbance or development. If there will be *site* disturbance or development that involves plantings or habitat enhancement of the functions and values of the wetland, provide a *site* plan and report prepared by a certified wetland biologist depicting the enhancement and planting plan and providing a summary of how this enhancement and/or planting will benefit the wetland.

5.6.2 Site Development Documentation. The developer shall provide a site plan that:

(a) depicts the areas of the *site* that are to be retained and/or developed as effective pervious surface pursuant to section 5.3.2(a) if applicable. The plan shall distinguish between those portions of the *site* that are being retained as effective pervious surface and those portions of the *site* that are being developed as effective pervious surface. The plan must show what device or devices are being utilized as effective pervious surface from the list in section 5.3.2(a) and must include visual details that demonstrate that the standards set forth in that section are being met. When *porous pavers* are used, provide the percentage of surface covered by open cells and a description of the material or vegetation in the open cells. When *permeable pavement* is used, provide the mix design and estimated percolation rate. When *permeable pavers* are used, provide a description of the pavers, the width of the gap between pavers, and the estimated percolation rate.

(b) depicts any areas of the *site* that have existing *native plants* and *adaptive plants*, the areas that will be retained pursuant to 5.3.2(b) if applicable, and an identification of specific *native plants* and *adaptive plant* species that are being retained and removed.

(c) depicts a planting plan pursuant to 5.3.2(c) if applicable, and an identification of specific plant species, including *native plants* and *adaptive plant* species, that are being included in that plan.

(d) provides the calculations and analysis necessary to demonstrate compliance with 5.3.2(a), (b) and (c).

(e) if one of the exceptions to 5.3.2(a) is being claimed, include the data, calculations and analysis necessary to demonstrate compliance with that exception as well as a visual depiction of any method used to capture and reuse rain on site.

5.6.3 Heat Island Effect Documentation. Demonstration of compliance with 5.3.3 shall include the following:

(a) For 5.3.3.1:

1. Provide a *site* plan drawing highlighting all non-roof impervious surfaces and portions of these surfaces where one or more strategies listed in 5.3.3.1 are employed in or on the *site hardscape*.
2. If one of the strategies employed is the use of vegetation, then the drawing shall include an indication of the specified plant species and expected plant “footprint”

after five years. Provide calculations of the effective shade coverage area, including shade coverage at 10 am, noon, and 3 pm on the summer solstice.

3. If one of the strategies employed is through the use of paving, provide third-party documentation of the SRI for materials used or proposed for the paving. A default SRI value of 35 for new concrete is allowed to be used in lieu of measurements.
4. If one of the strategies employed is through the use of *porous pavers*, provide the percentage of surface covered by open cells and a description of the material or vegetation in the open cells.
5. If the strategies employed are through the use of structures or buildings, provide the submittals required for Section 5.3.3.3.

(b) For 5.3.3.2:

1. Provide a *site* plan drawing (is allowed to be the same drawing as provided for section (a) above) indicating where the use of shade-providing plants, man-made structures, existing buildings, and hillsides are employed to provide shading to ground-level air conditioner condenser units. Provide calculations showing that 75% of the air conditioner condenser unit has shade coverage at 3 pm on the summer solstice, within 5 years of occupancy.
2. Provide elevation drawings for the east, south, and west above-grade *walls* and retaining structures. Indicate on these drawings the shade coverage provided by shade-providing plants, man-made structures, existing buildings, and hillsides at the required times on the summer solstice. For the south *walls* and retaining structures, also provide the arithmetic mean of the value at 10 am and 3 pm. Provide calculations that the required percentages of shade coverage are met. The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance.
3. For Exception (a) to 5.3.3.2, provide elevation drawings for the applicable east, south, and west above-grade *walls* and retaining structures indicating the SRI of the opaque *wall* surfaces. Provide third party documentation of the SRI for the compliant surfaces.

(c) For 5.3.3.3:

1. Provide a roof plan indicating the amount of roof area designated as penetrations, covered by *renewable energy power systems*, rainwater harvesting, or covered by green roofing systems. Determine the area of the remainder of the roof area. Indicate the amount of roof area meeting the requirements of 5.3.3.3 (a), (b), or the applicable exception.
2. For 5.3.3.3 (a), provide third party documentation of the SRI of the roof material(s).
3. For 5.3.3.3 (b) provide documentation indicating the roof material is Energy Star compliant.
4. For Exception (b) to 5.3.3.3, provide a report of the energy analysis simulation.

Indicate the SRI of the baseline roof (meeting the requirements of 5.3.3.3 (a)) and the proposed roof, and the energy cost and CO_2e savings of the proposed roof compared to the baseline roof

5. For Exception (c) to 5.3.3.3, provide third party documentation of the SRI of the roof material(s). A default SRI value of 35 for new concrete is allowed to be used in lieu of measurements.

5.6.4 Reduction of Light Pollution Documentation. Demonstration of compliance with 5.3.4 shall include the following:

(a) Product data and photometric test reports for all exterior luminaires indicating lamp wattage, zonal lumens, *candela* distribution, and IES *cutoff* classification. Photometric test reports shall be based on independent testing laboratory tests with all accessories, such as house side shields, specified for the project.

(b) Computer-generated point by point illuminance calculations showing horizontal and vertical illuminance at the boundary and at points beyond the boundary in accordance with Table 5.4.3.2. Vertical illuminance shall be calculated in a 1.5 m by 1.5 m (5 ft by 5 ft) grid in a vertical plane up to a point 1.5 m (5 ft) above-grade. Horizontal illuminance shall be calculated in a 1.5 m by 1.5 m (5 ft by 5 ft) grid at grade level between the boundary and the point beyond the boundary in accordance with Table 5.4.3.2. Document illuminance points on a *site* plan having a scale equal to the construction document plan specifying lighting layout. Document calculation inputs including lamp lumens and lamp lumen depreciation.

(c) Calculate percent of lumens above the 90 degree nadir using the zonal lumens from photometric test reports. Percentage shall be based on summation of all lumens emitted above 90 degree for all exterior luminaires divided by the summation of all lamp lumens emitted by all exterior luminaires. Percentage shall be based on initial lamp lumens.

6. WATER USE EFFICIENCY

6.1 Scope. This section specifies requirements for water use efficiency, both for the *site* and for the building, and water metering.

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

(a) 6.4, Prescriptive Option, or

(b) 6.5, Performance Option.

(Note that it not required that compliance for both site water use and building water use be demonstrated using the same compliance option, i.e. Prescriptive or Performance.) Documentation shall comply with 6.6, Submittals.

6.3 Mandatory Provisions

6.3.1 Site Water Use Reduction (Mandatory)

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 to 6.3.1.1:** The area of dedicated athletic fields (e.g. baseball, football, soccer, but excluding 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* vs. shrubs is required.

6.3.1.3 Controls. Any irrigation system for the project *site* shall be controlled by a *smart controller* that uses *evapotranspiration* and weather data to adjust irrigation schedules and that meets the following minimum requirements when tested in accordance with IA SWAT Climatological Based Controllers 7th Draft Testing Protocol.

(a) Irrigation adequacy – 80 percent or greater.

(b) Irrigation excess – not to exceed 10 percent.

6.3.2 Building Water Use Reduction (Mandatory)

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: Maximum flush volume when determined in accordance with ASME A112.19.2 – 4.8 L (1.28 gal).

(b) Water closets (toilets) – tank-type: Shall comply with USEPA WaterSense Tank-Type High-Efficiency Toilet Specification.

(c) Urinals: Maximum flush volume when determined in accordance with ASME A112.19.2 – 1.9 L (0.5 gal). 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 –1.9 L/min (0.5 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(e) Public metering self-closing faucet: Maximum water use – 1.0 L (0.25 gal) per metering cycle when tested in accordance with ASME A112.18.1/CSA B125.1.

(f) *Residential* bathroom sink faucets: Maximum flow rate – 5.7 L/min (1.5 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(g) *Residential* kitchen faucets: Maximum flow rate –8.3 L/min (2.2 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(h) *Residential* showerheads: Maximum flow rate – 7.6 L/min (2.0 gal/min) when tested in accordance with ASME A112.18.1/CSA B125.1.

(i) *Residential* shower compartment (stall) in *dwelling units* and guest rooms: Showerheads, including rain systems, bodyspray, jets, shall be limited to one (1) each per shower compartment, where the floor area of the shower compartment is less than 1.9 m^2 (3,000 in^2). For each increment of 1.9 m^2 (3,000 in^2) of floor area thereafter or part thereof, an additional showerhead is allowed to be installed.

Exception to 6.3.2.1(i): Shower stalls where the flow at any given time does not exceed the total allowed for a single showerhead in 6.3.2.1(h).

6.3.2.2 Appliances.

(a) Clothes washers and dishwashers installed within *dwelling units* shall comply with the USEPA Energy Star Program Requirements for Clothes Washers and Energy Star Program Requirements for Dishwashers and shall have a maximum *water factor* (WF) as follows:

1. Clothes Washers –maximum WF of 23 L/cycle (6.0 gal/cycle).
2. Dishwashers – maximum WF of 25 L/cycle (6.5 gal/cycle).

(See also the energy efficiency requirements in 7.3.2.1(a).)

(b) Clothes washers installed in other *residential* 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 WF of 32 L/cycle (8.5 gal/cycle). (See also the energy efficiency requirements in 7.3.2.1(a).)

6.3.2.3 HVAC Systems and Equipment.

(a) *Once-through cooling* is prohibited.

(b) Cooling towers shall be equipped with makeup and blowdown meters, conductivity controllers and overflow alarms and efficient drift eliminators which achieve drift reduction to 0.001 percent of the circulated water volume for counter flow towers and

0.005% for cross flow towers. (See also Table C-15.)

6.3.2.4 Roofs. The use of *potable water* to spray roofs is prohibited.

6.3.3 Water Metering

6.3.3.1 Meters. Controls, instrumentation and metering shall be integrated into the building to allow measurement and verification of project water use; tracking of utility costs; and the identification of deviations from normal use patterns that indicate equipment or system malfunctions, leaks, or other extraordinary water use events. In the event of the latter, metering systems shall enable corrective action or remediation to be taken by the facilities operator in the event that water use anomalies are indicated.

The domestic water supply (both potable and reclaimed) entering the *building project* shall be metered. In addition, for individual leased, rented, or other tenant or sub-tenant space within any building totaling in excess of 5,000 m^2 (50,000 ft^2) or if the space or any part thereof is used for a laundry/cleaners operation, restaurant/food service, medical/dental office, laboratory, or beauty salon/barbershop, separate submeters shall be provided. For buildings that use evaporative cooling, cooling tower(s), hot water makeup systems, or automatic landscape irrigation system(s), separate submeters shall be provided for each such application. Any project or building, or tenant or sub-tenant within a project or building, such as a commercial car wash or aquarium, shall be submetered where consumption is projected to exceed 3,800 L (1,000 gal) per day.

Provide meters with remote metering capability or automatic meter reading (AMR) capability to collect water use data for each water supply source (e.g. *potable water*, reclaimed water, rainwater) to the project that exceeds the thresholds listed in Table 6.3.3-1. Utility company service entrance/interval meters are allowed to be used provided they are configured for automatic meter reading (AMR) capability.

Table 6.3.3-1 Water Supply Source Meter Thresholds.

Water Source	Main Metering Threshold
Potable Water	3,800 L/day (1,000 gal/day)
Municipally reclaimed water	3,800 L/day (1,000 gal/day)
Alternate sources of water	1,900 L/day (500 gal/day)

Provide sub-metering with remote metering or AMR capability to collect water use data for each of following building subsystems, if they are sized above the threshold level in Table 6.3.3-2:

Table 6.3.3-2 Subsystem Water Use Thresholds

Subsystem	Sub-Metering Threshold
Cooling Towers	All

Central boilers and water heater feed	> 50 kW (500,000 Btu/h) input
Irrigated landscape area with controllers	> 2,500 m^2 (25,000 ft^2)
Separate campus buildings	All > 3,800 L/day (1,000 gal/day)
Separately leased on rental space	> 20% of water use not including above
Any large water using process	> 3,800 L/day (1,000 gal/day)

6.3.3.2 Meter Data Collection. All building meters and sub-meters installed to comply with the thresholds limits in 6.3.3.1 shall be configured to communicate water consumption data to a meter data management system. Meters shall provide data a minimum of daily and shall record a minimum of 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 and sub-meter data and creating user reports showing calculated hourly, daily, monthly and annual water consumption for each meter and sub-meter and provide alarming notification capabilities as needed to support the requirements of the Water Efficiency Measurement and Verification plan in 10.3.3.2.

6.4 Prescriptive Option

6.4.1 Site Water Use Reduction (Prescriptive Option). 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 areas, a maximum of one third of *improved landscape* is allowed to be irrigated with *potable water*. All other irrigation shall be provided from *alternate on-site sources of water* or municipally-reclaimed water.

Exceptions to 6.4.1:

(a) The area of dedicated athletic fields (e.g. baseball, football, soccer, but not a golf course or driving range) shall be excluded from the calculation of the *improved landscape* for schools, *residential* common areas, or public recreational facilities.

(b) To establish permanent landscape plantings, *potable water* is allowed to be temporarily used on such newly installed landscape for a two-year period beginning on the day installation of the permanent landscape begins. The amount of *potable water* that may be applied to the newly planted areas shall not exceed 70% of ETo for *turfgrass* and 55% of ETo for other plantings. If municipally-reclaimed water is available at a water main within 60 m (200 ft) of the project *site*, it shall be used in lieu of *potable water* during the establishment period. After the two-year establishment period has expired, all irrigation water use shall meet the requirements established elsewhere in this standard.

6.4.2 Building Water Use Reduction (Prescriptive Option).

6.4.2.1 Cooling Tower. Cooling towers for air conditioning systems such as chilled water systems shall achieve a minimum of five (5) cycles of concentration based on a ratio of the conductivity of the water being discharged (blowdown) divided by the conductivity of the feed (makeup) water(s), or shall achieve a minimum discharge

(blowdown) conductivity of 1500 mg/L (1500 ppm), or 175 mg/L (175 ppm) of silica measured as silicon dioxide whichever is met first.

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 4.9 L (1.3 gal) per minute or less and meet a 26-second performance requirement when tested in accordance with ASTM F2324),

(b) shall use high-efficiency dishwashers (i.e. undercounter dishwashers that function at 1.2 gal per rack or less, door dishwashers that function at 3.4 L (0.9 gal) per rack or less, and flight-type machines that shall use less than 680 L (180 gal) per hour,

(c) shall use boilerless/connectionless food steamers that use no more than 7.5 L (2.0 gal) per hour,

(d) shall use air-cooled ice machines that comply with 7.3.2.2, or shall use water-cooled ice machines that comply with 7.3.2.2 and are connected to a closed loop water system such that cooling water does not flow to waste, and

(e) shall not use conventional water-fed garbage disposers.

6.4.2.3 Medical and Laboratory Facilities. Medical and laboratory facilities (e.g. clinics, hospitals, medical centers, physician, dental offices, and medical and non-medical laboratories of all types):

(a) shall use water-efficient steam sterilizers that have (1) water tempering devices that only allow water to flow when the discharge of condensate or hot water from the sterilizer exceeds 60 C (140 °F) and (2) mechanical vacuum equipment in place of venturi-type vacuum systems for vacuum sterilizers,

(b) shall use film processor water recycling units where large frame x-ray films of more than 150 mm (6 in.) in either length or width are processed (small dental x-ray equipment is exempt from this requirement),

(c) shall use digital imaging and radiography systems where the digital networks are installed (as opposed to conventional film-based systems),

(d) shall have 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) shall use dry vacuum pumps, unless fire and safety codes for explosive, corrosive or oxidative gasses requires a liquid ring pump, and,

(f) shall have efficient water treatment systems that meet the following criteria:

1. For all filtration processes, have pressure gauges that determine when to backwash or change cartridges;

2. For all ion exchange and softening processes, have recharge cycles set by volume of water treated or based upon conductivity or hardness;
3. For reverse osmosis and nanofiltration equipment, reject water shall not exceed 60 % of the feed water and shall be used as scrubber feed water or other beneficial uses on the project *site*.

   Exception to 6.4.2.3: Food service operations within medical facilities shall comply with 6.4.2.2.

6.4.3 Special Water Features (Prescriptive Option). 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 and meeting USEPA standards for reclaimed water. Fountains and other features shall be equipped with makeup water meters and shall incorporate equipment to recirculate, filter, and treat the water for reuse within the system.

(b) Pools and spas:

1. Backwash water: recover filter backwash water for reuse on landscaping or other applications, or treat and reuse backwash water.
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) a pressure drop gauge to determine when the pool needs to be backwashed and (b) 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 *authority having jurisdiction*.

6.5.1 Site Water Use Reduction (Performance Option). *Potable water* consumption for the irrigation of *improved landscape* shall not exceed 35% of baseline *evapotranspiration* for that area of the country where the baseline is equal to 70% of ETo for *turfgrass* areas and 55% of ETo for all other plant material after adjustment for rainfall.

Water from *alternate on-site sources of water* shall not be used for irrigation if:

(a) total dissolved solids in the water exceed 1,000 mg/L (1,000 ppm), or

(b) the water exceeds quality limits established by the local stormwater or water quality *authority having jurisdiction*.

6.5.2 Building Water Use Reduction (Performance Option). The *building project* shall have an annual interior water use less than or equal to that achieved by compliance

with 6.3.2 and 6.4.2 and 6.4.3.

6.6 Submittals

6.6.1 Site Water Use Reduction (Mandatory) Documentation. Demonstration of compliance with 6.3.1 shall include the following:

(a) For 6.3.1.1, provide a post-development *site* plan that clearly delineates more than 60% of the area of the *improved landscape* is *native plants* and *adapted plants* other than *turfgrass*.

(b) For 6.3.1.2, provide a post-development *site* plan that clearly indicates the appropriate *hydrozoning* for different landscape zones.

(c) For 6.3.1.3, provide a design narrative that describes the irrigation controls used on the project. Provide irrigation controls cut-sheets and specifications.

6.6.2 Building Water Use Reduction (Mandatory) Documentation. Demonstration of compliance with 6.3.2 shall include the following:

(a) For 6.3.2.1, provide a table on the drawings that describes the performance characteristics including flow rates of the plumbing fixtures and fittings installed in the project.

(b) For 6.3.2.2, provide a table on the drawings that describes the performance characteristics including WF of the appliances installed in the project.

(c) For 6.3.2.3, provide notes on the drawings indicating that *once-through cooling* is not used and that cooling towers achieve drift reduction for the HVAC systems and equipment installed in the project.

(d) For 6.3.2.4, provide a note on the drawings indicating that *potable water* shall not be used to spray roofs.

6.6.3 Water Metering Documentation. Demonstration of compliance with 6.3.3 shall include the following:

(a) provide a design narrative that describes the project's water use meters and their data collection, storage and retrieval capabilities.

(b) provide water meter cut-sheets and specifications.

6.6.4 Site Water Use Reduction (Prescriptive Option) Documentation. Where the Prescriptive Option is used, demonstration of compliance with 6.4.1 shall include the following:

(a) provide a post-development *site* plan that shows the landscape irrigation system.

(b) Provide drawing notes and calculations to verify that the irrigation system complies with the limits on *potable water* for irrigation.

6.6.5 Building Water Use Reduction (Prescriptive Option) Documentation. Where the Prescriptive Option is used, demonstration of compliance with 6.4.2 shall include the following:

(a) provide calculations to show the cycles of concentration for the cooling tower.

(b) provide a table that specifies the water efficiency performance characteristics for commercial food service equipment referenced.

(c) provide a table that specifies the water efficiency performance characteristics for medical and laboratory equipment referenced.

6.6.5 Special Water Features (Prescriptive Option) Documentation. Where the Prescriptive Option is used, demonstration of compliance with 6.4.3 shall include the following:

(a) provide documentation of the source of water being used for fountains and other ornamental water features.

(b) provide documentation demonstrating compliance with the requirements listed for backwash, filtration and splash troughs

6.6.6 Site Water Use Reduction (Performance Option) Documentation. Where the Performance Option is used, demonstration of compliance with 6.5.1 shall include the following:

(a) calculation of the baseline evapotranspiration.

(b) Calculation of the *potable water* use for irrigation of the *improved landscape* for the proposed *building project*.

(Informative note: See example in Informative Appendix H.)

6.6.7 Building Water Use Reduction (Performance Option) Documentation. Where the Performance Option is used, demonstration of compliance with 6.5.2 shall include the following:

(a) calculation of the baseline building water use in accordance with 6.3.2, 6.4.2, and 6.4.3.

(b) calculation of the building water use for the proposed *building project*.

(Informative note: See example in Informative Appendix H.)

7. ENERGY EFFICIENCY

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

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

(a) 7.4, Prescriptive Option, or

(b) 7.5, Performance Option.

Documentation shall comply with 7.6, Submittals.

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 ASHRAE/IESNA Standard 90.1.

7.3.2 Equipment and Appliances. Equipment and appliances shall comply with 7.3.2.1 and 7.3.2.2.

7.3.2.1 Energy Star Equipment and Appliances. The following equipment and appliances within the scope of the applicable USEPA Energy Star program shall have the Energy Star label:

(a) appliances

1. battery chargers: Energy Star Program Requirements for Products with Battery Charger Systems (BCSs)
2. clothes washers: Energy Star Program Requirements for Clothes Washers (see also the water efficiency requirements in 6.3.2.2)
3. dehumidifiers: Energy Star Program Requirements for Dehumidifiers
4. dishwashers: Energy Star Program Requirements for Dishwashers (see also the water efficiency requirements in 6.3.2.2)
5. refrigerators and freezers: Energy Star Program Requirements for Refrigerators and Freezers
6. room air conditioners: Energy Star Program Requirements and Criteria for Room Air Conditioners (see also the energy efficiency requirements in 7.4.1)
7. room air cleaners: Energy Star Program Requirements for Room Air Cleaners
8. water coolers: Energy Star Program Requirements for Bottled Water Coolers

(b) heating and cooling

1. air-source heat pumps: Energy Star Program Requirements for ASHPs and Central Air Conditioners (see also the energy efficiency requirements in 7.4.1)
2. boilers: Energy Star Program Requirements for Boilers (see also the energy

efficiency requirements in 7.4.1)

3. central air conditioners: Energy Star Program Requirements for ASHPs and Central Air Conditioners (see also the energy efficiency requirements in 7.4.1)
4. ceiling fans: Energy Star Program Requirements for Residential Ceiling Fans
5. dehumidifiers: Energy Star Program Requirements for Dehumidifiers
6. furnaces: Energy Star Program Requirements for Furnaces (see also the energy efficiency requirements in 7.4.1)
7. geothermal heat pumps: Energy Star Program Requirements for Geothermal Heat Pumps (see also the energy efficiency requirements in 7.4.1)
8. light commercial packaged rooftop air-conditioners: Energy Star Program Requirements for Light Commercial HVAC (see also the energy efficiency requirements in 7.4.1)
9. programmable thermostats: Energy Star Program Requirements for Programmable Thermostats
10. room air conditioners: Energy Star Program Requirements and Criteria for Room Air Conditioners (see also the energy efficiency requirements in 7.4.1)
11. ventilating fans: Energy Star Program Requirements for Residential Ventilating Fans

(c) electronics

1. cordless phones: Energy Star Program Requirements for Telephony
2. combination units (TV/VCR/DVD): Energy Star Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units
3. DVD products: Energy Star Program Requirements for Consumer Audio and DVD
4. audio: Energy Star Program Requirements for Consumer Audio and DVD
5. televisions: Energy Star Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units
6. VCRs: Energy Star Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units

(d) office equipment

1. computers: Energy Star Computer Memorandum of Understanding
2. copiers: Energy Star Copier Memorandum of Understanding
3. fax machines: Printer, Fax, Printer/Fax, and Mailing Machine Memorandum of Understanding

4. laptops: Energy Star Computer Memorandum of Understanding
5. mailing machines: Printer, Fax, Printer/Fax, and Mailing Machine Memorandum of Understanding
6. monitors: Energy Star Program Requirements for Computer Monitors
7. multifunction devices (printer/fax/scanner): Energy Star Memorandum of Understanding for Multifunction Devices
8. printers: Printer, Fax, Printer/Fax, and Mailing Machine Memorandum of Understanding
9. scanners: Energy Star Scanner Memorandum of Understanding

(e) 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
3. ceiling fans: Energy Star Program Requirements for Residential Ceiling Fans

(f) 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 6.4.2.2)

(g) 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. traffic signals: Energy Star Program Requirements for Traffic Signals
4. transformers: Energy Star Program Requirements for Commercial and Industrial Transformers (see also the energy efficiency requirements in 7.4.5)
5. vending machines: Energy Star Program Requirements for Refrigerated Beverage Vending Machines

Exceptions to 7.3.2.1: Products with minimum efficiencies addressed in the USGPO Energy Policy Act (EPAct).

7.3.2.2 Ice Cube Machines, Commercial Refrigerators and Freezers, and Commercial Clothes Washers.

(a) Air-cooled ice cube machines shall comply with the minimum efficiencies in Table C-22 in Normative Appendix C.

(b) Water-cooled ice cube machines shall comply with the minimum efficiencies in Table C-23 in Normative Appendix C. (See also water efficiency requirements in 6.4.2.2.)

(c) Commercial refrigerators and freezers shall comply with the minimum efficiencies in Table C-24 in Normative Appendix C and all lighting within the unit shall be solid state (e.g. LED). Open refrigerated display cases are prohibited.

(d) Commercial clothes washers shall comply with the minimum efficiencies in Table C-25 in Normative Appendix C.

7.3.3 On-site Renewable Energy Power Systems. *Building projects* shall contain *on-site renewable energy power systems* with a peak electrical generating capacity of not less than 1.0% of the *electrical service load* as calculated in accordance with NFPA 70 for the *building project*.

Exceptions to 7.3.3:

(a) Provide an on-site solar water heating system meeting 100% of the domestic hot water needs or with a peak capacity equivalent to not less than 2.5 % of the *electrical service load* as calculated in accordance with NFPA 70 for the *building project* on a partial or complete basis. The system shall be certified in accordance with SRCC OG-100.

(b) *Building projects* that demonstrate compliance using the Performance Option in 7.5 and either

i. achieve a minimum additional 5.0% annual energy cost savings and a minimum additional 5.0% annual CO_2e savings beyond that required for compliance with 7.5, or

ii. provide any combination of energy cost and CO_2e savings achieving a minimum of 10.0% total.

7.3.4 Energy Metering

7.3.4.1 Meters. Provide meters with remote metering capability or automatic meter reading (AMR) capability to collect energy use data for each supply energy source (e.g. gas, electricity, district steam) to the building that exceed thresholds listed in Table 7.3.4-1. Utility company service entrance/interval meters are allowed to be used provided they are configured for automatic meter reading (AMR) capability.

Table 7.3.4-1 Energy Source Meter Thresholds

Energy Source	Main Metering Threshold
Electrical service	> 200 kVA
On-site renewable energy power	All systems > 1 kVA (peak)
Gas and steam service	> 300 kW (1,000,000 Btu/h) building load
Geothermal	> 300 kW (1,000,000 Btu/h) heating

Provide sub-metering with remote metering capability to collect energy use data for each component of the following building subsystems if they are sized above the threshold level in Table 7.3.4-2:

Table 7.3.4-2 Subsytem Energy Use Thresholds

Subsystem	Sub-Metering Threshold
Chillers/heat pumps	> 70 kW (240,000 Btu/h) cooling capacity
Packaged AC systems	> 70 kW (240,000 Btu/h) cooling
Fan systems	> 15 W (20 hp)
Pumps	> 15 W (20 hp)
Cooling towers	> 15 W (20 hp)
Boilers and other heating systems	> 300 kW (1,000,000 Btu/h) input
General lighting circuits	> 100 kVA
Miscellaneous electric loads	> 100 kVA

Meters shall be digital-type, utility grade. Existing buildings are allowed to reuse installed existing analog-type utility company service/interval meters.

7.3.4.2 Meter Data Collection. All building meters shall be configured to communicate energy consumption data to a meter data management system. Meters shall provide data a minimum of daily and shall record a minimum of hourly consumption of energy.

7.3.4.3 Data Storage and Retrieval. The meter data management system shall be capable of electronically storing energy meter data and creating user reports showing calculated hourly, daily, monthly and annual energy consumption for each meter.

7.4 Prescriptive Option

7.4.1 General Comprehensive Prescriptive Requirements. When a requirement is provided below, it supersedes the requirement in ASHRAE/IESNA Standard 90.1. For all

other criteria, the *building project* shall comply with the requirements of ASHRAE/IESNA Standard 90.1.

For multifamily *residential building projects*, the *dwelling units* shall be no larger than 90 m^2 (900 ft^2) for one-bedroom units, 125 m^2 (1,250 ft^2) for two-bedroom units, 170 m^2 (1,700 ft^2) for three-bedroom units and 210 m^2 (2,100 ft^2) for units with four or more bedrooms. Projects with larger *dwelling units* shall demonstrate compliance using 7.5.1.

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

(a) Tables 5.5-1 to 5.5-8 of ASHRAE/IESNA Standard 90.1: The *building envelope* shall comply with the requirements 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 ASHRAE/IESNA Standard 90.1.

Exception to 7.4.2(a): Buildings that comply with 9.3.7 regardless of building area are exempt from the *SHGC* criteria for *skylights*.

(b) Section 5.5.3.1 of ASHRAE/IESNA Standard 90.1: *Roofs* shall comply with the provisions of 5.3.3.3 and Tables A-1 to A-8 of this Standard. Section 5.5.3.1.1 of ASHRAE/IESNA Standard 90.1 and Table 5.5.3.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

(c) Section 5.5.3.1, Section A2.4.2.4, and Table A2.4.2 of ASHRAE/IESNA Standard 90.1: *Single-rafter roofs* shall comply with the criteria for *attic and other roofs*. These requirements supersede the requirements in Section A2.4.2.4 of ASHRAE/IESNA Standard 90.1. Section A2.4.2.4 and Table A2.4.2 of ASHRAE/IESNA Standard 90.1 shall not apply.

(d) Section 5.5.4.2.1 of ASHRAE/IESNA Standard 90.1: 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 ASHRAE/IESNA Standard 90.1.

(e) Section 5.5.4.4 of ASHRAE/IESNA Standard 90.1: 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 *projection factor* of not less than 0.50 and that will last as long as the building itself. The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance.

(f) Section 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1: For *SHGC* compliance, the methodology in exception (b) to Section 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1 is allowed provided that the *SHGC* multipliers in Table 7.4.2 are used. This requirement supersedes the requirement in Table 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1. Table 5.5.4.4.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

Table 7.4.2 SHGC Multipliers for Permanent Projections

Projection Factor	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

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

(h) Section 5.6 of ASHRAE/IESNA Standard 90.1: The *building envelope* trade-off option in Section 5.6 of ASHRAE/IESNA Standard 90.1 shall not apply unless the procedure incorporates the modifications and additions to ASHRAE/IESNA Standard 90.1 noted above and below.

(i) In addition to ASHRAE/IESNA Standard 90.1, 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 meet the following requirements:

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

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

2. For *climate zones* 5 and 6:

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

Where:

$SHGC_x$ = the *SHGC* for orientation x

A_x = *fenestration area* for orientation x

N = north

S = south

E = east

W = west

The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance.

Exception to 7.4.2(i): Buildings adjacent to existing buildings on one or more sides.

(j) In addition to ASHRAE/IESNA Standard 90.1, 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 to 7.4.2 (j): *Building envelopes* of buildings in *climate zones* 1, 2, and 3; buildings over 7 stories above grade in all *climate zones*; or *semiheated spaces* in all *climate zones* provided the *building envelope* complies with Section 5.4.3.1 of 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 ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Section 6.3.2 of ASHRAE/IESNA Standard 90.1: Criteria (c) of Section 6.3.2 of ASHRAE/IESNA Standard 90.1 is modified to strike the allowance for higher efficiency equipment in lieu of installing economizer. Table 6.3.2 of ASHRAE/IESNA Standard 90.1 shall not apply.

(b) Sections 6.4.1.1 and 6.4.1.2 and Tables 6.8.1A to 6.8.1J of ASHRAE/IESNA Standard 90.1: Projects shall comply with one of the following:

1. **EPAct baseline.** Products with minimum efficiencies addressed in the National Appliance Energy Conservation Act (NAECA) and Energy Policy Act (EPAct) provided that the *building project* contains:
   i. *on-site renewable energy power systems* with twice the minimum capacity of that specified in 7.3.3, and
   ii. peak load reduction systems with twice the peak load reduction specified in 7.4.5.
2. **Higher Efficiency.** For those products where there is an Energy Star program, the minimum efficiency shall be the greater of the Energy Star requirements in 7.3.2.1 or the values in Tables C-1 to C-15 in Normative Appendix C. For other products, the equipment efficiency shall be a minimum of the values in Tables C-

1 to C-15 in Normative Appendix C. These requirements supersede the requirements in Tables 6.8.1A to 6.8.1J of ASHRAE/IESNA Standard 90.1.

(c) Sections 6.4.3.4.1 and 6.4.3.4.2 of ASHRAE/IESNA Standard 90.1: Motorized dampers shall be installed for all applications. Exception a to Sections 6.4.3.4.1 and 6.4.3.4.2 of ASHRAE/IESNA Standard 90.1 shall not apply for outdoor intake dampers.

(d) Section 6.4.3.9 of ASHRAE/IESNA Standard 90.1: The threshold for controls to automatically reduce outdoor air intake below design rates when spaces are partially occupied shall be systems with design outdoor air capacities greater than 500 L/s (1000 cfm) serving areas having an average design occupancy density of 15 or more people per 100 m^2 (1000 ft^2). These requirements supersede the requirements in Section 6.4.3.9 of ASHRAE/IESNA Standard 90.1.

(e) Section 6.4.4.2 and Table 6.4.4.2A of ASHRAE/IESNA Standard 90.1: For duct sealing, Seal Level A shall be used. This requirement supersedes the requirements in Table 6.4.4.2A of ASHRAE/IESNA Standard 90.1.

(f) Section 6.5.1 and Table 6.5.1 of ASHRAE/IESNA Standard 90.1: Systems shall have economizers as specified in Table 7.4.3-1 and high-limit controls as specified in Table 7.4.3-2. These requirements supersede the requirements in Table 6.5.1 of ASHRAE/IESNA Standard 90.1. Exception (i) to Section 6.5.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

Table 7.4.3-1 Minimum System Size for Which an Economizer is Required

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

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

Table 7.4.3-2 High Limit Shutoff Control Options for Air Economizer

Climate Zones	Allowable Control Types
1A, 2A, 3A, 4A	Differential Enthalpy
1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	Differential Enthalpy or Differential Drybulb

(g) Section 6.5.2.1 of ASHRAE/IESNA Standard 90.1: Exception (a) to Section 6.5.2.1

of ASHRAE/IESNA Standard 90.1 shall be revised to be limited to zones for which the volume of air that is reheated, recooled, or mixed is no greater than the volume of outdoor air required to meet the ventilation requirements of 9.3.1 for the zone. Systems that reheat, recool, or mix greater volumes are not allowed. The remainder of exception (a) to 6.5.2.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

(h) Section 6.5.3.1 and Table 6.5.3.1.1A of ASHRAE/IESNA Standard 90.1: Systems shall have fan power limitations 10% below limitations specified in Table 6.5.3.1.1A of ASHRAE/IESNA Standard 90.1. This requirement supersedes the requirement in Section 6.5.3.1 and Table 6.5.3.1.1A and of ASHRAE/IESNA Standard 90.1. All exceptions in Section 6.5.3.1 of ASHRAE/IESNA Standard 90.1 shall apply.

(i) Section 6.5.3.2.1 of ASHRAE/IESNA Standard 90.1: In addition, *DX* systems with a capacity greater than 19 kW (65,000 Btu/h) shall have a minimum of 2 stages of cooling capacity. In addition when used for constant-volume application, the indoor fans shall be equipped with a reduced-fan-speed option that will result in less than 40% power at 66% flow. Controls shall be configured to use the reduced-speed-fan option when the unit mechanical cooling capacity is less than 65% or when the economizer is being used for cooling and the damper position is less than 90% open.

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

(j) Section 6.5.4.1 of ASHRAE/IESNA Standard 90.1: Motors exceeding 15 kW (20 hp) shall have controls and/or devices (such as variable speed control) that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow. This requirement supersedes the requirements in Section 6.5.4.1 of ASHRAE/IESNA Standard 90.1.

(k) Section 6.5.6.1 of ASHRAE/IESNA Standard 90.1: The system shall comply with the energy recovery requirements in Table 7.4.3-3. Where a single room or space is supplied by multiple units, the aggregate supply L/s (cfm) of those units shall be used in applying this requirement.

Energy recovery systems shall have a minimum of 60% recovery effectiveness per Table 7.4.3-4. Provision shall be made for all outdoor, exhaust, and supply air to bypass the energy recovery device when the system has an economizer or during periods when use of the device would increase the energy consumption of the system.

In addition, this requirement shall apply to commercial kitchen hoods. Exception (d) to 6.5.6.1 of ASHRAE/IESNA Standard 90.1 shall not apply.

These requirements supersede the requirements in Section 6.5.6.1 of ASHRAE/IESNA Standard 90.1. Other than exception (d), all exceptions in 6.5.6.1 of ASHRAE/IESNA Standard 90.1 shall apply.

Table 7.4.3-3 Energy Recovery Requirement (SI)

Zone	% Outside Air at Full Design L/s								
	≥5% and < 10%	≥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 L/s								

3C	NR	NR	NR	NR	≥8000	≥4500	≥2500	≥2000	≥2000
2B, 3A, 3B, 4A, 4B, 4C, 5B, 5C	≥6000	≥5000	≥3500	≥2500	≥2000	≥2000	≥1500	≥1000	≥500
1A, 1B, 2A, 5A, 6A, 6B	≥2500	≥2500	≥2000	≥2000	≥1500	≥1000	≥500	>0	>0
7,8	≥1000	≥1000	≥0	>0	>0	>0	>0	>0	>0

Table 7.4.3-3 Energy Recovery Requirement (IP)

Zone	% Outside Air at Full Design CFM								
	≥5% and < 10%	≥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 CFM								
3C	NR	NR	NR	NR	≥16500	≥9500	≥5500	≥4500	≥4000
2B, 3A, 3B, 4A, 4B, 4C, 5B, 5C	≥13000	≥11000	≥7000	≥5500	≥4500	≥4000	≥3500	≥2000	≥1000
1A, 1B, 2A, 5A, 6A, 6B	≥5500	≥5000	≥4500	≥4000	≥3500	≥2500	≥1500	>0	>0
7,8	≥2500	≥2000	≥0	>0	>0	>0	>0	>0	>0

Table 7.4.3-4 Performance Requirement for Energy Recovery Equipment (SI)

Equipment Type	Application	Rating Condition	Performance Required	Test Procedure
Energy Recovery	Cooling	35 C DB/25.6 C WB	≥ 60%Total Effectiveness	ARI 1060
Energy Recovery	Heating	1.7 C DB/0.6 C WB	≥ 60% Total Effectiveness	ARI 1060

Table 7.4.3-4 Performance Requirement for Energy Recovery Equipment (IP)

Equipment Type	Application	Rating Condition	Performance Required	Test Procedure
Energy Recovery	Cooling	95°F DB/78°F WB	≥ 60%Total Effectiveness	ARI 1060
Energy Recovery	Heating	35°F DB/33°F WB	≥ 60% Total Effectiveness	ARI 1060

(l) Section 6.5.7.1 of ASHRAE/IESNA Standard 90.1, variable speed fan control for commercial kitchen hoods: In addition to the requirements in 6.5.7.1, commercial kitchen Type I and Type II hoods shall have variable speed control for exhaust and make-up fans to reduce hood airflow rates at least 50% during those times when heat and smoke are not being produced by the cooking equipment the hood is serving. These requirements supersede the requirements in Section 6.5.7.1 of ASHRAE/IESNA Standard 90.1. All exceptions in 6.5.7.1 of ASHRAE/IESNA Standard 90.1 shall apply

(m) Section 6.8.2 and Tables 6.8.2A and Table 6.8.2B of ASHRAE/IESNA Standard

90.1: Duct insulation shall comply with the minimum requirements in Tables C-16 and C-17 in Normative Appendix C. These requirements supersede the requirements in Tables 6.8.2A and Table 6.8.2B of ASHRAE/IESNA Standard 90.1.

(n) Section 6.8.3 and Table 6.8.3 of ASHRAE/IESNA Standard 90.1: Pipe insulation shall comply with the minimum requirements in Table C-18 in Normative Appendix C. These requirements supersede the requirements in Table 6.8.3 of ASHRAE/IESNA Standard 90.1.

(o) In addition to ASHRAE/IESNA Standard 90.1, piping system pressure loss limitations: All HVAC chilled water and condenser water piping systems shall be designed such that the fluid flow in L/s (gpm) in each pipe segment shall not exceed the values listed in Table 7.4.3-5 for the appropriate total annual hours of operation. Pipe size selections for systems that operate under variable flow conditions are allowed to be made from the "Variable Flow/ Constant Speed" column. Pipe size selections for systems that operate under variable flow conditions and that contain variable frequency drive pump motors are allowed to be made from the "Variable Flow/Variable Speed" columns. All others shall be made from the "Constant Flow/Constant Speed" columns.

Table 7.4.3-5: Piping System Design Maximum Flow Rate in L/S (SI)

	<=2000 hours/yr			<=4400 hours/year			<=8760 hours/year		
Diameter Nominal (mm)	Constant Flow/ Constant Speed	Variable Flow/ Constant Speed	Variable Flow/ Variable Speed	Constant Flow/ Constant Speed	Variable Flow/ Constant Speed	Variable Flow/ Variable Speed	Constant Flow/ Constant Speed	Variable Flow/ Constant Speed	Variable Flow/ Variable Speed
15	0.2	0.3	0.3	0.2	0.2	0.2	0.1	0.2	0.2
20	0.5	0.6	0.7	0.4	0.4	0.6	0.3	0.3	0.4
25	0.8	0.9	1.3	0.6	0.8	0.9	0.5	0.6	0.8
32	1.2	1.4	1.8	0.9	1.1	1.4	0.7	0.8	1.1
40	1.8	2.2	2.8	1.4	1.7	2.1	1.1	1.3	1.6
50	4	5	6	3	4	5	2	3	4
65	5	6	7	4	4	5	3	3	4
80	9	11	14	7	8	11	6	7	8
100	18	21	27	13	16	20	11	13	16
150	37	44	56	28	33	42	22	26	33
200	49	58	76	37	45	56	29	35	44
250	88	107	139	63	82	101	54	63	82
300	120	145	189	88	107	139	69	82	107
350	208	246	316	151	189	240	120	145	189
400	259	309	391	196	233	297	151	183	233
450	353	416	530	271	316	404	208	252	316
500	391	461	587	297	353	448	233	278	353
600	581	694	883	442	530	631	347	416	530
700	757	883	1136	587	694	883	461	549	694

750	1073	1199	1578	757	947	1136	631	757	947

Table 7.4.3-5: Piping System Design Maximum Flow Rate in GPM (IP)

	<=2000 hours/yr			<=4400 hours/year			<=8760 hours/year		
Nominal Pipe Size (in.)	Constant Flow/ Constant Speed	Variable Flow/ Constant Speed	Variable Flow/ Variable Speed	Constant Flow/ Constant Speed	Variable Flow/ Constant Speed	Variable Flow/ Variable Speed	Constant Flow/ Constant Speed	Variable Flow/ Constant Speed	Variable Flow/ Variable Speed
½	3.5	4.1	5.2	2.6	3.1	3.9	2.0	2.4	3.2
¾	7.7	9.2	11	5.8	7.0	8.8	4.6	5.5	6.9
1	13	15	20	10	12	15	7.9	9.5	12
1-1/4	19	22	29	14	17	22	11	13	17
1-1/2	29	35	44	22	27	34	17	21	26
2	65	77	98	49	59	74	39	46	59
2-1/2	76	90	110	58	69	87	46	54	69
3	150	180	220	110	130	170	91	110	130
4	280	330	420	210	250	320	170	200	250
5	330	400	510	250	300	380	200	240	300
6	580	690	880	440	530	670	350	410	530
8	780	920	1200	590	710	890	460	560	700
10	1400	1700	2200	1000	1300	1600	850	1000	1300
12	1900	2300	3000	1400	1700	2200	1100	1300	1700
14	3300	3900	5000	2400	3000	3800	1900	2300	3000
16	4100	4900	6200	3100	3700	4700	2400	2900	3700
18	5600	6600	8400	4300	5000	6400	3300	4000	5000
20	6200	7300	9300	4700	5600	7100	3700	4400	5600
24	9200	11000	14000	7000	8400	10000	5500	6600	8400
26	12000	14000	18000	9300	11000	14000	7300	8700	11000
30	17000	19000	25000	12000	15000	18000	10000	12000	15000

(p) In addition to ASHRAE/IESNA Standard 90.1, automatic control of HVAC and lights in hotel/motel guest rooms: A minimum of one of the following control technologies shall be required in hotel/motel guest rooms with over 50 guest rooms such that all the power to the lights and switched outlets in a hotel or motel guest room would be turned off when the occupant is not in the room and the space temperature would automatically setback (winter) or set up (summer) by no less than 3 C (5 ºF):

1. Controls that are activated by the room occupant via the primary room access method—key, card, deadbolt, etc.
2. Occupancy sensor controls that are activated by the occupant's presence in the room.

7.4.4 Service Water Heating. The *service water heating* shall comply with Section

7 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Section 7.4.2 and Table 7.8 of ASHRAE/IESNA Standard 90.1: Equipment shall comply with the minimum efficiencies in Table C-19 in Normative Appendix C. These requirements supersede the requirements in Table 7.8 of ASHRAE/IESNA Standard 90.1.

(b) Section 7.4.3 of ASHRAE/IESNA Standard 90.1: Pipe insulation shall comply with 7.4.3(k) above. These requirements supersede the requirements in Section 7.4.3 of ASHRAE/IESNA Standard 90.1.

(c) In addition to ASHRAE/IESNA Standard 90.1, insulation for spa pools: Pools heated to more than 32 C (90°F) shall have side and bottom surfaces insulated on the exterior with a minimum insulation value of R-2.1 (R-12).

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

(a) In addition to ASHRAE/IESNA Standard 90.1, transformer efficiency: Transformers shall comply with the minimum requirements in Table C-21 in Normative Appendix C.

(b) In addition to ASHRAE/IESNA Standard 90.1, *load factor*/peak load reduction: *Building projects* shall contain automatic systems such as demand-limiting or load shifting (but not standby emergency power generation) to reduce peak capacity of the building, equivalent to not less than 5.0% of the *electrical service load* as calculated in accordance with NFPA 70 for the *building project* on a partial or complete basis.

7.4.6 Lighting. The lighting shall comply with Section 9 of ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Sections 9.5 and 9.6 of ASHRAE/IESNA Standard 90.1: For all spaces except retail, 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. These requirements supersede the requirements in Sections 9.5 and 9.6 of ASHRAE/IESNA Standard 90.1.

(b) In addition to ASHRAE/IESNA Standard 90.1, occupancy sensor controls: Offices 25 m^2 (250 ft^2) or smaller, *classrooms* of any size, lecture, training, or vocational rooms of less than 100 m^2 (1000 ft^2), multipurpose rooms of less than 100 m^2 (1000 ft^2), and conference rooms and meeting rooms less than 100 m^2 (1000 ft^2) in hotels, convention, conference, multipurpose and meeting centers shall be equipped with occupant sensor(s) to shut off the lighting. In addition, controls shall be provided that allow manual shutoff of all lights. Occupancy sensors shall be either "manual ON" occupancy sensor or a 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 spaces are within a daylit area, occupancy sensor shall work in conjunction with daylighting controls meeting 7.4.6(e).

(c) In addition to ASHRAE/IESNA Standard 90.1, 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:

1. Hotel and motel hallways.
2. Commercial and Industrial Storage stack areas.
3. Library Stack areas.

(d) In addition to ASHRAE/IESNA Standard 90.1, 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 3 W/m^2 (0.3 W/ft^2). All other egress and security lighting shall be controlled by a time switch control device that turns off all lights.

(e) In addition to ASHRAE/IESNA Standard 90.1, automatic controls for lighting in daylight zones: Lighting in all *daylight zones*, both *daylight zones under skylights* and *daylight zones adjacent to vertical fenestration*, shall be provided with controls that automatically reduce lighting power in response to available daylight by either:

1. a combination of dimming ballasts and daylight-sensing automatic controls, which are capable of dimming the lights continuously, or
2. 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.

(f) In addition to ASHRAE/IESNA Standard 90.1, "manual ON" occupancy sensors: Occupancy sensors shall have "manual ON", "automatic OFF" controls.

(g) In addition to ASHRAE/IESNA Standard 90.1, controls for outdoor lighting: For lighting of building facades, parking lots, garages, sales and non-sales canopies, and all outdoor sales areas, where two or more luminaires are used, an automatic time switch shall be installed that has the capability to turn off the lighting when not needed and reduces the lighting power (in watts) by a minimum of 50% but not exceeding 80% or provides continuous dimming through a range that includes 50% through 80% reduction.

Exceptions to 7.4.6(g):

(a) Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.

(b) Lighting for steps or stairs that require illumination during daylight hours.

(c) Lighting that is controlled by a motion sensor and photocontrol.

(d) Lighting for facilities that have equal lighting requirements at all hours and are designed to operate continuously.

(e) Temporary outdoor lighting.

(f) Internally illuminated, externally illuminated, and unfiltered signs.

7.4.7 Other Equipment. The other equipment shall comply with Section 10 of

ASHRAE/IESNA Standard 90.1 with the following modifications and additions:

(a) Section 10.4.1 and Table 10.8 of ASHRAE/IESNA Standard 90.1: Motors shall comply with the minimum requirements in Table C-20 in Normative Appendix C. These requirements supersede the requirements in Section 10.4.1 and Table 10.8 of ASHRAE/IESNA Standard 90.1.

(b) In addition to ASHRAE/IESNA Standard 90.1, condenser heat recovery for space heating: Supermarkets 5,000 m^2 (50,000 ft^2) or greater shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for either for space heating, service water heating, or for dehumidification reheat for maintaining low space humidity.

(c) In addition to ASHRAE/IESNA Standard 90.1, wastewater heat recovery from commercial dishwashers: for hot water sanitizing (high temperature) dishwashers used in commercial food service operations, shall provide wastewater heat recovery with a minimum energy recovery effectiveness of 30 percent of the available heat to preheat domestic hot water make-up for the dishwasher or other uses.

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

7.5 Performance Option

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

The baseline for a multifamily *residential* building shall be a building with the same number of *dwelling units*. Each *dwelling unit* in the building shall be the smaller of:

(a) a baseline *dwelling unit* of the same size as in the proposed building, or

(b) a baseline *dwelling unit* no larger than 90 m^2 (900 ft^2) for one-bedroom units, 125 m^2 (1,250 ft^2) for two-bedroom units, 170 m^2 (1,700 ft^2) for three-bedroom units and 210 m^2 (2,100 ft^2) for units with four or more bedrooms.

7.5.2 Annual Energy Cost. The *building project* shall have an annual energy cost less than or equal to that achieved by compliance with 7.3 and 7.4, as well as 5.3.3.2, 5.3.3.3, 6.3.2, 6.4.2, 9.3.1, 9.3.7, and 9.4.1. 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 7.4.1 through 7.4.7, as well as 5.3.3.2, 5.3.3.3, 6.3.2, 6.4.2, 9.3.1, 9.3.7, and 9.4.1.

> **Exceptions to 7.5.2:** Credit for daylighting controls is allowed to be taken up to a distance of 2.5 x window head height where all lighting more than 4.5 m (15 ft) from the perimeter is automatically controlled separately from lighting within 4.5 m (15 ft) 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 7.3 and 7.4, as well as 5.3.3.2, 5.3.3.3, 6.3.2, 6.4.2, 9.3.1, 9.3.7, and 9.4.1. 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 7.4.1 through 7.4.7, as well as 5.3.3.2, 5.3.3.3, 6.3.2, 6.4.2, 9.3.1, 9.3.7, and 9.4.1. To determine the CO_2e value for each energy source, multiply the energy consumption by the emissions factor. CO_2e emission factors shall be taken from Table 7.5.3.

Table 7.5.3: CO_2e Emission Factors

Fuel	**CO_2e** kg/kWh (lb/kWh)
Grid delivered electricity	0.799 (1.760)
LPG	0.229 (0.505)
Fuel oil (residual)	0.265 (0.584)
Fuel oil (distillate)	0.254 (0.560)
Coal (bituminous)	0.398 (0.878)
Coal (lignite)	0.551 (1.215)
Gasoline	0.272 (0.600)
Natural gas[1]	0.184 (0.406)
Natural gas[2]	0.205 (0.452)
Natural gas[3]	0.188 (0.415)
Natural gas[4]	0.181 (0.400)

[1] Value for natural gas for on-site combustion in a commercial boiler and other uses not specified in this table.

[2] Value for natural gas for on-site combustion in stationary reciprocating engines.

[3] Value for natural gas for on-site combustion in a small turbine.

[4] Value for natural gas for on-site combustion in a residential furnace.

7.6 Submittals. Submittals are necessary to demonstrate compliance with some of the sections in Chapter 7. Those submittals are as follows:

7.6.1 General Documentation. Demonstration of compliance with 7.3.1 shall be in accordance with Sections 4.2.2, 5.7, 5.8, 6.7, 7.7, and 8.7 of ASHRAE/IESNA Standard 90.1.

7.6.2 Equipment and Appliances Documentation. Demonstration of compliance with 7.3.2 shall include the following:

(a) For 7.3.2.1, provide manufacturer's specifications and a table on the drawings that describes the performance characteristics for products to be installed as part of the permit application. For products to be installed later by the tenant, provide complying specifications generic to the product category.

(b) For 7.3.2.2, provide manufacturer's specifications and a table on the drawings that describes the performance characteristics. For products to be installed later by the tenant, provide complying specifications generic to the product category.

7.6.3 On-site Renewable Energy Power Systems Documentation. Demonstration of compliance with 7.3.1 shall include a table with the peak electrical generating capacity of installed *on-site renewable energy power systems* and a calculation showing what the percentage of the *electrical service load*.

7.6.4 Energy Metering Documentation. Demonstration of compliance with 7.3.4 shall include the following:

(a) provide a design narrative that describes the project's energy meters and their data collection, storage and retrieval capabilities.

(b) provide energy meter cut-sheets and specifications.

7.6.5 General Comprehensive Prescriptive Requirements Documentation. Where the Prescriptive Option is used, demonstration of compliance with 7.4.1 shall include the following:

(a) provide documentation in accordance with Sections 4.2.2, 5.7, 5.8, 6.7, 7.7, and 8.7 of ASHRAE/IESNA Standard 90.1.

(b) provide table for *dwelling units* showing number of bedrooms for each and *dwelling unit* size.

7.6.6 Building Envelope Documentation. Where the Prescriptive Option is used, demonstration of compliance with 7.4.2 shall include the following:

(a) For 7.4.2(a)-(h), provide documentation in accordance with Sections 4.2.2, 5.7, and 5.8 of ASHRAE/IESNA Standard 90.1.

(b) For 7.4.2(i), provide calculations of the *fenestration* solar heat gain by orientation, as applicable based on *climate zone*.

(c) For 7.4.2(j), show details for *continuous air barrier*.

7.6.7 Heating, Ventilating, and Air Conditioning Documentation. Where the Prescriptive Option is used, demonstration of compliance with 7.4.3 shall include the following:

(a) For 7.4.3(a)-(k), provide documentation in accordance with Sections 4.2.2, 5.7, and 5.8 of ASHRAE/IESNA Standard 90.1.

(b) For 7.4.3(l), provide calculations of the piping system pressure loss.

(c) For 7.4.3(m), provide control schedule for HVAC and lights in hotel/motel guest rooms.

7.6.8 Service Water Heating Documentation. Where the Prescriptive Option is used, demonstration of compliance with 7.4.4 shall include the following:

(a) For 7.4.4(a)-(b), provide documentation in accordance with Sections 4.2.2 and 7.7 of ASHRAE/IESNA Standard 90.1.

(b) For 7.4.4(c), provide manufacturer’s specifications for insulation or show construction detail with insulation.

7.6.9 Power Documentation. Where the Prescriptive Option is used, demonstration of compliance with 7.4.5 shall include the following:

(a) For 7.4.5(a), provide documentation in accordance with Sections 4.2.2 and 8.7 of ASHRAE/IESNA Standard 90.1.

(b) For 7.4.5(b), provide control sequences and schematics for peak load reduction.

7.6.10 Lighting Documentation. Where the Prescriptive Option is used, demonstration of compliance with 7.4.6 shall include the following:

(a) For 7.4.6(a), provide documentation in accordance with Section 4.2.2 of ASHRAE/IESNA Standard 90.1.

(b) For 7.4.6(b), provide lighting layout and control schedule showing occupancy sensors in applicable spaces.

(c) For 7.4.6(c), provide control schedule showing occupancy sensors with dimming in applicable spaces.

(d) For 7.4.6(d), provide lighting layout showing egress and security lighting.

(e) For 7.4.6(e), provide lighting layout and control schedule showing automatic controls for lighting in *daylight zones*.

(f) For 7.4.6(f), provide control schedule showing occupancy sensor features.

(g) For 7.4.6(g), provide lighting layout and control schedule for outdoor lighting.

7.6.11 Building Envelope Documentation. Where the Prescriptive Option is used, demonstration of compliance with 7.4.7 shall include documentation in accordance with Section 4.2.2 of ASHRAE/IESNA Standard 90.1.

7.6.12 General Comprehensive Performance Requirements Documentation. Where the Performance Option is used, demonstration of compliance with 7.5.1 shall include the following:

(a) provide documentation in accordance with Sections 4.2.2, 5.7, 5.8, 6.7, 7.7, and 8.7 of ASHRAE/IESNA Standard 90.1.

(b) provide table for *dwelling units* showing number of bedrooms for each and *dwelling unit* size.

7.6.13 Annual Energy Cost Documentation. Where the Performance Option is used, demonstration of compliance with 7.5.2 shall include documentation in accordance with Section D1.4. (Informative note: See example in Informative Appendix I.)

7.6.14 Annual CO_2e Documentation. Where the Performance Option is used, demonstration of compliance with 7.5.3 shall include calculations of the annual CO_2e. (Informative note: See example in Informative Appendix I.)

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

8.1 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.

8.2 Compliance. The building materials shall comply with 8.3, Mandatory Provisions; and either

(a) 8.4, Prescriptive Option, or

(b) 8.5, Performance Option.

Documentation shall comply with 8.6, Submittals.

8.3 Mandatory Provisions

8.3.1 Construction Waste Management. Divert a minimum of 50% of non-hazardous construction and demolition debris from disposal in landfills and incinerators by using recycling and/or salvage. Diversion includes donation of materials to charitable organizations and salvage of materials on-site. 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 segregated or co-mingled collection of recyclable materials, and recycling efforts shall be tracked throughout the construction process.

8.3.2 Wood Products. The wood products in the project:

(a) shall be harvested according to the laws and regulations of the country of origin.

(b) shall not contain wood from endangered wood species, as listed by the Convention on International Trade in Endangered Species (CITES) except when complying with 8.4.1.3.

8.3.3 Refrigerants. CFC-based refrigerants in HVAC&R systems shall not be used so as to minimize or eliminate the emission of compounds that contribute to ozone depletion and global warming. The HVAC&R equipment shall comply with the following formula, which sets a maximum threshold for the combined contributions to ozone depletion and global warming potential:

$$LCGWP + LCODP \times 10^5 \leq 775\ (100)$$

where:

$LCGWP$ = $[GWP_r \times (L_r \times Life + M_r) \times R_c]/Life$

$LCODP$ = $[ODP_r \times (L_r \times Life + M_r) \times R_c]/Life$

$LCGWP$ = Lifecycle Direct Global Warming Potential, kg CFC11/kw-yr (lb CO_2/ton-yr)

$LCODP$ = Lifecycle Ozone Depletion Potential, kg CFC11/kw-yr (lb CFC11/ton-

yr)

GWP_r = Global Warming Potential of Refrigerant, 0 to 12,000 kg CO_2/kg r (lb CO_2/lb r)

ODP_r = Ozone Deletion Potential of Refrigerant, 0 to 0.2 kg CO_2/kg r (lb CFC11/lb r)

L_r = Refrigerant Leakage Rate, 0.5% to 2.0%; default of 2% unless otherwise demonstrated

M_r = End-of-life Refrigerant Loss, 2% to 10%; default of 10% unless otherwise demonstrated

R_c = Refrigerant Charge, 0.2 to 2.3 kg (0.5 to 5.0 lbs) of refrigerant per ton of cooling capacity

Life = Equipment Life, 10 years; default based on equipment type, unless otherwise demonstrated

For multiple types of equipment, a weighted average of all HVAC&R equipment shall be applied using the following formula:

$$[\sum (LCGWP + LCODP \times 10^5) \times Q_{unit}] / Q_{total} \leq 775 \ (100)$$

where:

Q_{unit} = Cooling capacity of an individual HVAC or refrigeration unit, kW (tons)

Q_{total} = Total cooling capacity of all HVAC or refrigeration

Exception to 8.3.3: Small HVAC units (defined as containing less than 0.23 kg (0.5 lb) of refrigerant), and other equipment such as standard refrigerators, small water coolers, and any other cooling equipment that contains less than 0.23 kg (0.5 lb) of refrigerant.

Fire suppression systems shall not contain ozone-depleting substances (CFCs, HCFCs or Halons).

8.3.4 Storage and Collection of Recyclables and Discarded Goods.

8.3.4.1 Recyclables. There shall be an easily accessible area that serves the entire building and is dedicated to the collection and storage of non-hazardous materials for recycling, including (at a minimum) paper, corrugated cardboard, glass, plastics and metals. The size and functionality of the recycling areas shall be coordinated with the anticipated collection services for glass, plastic, office paper, newspaper, cardboard and organic wastes to maximize the effectiveness of the dedicated areas.

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

8.3.4.3 Fluorescent and HID Lamps and Ballasts. To reduce lamp breakage and

potential releases of mercury during storage, there shall be an easily accessible area that serves the entire building and is dedicated to the collection and storage of fluorescent lamps and ballasts and facilitates proper disposal and/or recycling according to state and local hazardous waste requirements.

8.4 Prescriptive Option

8.4.1 Reduced Impact Materials. The *building project* shall contain materials that comply with 8.4.1.1, 8.4.1.2, or 8.4.1.3. Elevators and equipment shall not be included in the calculations for 8.4.1. Calculations shall only include materials permanently installed in the project.

8.4.1.1 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* value of a material assembly shall be determined by weight. The recycled fraction of the assembly shall then be multiplied by the cost of assembly to determine the *recycled content* value. Not more than 5% (one-half of the 10%) of the *recycled content* for this requirement shall come from one type of material such as steel or concrete.

Mechanical, electrical, and plumbing distribution components such as ductwork, conduit, and piping (but not instrumentation and controls) shall be included in the calculation. The *recycled content* of the cementitious materials in concrete is allowed to be used as the *recycled content* of the concrete.

8.4.1.2 Regionally Extracted, Processed, and Manufactured Materials. A minimum of 15% of building materials or products used (based on cost) shall be regionally extracted, processed and manufactured. For a building material or product to qualify, a minimum of 80% of the mass of the building material or product shall be extracted, and harvested or recovered, and manufactured either:

(a) within a radius of 800 km (500 mi) of the project *site*; or

(b) within a radius of 2400 km (1500 mi) and shipped by rail or water; or

(c) a combination of (a) and (b) such that the percentage from (a) and (b) shall add up to 15%.

Mechanical, electrical, and plumbing components shall not be included in the calculation.

8.4.1.3 Biobased Products. A minimum of 5% of building materials used (based on cost) shall be *biobased product*s. 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.

Wood building components used to comply with this requirement shall be from sources proven legal and which practice sustainable forest management as verified through accredited, independent, third-party certification bodies. Chain of custody

documentation is required and shall verify that certified components contain a minimum of 70% certified raw material. Acceptable forest management certification bodies are those with principles, criteria, and standards developed using ISO/IEC Guide 59 Code of Good Practice for Standardization, or the World Trade Organization (WTO) Technical Barriers to Trade (TBT) Agreement Annex 3 Code of Good Practice for the Preparation, Adoption and Application of Standards. (Informative note: See examples such as the Forest Stewardship Council (FSC), the Programme for the Endorsement of Forest Certification schemes (PEFC), the Sustainable Forestry Initiative (SFI), or the Canadian Standards Association (CSA) listed in Informative Appendix F.) Wood building components include, but are not limited to, structural framing and general dimensional framing, flooring, sub-flooring, wood window sash and frames, solid wood doors, and architectural millwork.

Mechanical, electrical, and plumbing components shall not be included in the calculation.

8.5 Performance Option

8.5.1 Life Cycle Assessment. Perform a *life cycle assessment (LCA)* according to ISO Standard 14044 of a minimum of two building alternatives. Each alternate building shall consist of a common design, construction, and materials for the locale, including building size and use, as commonly approved by the *authority having jurisdiction*. Each building shall have an annual energy cost less than or equal to that achieved by compliance with 7.3 and 7.4. Each building shall include permanently installed materials according to ISO 14044 criteria. The service life of the building shall be no less than that determined using Table 10.3.5, except that the design life of long-life buildings shall be no less than 75 years.

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

8.5.1.2 Procedure. An LCA consists of the following three steps:

(a) Step 1: Perform a life cycle inventory (LCI). The LCI accounts for all the individual environmental flows to and from the products 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:
    i. Extracting and harvesting materials and fuel sources from nature.
    ii. Processing building materials and manufacturing building components.
    iii. Transporting materials and components.
    iv. Assembly and construction.
    v. Operation including energy consumption, maintenance, repair, and

renovations during the design life.

vi. 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:

i. Criteria air pollutants as defined by the USEPA in accordance with the Clean Air Act: carbon monoxide (CO), nitrogen oxides (NOx), lead (Pb), sulfur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3) and ozone precursors: volatile organic compounds (VOC) and ammonia (NH_3).

ii. Greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases: hydrofluorocarbons, perfluorocarbons, and sulfur hexaflouride.

iii. Hazardous air pollutants as defined by the USEPA in accordance with the Clean Air Act such as cadmium, formaldehyde, and lead.

(b) Step 2: Compare the two alternate buildings using a published third-party impact indicator method that includes, at a minimum the impact categories listed in 8.5.1.1.

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

8.6 Submittals. Submittals are necessary to demonstrate compliance with some of the sections in Chapter 8. Those submittals are as follows:

8.6.1 Construction Waste Management Documentation. Demonstration of compliance with 8.3.1 for construction waste management diversion shall be submitted to the *authority having jurisdiction* and include:

(a) General description of each type/category of waste generated;

(b) Name and location of receiving agent (recycler, salvager, charitable organization, incinerator, or landfill) for waste; and

(c) Quantity of waste diverted (by category) and sent to landfill in metric tons (tons), or cubic meters (cubic yards). Calculations are allowed to be done by either weight or volume, but shall be consistent throughout.

Construction waste diverted from landfill = (Sum of diverted waste)/(Sum of diverted waste + Sum of waste sent to landfill)

Construction waste diverted from landfill shall be greater than or equal to 50%.

(Informative note: See the example in Informative Appendix J.)

8.6.2 Refrigerants Documentation. Demonstration of compliance with 8.3.3 shall include documentation of the refrigerants calculation and shall be submitted to the *authority having jurisdiction*.

8.6.3 Storage and Collection of Recyclables and Discarded Goods Documentation. Demonstration of compliance with 8.3.4 shall include documentation

on the drawings of the locations for recyclables, reusable goods, and lamps and ballasts.

8.6.4 Reduced Impact Materials Documentation. Where the Prescriptive Option is used, documentation of compliance with 8.4.1 showing reduced impact materials shall be submitted to the *authority having jurisdiction* for a minimum of one of the following sections.

(a) For 8.4.1.1, documentation shall include the total cost of materials on the project (excluding labor, equipment, and elevators) and, for each material with *recycled content*:

1. Material name
2. Manufacturer
3. Material cost, $
4. *Post-consumer recycled content*, %
5. *Pre-consumer recycled content*, %
6. *Recycled content* information source (an invoice, letter, or description from the product manufacturer indicating the *recycled content*). Alternatively, for steel products manufactured in basic oxygen furnaces and electric arc furnaces, documentation with the annual average industry values is allowed to be used for *recycled content* percentage. For concrete products, include documentation of the mix design(s) indicating the proportion or quantity of *recycled content* of the cementitious materials (e.g. fly ash or slag cement) and other constituent materials, and the quantity of delivered concrete with that mix design.

Total *recycled content* (%) = [(% *post-consumer recycled content* x material cost) + 0.5 x (% *pre-consumer recycled content* x material cost)] / (total cost of materials on the project)

The total *recycled content* shall be greater than or equal to 10%, and not more than 5% (one-half of the 10%) shall be from one type of material.

A value of 45% of the total construction cost is allowed to be used in lieu of the actual total cost of materials.

(Informative note: See the example in Informative Appendix J.)

(b) For 8.4.1.2, documentation shall include the total cost of materials on the project (excluding labor, equipment, and elevators) and, for each product considered for compliance:

1. Product name
2. Manufacturer
3. Product cost, $
4. Extraction distance (distance between project and extraction/harvest/recovery site), km (miles)

5. Transportation method from extraction/harvest/recovery site - rail, water or other
6. Manufactured distance (distance between project and final manufacturing location), km (miles)
7. Transportation method from manufacturing location - rail, water or other
8. Documentation that 80% of the mass is extracted, and harvested or recovered, and manufactured within the specified distances (an invoice, letter, or description from the product manufacturer)

The sum of the compliant product costs divided by the total cost of materials shall be greater than or equal to 15%.

If either the extraction or manufactured distance is a combination of rail and/or water and other, then the combined distance ratios below shall each be less than or equal to 1.0 for compliance.

Combined extraction distance ratio = (Extraction distance by rail or water)/2400 km [1500 mi.] + (Extraction distance by other means)/800 km [500 mi.]

Combined manufactured distance ratio = (Manufactured distance by rail or water)/2400 km [1500 mi.]+ (Manufactured distance by other means)/800 km [500 mi.]

A value of 45% of the total construction cost is allowed to be used in lieu of the actual total cost of materials.

(Informative note: See the example in Informative Appendix J.)

(c) For 8.4.1.3, documentation shall include the total cost of materials on the project (excluding labor, equipment, and elevators) and, for each product with biobased content:

1. Product name
2. Manufacturer or *vendor*
3. Product cost, $
4. For a product other than wood, bamboo, wool, cotton, cork, or agricultural fibers, provide the biobased content or other documentation indicating it meets the *biobased product* requirements.
5. For certified wood, chain of custody certificate number from *vendor* for wood products. Also, provide *vendor* invoices that contain the *vendor's* chain of custody number and identify each product on a line-item basis. The chain of custody documentation shall indicate either physical separation during procurement, processing, and trade, or that the known percentage of certified raw material from an input batch is a minimum of 70%. Alternatively, this requirement is allowed to be met by providing a copy of the *vendor's* documentation of the annual average amount of certified wood products purchased for which they have chain of custody verification, as a percentage of all wood products purchased. This documentation shall provide separate subtotals for

each certification source and shall be current (no older than two years). This percentage multiplied by the product cost shall be the compliant product value.

The sum of the compliant product values divided by the total cost of materials shall be greater than or equal to 5 %.

A value of 45% of the total construction cost is allowed to be used in lieu of the actual total cost of materials.

(Informative note: See the example in Informative Appendix J.)

8.6.5 Performance Option Life Cycle Assessment Documentation. Where the Performance Option in 8.5.1 is used, a report including the following shall be submitted to the *authority having jurisdiction* containing:

(a) A description of the baseline and proposed buildings including their differences.

(b) The impact indicator method and impact categories used.

(c) The results of the LCA indicating a minimum of 5% improvement in the proposed building compared to the baseline building for a minimum of two impact categories.

(d) The documentation of critical peer review by a third party (e.g. a letter or report) including the results from the review and the reviewer's name and contact information.

9. INDOOR ENVIRONMENTAL QUALITY (IEQ)

9.1 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.

9.2 Compliance. The indoor environmental quality shall comply with 9.3, Mandatory Provisions; and either

(a) 9.4, Prescriptive Option, or

(b) 9.5, Performance Option.

(Note that it not required that compliance for both daylighting and low-emitting materials be demonstrated using the same compliance option, i.e. Prescriptive or Performance.) Documentation shall comply with 9.6, Submittals.

9.3 Mandatory Provisions

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

(a) Compliance shall be demonstrated using the Ventilation Rate Procedure in Section 6.1.1 of ASHRAE Standard 62.1. The IAQ Procedure shall not be used.

(b) The minimum *breathing zone* outdoor air ventilation rates to all occupied office spaces in *climate zones* 1 through 5 and *classrooms* in all *climate zones* shall be 1.3 times the minimum rates given in Table 6.1 of ASHRAE Standard 62.1.

9.3.2 Environmental Tobacco Smoke Control

(a) Smoking shall not be allowed inside the building. Signage shall be posted within 3 m (10 ft) of each *building entrance*.

(b) Any exterior designated smoking areas shall be located a minimum of 7.5 m (25 ft) away from entries, outdoor air intakes, and operable windows.

9.3.3 Outdoor Air Delivery Monitoring

9.3.3.1 Mechanically Ventilated Spaces.

(a) For each *densely occupied space*, carbon dioxide concentrations shall be capable of being monitored with permanent carbon dioxide monitoring systems that record ventilation system performance. CO_2 sensors shall be located in the room between 1 m and 2 m (3 ft and 6 ft) above the floor. The CO_2 sensor shall be capable of either providing a direct read-out display in the occupied space, or sending a signal of the CO_2 level to a building central monitoring system. Outdoor air CO_2 concentration shall be determined by one of the following:

1. CO_2 concentration shall be assumed to be 400 ppm_v without any direct measurement; or
2. CO_2 concentration shall be dynamically measured using a CO_2 sensor located near the position of the outdoor air intake.

   Exception to 9.3.3.1(a): The outdoor air ventilation rate is not required to be larger than the design outdoor air ventilation rate required by complying with section 9.3.1, regardless of CO_2 concentration.

(b) For each mechanical ventilation system serving *non-densely occupied spaces* or a combination of *densely occupied spaces* and *non-densely occupied spaces*, a direct outdoor airflow measurement device shall be provided that is capable of measuring the design minimum outdoor airflow rate, as defined by 9.3.1. If, during building occupied mode, the device senses flow less than the minimum outdoor airflow rate (±15%), the device shall trigger an alarm to the building operator or action by the building control system to increase the flow back to required levels.

9.3.3.2 Naturally Ventilated Spaces. For all enclosed spaces that are naturally ventilated, carbon dioxide concentrations shall be capable of being monitored. CO_2 monitoring shall be located within the room between 1 m and 2 m (3 ft and 6 ft) above the floor and on the far wall from operable openings or 6 m (20 ft), whichever is less. The CO_2 sensor shall be capable of either providing a direct read-out display in the occupied space, or sending a signal of the CO_2 level to a building central monitoring system. Where floor plans are less than 12 m (40 ft) wide, sensors shall be located as close to center of space as practical. One CO_2 sensor is allowed to be used to represent multiple spaces if the natural ventilation design uses passive stack(s) or other means to induce airflow through those spaces equally and simultaneously without intervention by building occupants.

9.3.4 Thermal Comfort. The *building envelope* and HVAC systems shall be designed to comply with ASHRAE Standard 55.

9.3.5 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.

9.3.5.1 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 1 m (3 ft) long.

(d) shall be either permanently mounted grates or removable mats with knobby or squeegee-like projections.

9.3.5.2 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 1 m (3 ft) long, and generally made from nylon or combinations of nylon and heavily textured piles of polypropylene that can perform both a scraping action and a moisture wicking action.

9.3.5.3 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 1.2 m (4 ft) long, and generally made from polypropylene with a course fiber surface that will both capture and hold any remaining particles or moisture.

Exception to 9.3.5: 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 1 m (3 ft) of indoor surface, with a minimum combined length of 2 m (6 ft).

9.3.6 Acoustical Control. STC values for assemblies and components shall be determined in accordance with ASTM E90 and ASTM E413.

9.3.6.1 Exterior Sound. *Wall* and floor-ceiling assemblies that are part of the *building envelope* shall have a sound transmission class (STC) of 50 or greater and *fenestration* that is part of the *building envelope* shall have an STC of 30 or greater for any of the following conditions:

(a) Within 300 m (1000 ft) of interstate highways.

(b) Within 8 km (5 mi) of airports serving more than 10,000 commercial jets per year.

(c) Where sound levels at the property line regularly exceed 65 decibels, other than occasional sound due to church bells, train horns, emergency vehicles, and public warning systems.

9.3.6.2 Interior Sound. Wall and floor-ceiling assemblies separating *dwelling units*, *dwelling units* and public spaces, tenant spaces, tenant spaces and public places, and *classrooms* shall have an STC of 50 or greater. Wall and floor-ceiling assemblies separating hotel rooms and hospital rooms shall have an STC of 45 or greater.

9.3.7 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 2,000 m^2 (20,000 ft^2) directly under a roof with a finished ceiling heights greater than 3.5 m (12 ft) and that have a lighting power density (LPD) for general lighting equal to or greater than 5.5 W/m^2 (0.5 W/ft^2) shall comply with the following:

Exceptions to 9.3.7:

(a) Buildings in *climate zones* 7 and 8.

(b) Auditoria, theaters, museums, places of worship, and refrigerated warehouses.

(a) **Minimum Daylight Zone by Toplighting.** A minimum of 50% of the floor area 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 9.3.7.

Table 9.3.7 Minimum Toplighting Area

General Lighting Power Density in Daylight Zone W/m^2 (W/ft^2)	Minimum Toplighting Area to Daylight Zone Area Ratio
14 W/m^2 (1.4 W/ft^2) $\leq$ LPD	3.6%
10 W/m^2 (1.0 W/ft^2) $\leq$ LPD < 14 W/m^2 (1.4 W/ft^2)	3.3%
5 W/m^2 (0.5 W/ft^2) $\leq$ LPD < 10 W/m^2 (1.0 W/ft^2)	3.0%

(b) **Skylight Characteristics.** *Skylights* 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 *authority having jurisdiction*.

Exceptions to 9.3.7(b):

(a) *Tubular daylighting devices* having a diffuser.

(b) Roof monitors and clerestories having one or more of the following that prevent direct sunlight from entering the space below the well:

1. automated shading devices.
2. a diffuser.
3. fixed internal baffles.

9.4 Prescriptive Option

9.4.1 Daylighting by Sidelighting.

9.4.1.1 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 9.4.1.1.

(b) Interior surfaces in *daylight zones* shall have visible light reflectances greater than or equal to 80% for ceilings and 70% for partitions higher than 1.5 m (60 in.) in *daylight zones*.

Table 9.4.1.1 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

Exceptions to 9.4.1.1:

(a) Spaces with programming that requires dark conditions (e.g. photographic processing centers, museums).

(b) Spaces required to have *toplighting* under 9.3.7.

(c) Facades that are less than 3 m (10 ft) from an adjacent building. (For a space with multiple facades, those portions of other facades that do not qualify under this exception shall comply with 9.4.1.1.)

9.4.1.2 Office Space Shading. Each west-, south-, and east-facing façade, shall have a shading *projection factor* no less than that specified in 7.4.2(e). Shading is allowed to be external or internal. 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:

(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.

(c) External buildings and other permanent infrastructure or geological formations that are not part of the building. Trees, shrubs, or any other organic shading device shall not be used to comply with the shading *projection factor* requirements.

Exception to 9.4.1.2:

(a) *Building projects* that comply with the prescriptive compliance option in 7.4.2.

(b) 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 authority having jurisdiction do not require external shading devices.

9.4.2 Low Emitting Materials

9.4.2.1 Adhesives and Sealants. 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 the following reference standards:

(a) Adhesives, Sealants and Sealant Primers: VOC content shall be determined according to and meet the limit requirements of SCAQMD Rule 1168.

(b) Aerosol Adhesives: VOC content shall be determined according to and meet the limit requirements of Green Seal Standard GS-36.

9.4.2.2 Paints and 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 the following criteria:

(a) Architectural paints, coatings and primers applied to interior walls and ceilings: VOC content shall be determined according to and meet the limit requirements of Green Seal Standard GS-11.

(b) Clear wood finishes, floor coatings, stains, sealers, and shellacs: VOC content shall be determined according to and meet the limit requirements of SCAQMD Rule 1113.

9.4.2.3 Floor Covering Materials. All 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 CDHS California Section 01350. Products that have been verified and labeled to be in compliance with California Section 01350 comply with this requirement. (Informative note: See example such as the Carpet and Rug Institute's Green Label Plus listed in Informative Appendix F.)

(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 SCS-EC10-2004. Products that have been verified and labeled to be in compliance with SCS-EC10-2004 by a third-party certifier comply with this requirement. (Informative note: See example such as the Resilient Floor Covering Institute's FloorScore listed in Informative Appendix F.)

9.4.2.4 Composite Wood and Agrifiber Products. Composite wood 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), plywood, wheatboard, strawboard, panel substrates and door cores. Materials considered fit-out, furniture, and equipment (FF&E) are not considered base building elements and are not included.

> **Exception to 9.4.2.4:** Structural panel components within the *conditioned space* 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.

9.5 Performance Option

9.5.1 Daylighting Simulation.

9.5.1.1 Usable Illuminance in Office Spaces and Classrooms. The design for the *building project* shall demonstrate a useable illuminance of 300 lux (30 fc) on all work surfaces at a distance of 4.5 m (15 ft) from the façade at noon on the equinox using an accurate physical or computer daylighting model that includes all regularly occupied daylit spaces.

(a) Computer models shall be built using daylight simulation software based on the ray-tracing methodology.

(b) Simulation is to be done using either the CIE Overcast Sky Model or the CIE Clear Sky Model and measurements shall be taken at noon on the equinox.

(c) Simulation shall measure illuminance at points 0.75 m (30 in.) above the floor on a 3 m by 3 m (10 ft by 10 ft) grid. Every modeled point within a space shall achieve the minimum illuminance.

(d) Achievement of minimum illuminance levels shall not include measurement points on which there is a direct beam solar component that is incident on the measured plane. If an advanced daylighting system is used to harness and redirect direct solar radiation, then direct beam solar component is allowed to be included in the simulation, as long as it is not used to comply with the minimum illuminance through direct incidence on the measured plane.

(e) Scheduling used to determine regularly occupied spaces shall be consistent with energy calculation scheduling. A space that is scheduled to be used more than 4 hours per day constitutes a regularly occupied space.

9.5.1.2 Direct Sun Limitation on Workplane in Offices. It shall be demonstrated that direct sun does not strike the workplane in any daylit space for more than 20% of the occupied hours during an equinox day in regularly occupied office spaces.

9.5.2 Low Emitting Materials. All spaces within the building shall be modeled for IAQ concentration and shall be shown to be in compliance with CDHS California Section 01350. IAQ modeling shall use standardized building scenarios. Spaces other than *classrooms* shall use the office space scenario. Materials used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall be tested in accordance with the requirements of CDHS California Section 01350. All of the following products shall be tested in whole or by representative sample in small-scale environmental chambers:

(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, plywood, and particleboard.

(d) Insulation batt 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.

Exception to 9.5.2: Salvaged materials that have not been refurbished or refinished within one year prior to installation are excepted from this requirement.

9.6 Submittals. Submittals are necessary to demonstrate compliance with some of the sections in Chapter 8. Those submittals are as follows:

9.6.1 Minimum Indoor Air Quality Documentation. Demonstration of compliance with 9.3.1 shall include documentation in accordance with Section 7.2.6 of ASHRAE Standard 62.1 demonstrating that each *breathing zone* in the building is designed in accordance with 9.3.1.

9.6.2 Environmental Tobacco Smoke (ETS) Control Documentation. Demonstration of compliance with 9.3.2 shall include a *site* plan showing any designated exterior smoking areas.

9.6.3 Outdoor Air Delivery Monitoring Documentation. Demonstration of compliance with 9.3.3 shall include showing the location of CO_2 sensors required by 9.3.3.1 and 9.3.3.2 on architectural and mechanical plans.

9.6.4 Thermal Comfort Documentation. Demonstration of compliance with 9.3.4 shall include documentation in accordance with Section 6.1.1 of ASHRAE Standard 55.

9.6.5 Building Entrances Documentation. Demonstration of compliance with 9.3.5 shall include showing all permanent entry mat systems on architectural plans.

9.6.6 Acoustical Control Documentation. Demonstration of compliance with 9.3.6 shall include indicating the STC values for applicable *wall*, floor-ceiling, and *fenestration* on building plan drawings or similar format acceptable to the *authority having jurisdiction*.

9.6.7 Daylighting by Toplighting Documentation. Demonstration of compliance with 9.3.7 shall include showing the location of the *daylight zone* under *toplighting* on architectural and electrical plans, and providing calculations of area of *toplighting*, as well as a table showing tested haze value for all *toplighting* glazing materials.

9.6.8 Daylighting by Sidelighting Documentation. Where the Prescriptive Option in 9.4.1 is used,

(a) For 9.4.1.1, provide calculations for *effective aperture for vertical fenestration* showing compliance with the values given in Table 9.4.1.1.

(b) For 9.4.1.2, if shading is required for regularly occupied office spaces, show all interior and exterior shading features on architectural plans and provide necessary calculations for compliance.

9.6.9 Low Emitting Materials Documentation. Where the Prescriptive Option in 9.4.2 is used, provide documentation verifying compliance for all materials covered in 9.4.2.

9.6.10 Daylighting Simulation Documentation. Where the Performance Option in 9.5.1 is used, a copy of the output reports shall be provided that:

(a) demonstrates required illuminance levels at noon on the equinox, and

(b) demonstrates compliance with 9.5.1.2.

9.6.11 Low Emitting Materials Documentation. Where the Performance Option in 9.5.2 is used, demonstration of compliance shall include documentation of modeling for all spaces within the building and emissions levels of materials as required by 9.5.2.

10. CONSTRUCTION AND OPERATION PLANS

10.1 Scope. This section specifies requirements for construction and operation plans including *building commissioning*, 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. Documentation shall comply with 10.6, Submittals. All provisions shall be complied with prior to issuance of the final certificate of occupancy unless specifically indicated in Section 10.3 subsections

10.3 Mandatory Provisions

10.3.1 Building Project Commissioning

10.3.1.1 Scope. For buildings that exceed 500 m^2 (5,000 ft^2) of gross floor area, commissioning shall be performed in accordance with this section using *generally accepted engineering standards* and handbooks acceptable to the *authority having jurisdiction*. (Informative note: See examples such as ASHRAE Guideline 0, ASHRAE Guideline 1, ASHRAE Guideline 4, and USGSA Building Commissioning Guide listed in Informative Appendix F.)

A *building commissioning* process shall be incorporated into the design and construction of the *building project* that verifies that the building and its component systems complies with the documented *owner's project requirements*.

10.3.1.2 Activities prior to Building Permit. The following activities shall be completed:

(a) Designate a project *commissioning agent* (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 *owner's project requirements (OPR)*. The OPR will be distributed to all parties participating in project design, construction and operations.

(c) The design team shall develop the *basis of design (BOD)*.

(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) Commissioning requirements shall be incorporated into project specifications and other construction documents by developed by the design team.

(f) The CxA shall conduct two focused reviews of the construction documents prior to the 50% and 100% complete stages. The purpose of these reviews is to ensure that the construction documents incorporate the requirements set forth in the *OPR* and

BOD.

(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 10.3.1.5.

10.3.1.3 Activities prior to Building Occupancy. The following activities shall be completed:

(a) The contractor shall submit a *commissioning plan* which the CxA shall, based on professional judgment and experience, review to ensure it is sufficiently detailed and complete for the project being undertaken.

(b) Verify the installation and performance of the systems to be commissioned, including completion of pre-functional checklist and full *functional testing*.

> **Exception**: 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.

(c) Verify the owner requirements for training operating personnel and building occupants are completed.

> **Exception:** Training for systems whose operational seasonal dependence results in their not being fully commissioned at the time of occupancy shall have their training completed at earliest time after occupancy when operation of systems is allowed to be fully demonstrated as determined by CxA.

(d) Complete preliminary commissioning report.

(e) 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 optimally operate the commissioned systems.

10.3.1.4 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;

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

(a) Heating, ventilating, air conditioning and refrigeration systems (mechanical and/or passive) and associated controls. Control sequences to be verified for compliance

with construction documentation as part of full functional performance testing.

(b) *Building envelope* components and assemblies to confirm thermal and moisture integrity.

(c) Building envelope pressurization to confirm air-tightness if included in *basis of design* 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.

10.3.1.6 Documentation. Owner shall retain the System Manual and Final Commissioning Report for future use by owner and for local, state and federal agencies or their representatives that may request these data.

10.3.2 Building Acceptance Testing

10.3.2.1 Scope. For buildings 500 m^2 (5,000 ft^2) or less gross floor area, acceptance testing shall be performed in accordance with this section using *generally accepted engineering standards* and handbooks acceptable to the *authority having jurisdiction*. (Informative note: See examples such as the CEC Nonresidential Compliance Manual listed in Informative Appendix F.)

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.

10.3.2.2 Activities prior to Building Permit. Complete the following:

(a) Designate a project Acceptance Agent to lead, review and oversee completion of the acceptance testing activities.

(b) Construction documents indicating clearly who is to perform acceptance tests and the details of the tests to be performed

(c) Acceptance Agent to review construction documents to verify relevant sensor locations, devices and control sequences are properly documented,

10.3.2.3 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, full

warranty information and provides operating staff the information needed to understand and optimally operate building systems.

10.3.2.4 Systems. The following systems, if included in the *building project*, shall have Acceptance Testing:

(a) Mechanical Systems:

1. Heating, ventilating, air conditioning and refrigeration systems (mechanical and/or passive) and associated controls.

(b) Lighting Systems:

1. Automatic daylighting controls
2. Manual daylighting controls
3. Occupancy sensing devices, and
4. Automatic shut-off controls

(c) Renewable energy systems.

10.3.2.5 Documentation. Owner shall retain completed Acceptance Test forms for future use by owner and for local, state and federal agencies or their representatives that may request these data.

10.3.3 Measurement and Verification Plan. The plan shall be prepared and submitted to the owner prior to completion of design development. The owner is responsible for ensuring plan implementation after construction, documenting plan implementation and retaining a copy of the plan and implementation documentation both for owner's future use and for local, state and federal agencies or their representatives that may request this data.

10.3.3.1 Sustainable Sites. Where trees and vegetation are used to comply with the shade requirements of5.3.3.1, verify that this shade is obtained within 5 years after trees and vegetation are planted at project *site*.

10.3.3.2 Water Use Efficiency. For systems where metering is required in 6.3.3.1, the measurement and verification of water use is required in order to ensure that fixtures and other building equipment are operating as specified. This involves both the short-term measurement of specific equipment at the time of installation and permanent metering and sub-metering of major water using components at each facility within the project.

10.3.3.2.1 Water Consumption Baseline. After installation and commissioning of a metered and sub-metered piece of water-using equipment or system and subsequent to issuance of certificate of occupancy, measure water use through a *complete operational cycle*. This is allowed to be performed with any type of calibrated measurement device or water meter. The measured output shall serve as the baseline water use for comparison to on-going measured water consumption by metered and submetered water consuming equipment and systems.

Output from master meters and submeters and instrumentation shall be integrated into the master measurement and verification plans for the project. The output shall be displayed and recorded through electronic or other means such that consumption anomalies can be readily identified by facility operators on an ongoing basis.

10.3.3.2.2 Post-Occupancy Water Measurement and Verification. A maximum of 12 months after baseline water consumption values are established for any metered or sub-metered piece of water-using equipment or system the measured water consumption shall be compared against the predicted water consumption as identified in the baseline calculation. Any variations of 10% or greater in the baseline water consumption versus the actual measured water consumption shall be documented and corrective action taken by the facility operators where warranted. New baseline water consumption levels shall be established where building or operational conditions warrant such an adjustment. This new baseline water consumption data shall be fully documented and shall be used for future post-occupancy evaluations of water use. Subsequent evaluations of measured water consumption relative to the baseline shall be performed thereafter, a minimum of yearly after the initial evaluation.

10.3.3.2.3 Documentation of Water Efficiency.

(a) Document Section 10.3.3.2.1 initial baseline water measurement and verification (M&V) activities. Create report summarizing baseline water consumption data. Owner shall retain documentation for future use by owner and for local, state and federal agencies or their representatives that may request this data.

(b) Document Section 10.3.3.2.2 post-occupancy water consumption M&V activities. Create report summarizing measured meter and sub-meter consumption relative to baseline consumption, for the most recent post-occupancy period. These documents, along with a report of actions taken by facility operators and their results, shall be retained by owner for future post-occupancy evaluations and for any local, state and federal agencies or their representatives that may request this data.

(c) Retain all collected meter and sub-meter data for a minimum of 3 years.

10.3.3.3 Energy Efficiency. Use energy metering collection/storage infrastructure provided under 7.3.4 to collect and store meter data for each meter and sub-meter, starting no later than after *building commissioning* has been completed and either occupancy certificate has been issued or a minimum of 80% of occupancy occurs.

Building projects whose size exceeds the applicable threshold in Table 10.3.3.3 shall perform energy measurement and verification activities in accordance with no less than one of the following two compliance paths:

(a) Benchmark performance against the USDOE Commercial Building Energy Consumption Survey (CBECS) database (Section 10.3.3.3.1).

(b) Benchmark performance using energy simulation model (Section 10.3.3.3.2).

10.3.3.3.1 CBECS Benchmarking Compliance Path. After 12 months and no later than 18 months after either certificate of occupancy has been issued or a minimum

of 80% occupancy occurs, the owner shall compare whole building energy consumption data with the current CBECS database to determine relative building performance. The building shall be compared to all buildings in the database of the same floor area and space type. The comparison shall be weather normalized and shall use default average values for all other building parameters (e.g. number of occupants, hours of operation, equipment loads, etc.) such as the USEPA Portfolio Manager for those building uses that are addressed in this program.

If the building is not rated in the top 8% of CBECS buildings on an energy consumption per unit area basis (92 or greater on the Energy Star Portfolio Manager scale), the owner shall retain the services of a *commissioning agent*. The *commissioning agent* shall analyze systems operation and document for the owner reasons why whole building performance does not meet criteria, along with recommendations for actions that would correct performance. The *commissioning agent* shall submit a commissioning report documenting system deficiencies to the authority having jurisdiction and to the owner.

Subsequent evaluations of whole building measured energy performance relative to CBECS shall be performed thereafter, a minimum of every three years after the initial evaluation.

10.3.3.3.2 Energy Simulation Compliance Path.

10.3.3.3.2.1 Initial Measurement and Verification. Perform the following to baseline energy performance:

Table 10.3.3.3 Threshold for Energy M&V Evaluation

Building Usage Category	M&V Threshold, m^2 (ft^2)
Food Service/Sales Health Care Inpatient Health	>2,000 (20,000)
Lodging Office Public Order & Safety Outpatient Health Public Assembly Education	> 4,000 (40,000)
Retail Religious Worship	> 5,000 (50,000)
Warehouse Non-Refrigerated Storage	> 8,000 (80,000)
Other*	> 2,000 (20,000)

*For buildings in "Other" category, threshold is allowed to be raised to 4,000 m^2 (40,000 ft^2) if the whole building annual energy intensity is less than 250 kWh/m^2 (80,000 Btu/ft^2).

After 12 months and no later than 18 months after meter data collection begins, compare all measured energy consumption from the main meters and sub-meters against the predicted energy consumption of the systems and subsystems, as obtained by an energy simulation model for the whole building. If an existing building energy simulation model has been created previously (e.g., to satisfy performance requirements of 7.5) this model is allowed to be re-used; otherwise, a new energy simulation model shall be created using as-built construction documentation and following the modeling methodology and requirements referenced in 7.5.

Variations of 10% or more in the predicted annual energy consumption versus measured energy consumption and/or variations of 20% or more in peak demand or consumption for any individual month shall be documented. If required in order to reconcile measured building energy meter data to the energy model predicted values, provide short-term metering for sub-systems and process loads that do not have permanent metering per 7.3.4, documenting findings.

Establish an updated baseline for monthly and annual energy consumption and demand for the building at the building boundary. Correct and calibrate the energy simulation model for each major energy consuming system by normalizing based on actual weather and operational conditions (e.g., use and occupancy patterns, equipment operating schedules) during the timeframe meter data was collected so it matches the energy baseline within 10% annually and within 20% for each individual month.

10.3.3.3.2.2 Post Occupancy Measurement and Verification Evaluation.

Perform periodic post-occupancy evaluations of energy performance as follows:

(a) three years after receiving the certificate of occupancy or a minimum of 80% of occupancy, whichever is later, then

(b) subsequent post-occupancy evaluations of energy performance shall be performed a minimum of every three years.

Evaluate building energy monthly consumption and peak demand and system and sub-system performance using meter and sub-meter data (collected for the prior 12 months, the “occupancy period”) relative to baseline monthly energy consumption and peak demand data established under 10.3.3.3.1. The impact of any functional changes that might have occurred during or prior to the occupancy period shall be documented and credited or debited against the baseline monthly energy consumption and peak demand data and actual weather data for the occupancy period used to adjust baseline energy use. If the measured results are not within the 10% of the established baseline annual energy use or within 20% of the established baseline monthly energy consumption and peak demand, the owner shall retain the services of a *commissioning agent*. The *commissioning agent* shall analyze systems operation and document for the owner reasons why deviations exceed maximums for any metered energy using system, along with recommendations for actions that would correct any documented degradation in systems’ performance.

Where the building or the building’s use changes significantly enough over time to

warrant permanent adjustment to the energy baseline, a new energy baseline is allowed to be established using procedures established in 10.3.3.3.1 and occupancy period meter data. This new baseline energy consumption data shall be documented and shall be used for future post-occupancy evaluations of building energy performance.

10.3.3.3 3 Documentation of Energy Efficiency.

(a) If performance has been benchmarked using the CBECS compliance path in 10.3.3.3.1, document the CBECS benchmarking M&V activities. Create report documenting measured annual energy use intensity for the overall building and by fuel, in kWh/m^2 (kBtu/ft^2), along with comparison of building performance relative to appropriate CBECS data set. These documents, along with the *commissioning agent's* report, shall be retained by owner for future post-occupancy evaluations by owner and for any local, state and federal agencies or their representatives that may request this data.

(b) If performance has been benchmarked using the energy simulation compliance path in 10.3.3.3.2, then:

1. Document 10.3.3.3.2.1initial baseline energy simulation M&V activities. Create reports summarizing measured meter and sub-meter data and baseline energy consumption data, with metrics summarizing the baseline annual energy use intensity for the overall building and by fuel, in kWh/m^2 (kBtu/ft^2). Owner shall retain documentation for future use by owner and for local, state and federal agencies or their representatives that may request this data.
2. Document 10.3.3.3.2.2 post-occupancy energy simulation M&V activities. Create reports summarizing measured meter and sub-meter relative to baseline energy consumption along with metrics of corrected baseline annual energy use for the overall building and by fuel, in kWh/m^2 (kBtu/ft^2), for the occupancy period. These documents, along with the *commissioning agent's* report, shall be retained by owner for future post-occupancy evaluations by owner and for any local, state and federal agencies or their representatives that may request this data.

(c) Retain all collected meter and sub-meter data for a minimum of 3 years.

10.3.3.4 The Building's Impact on the Atmosphere, Materials and Resources. Verify annually that areas for recyclables (8.3.4.1), reusable goods (8.3.4.2), and fluorescent and HID lamps and ballasts (8.3.4.3) are maintained. Certificates of lamp and ballast recycling shall be maintained by owner on an ongoing basis, beginning with the first lamp and ballast retrofit and/or replacement project within the building.

10.3.3.5 Indoor Environmental Quality (IEQ). Using equipment required for monitoring of either CO_2 levels or outdoor air delivery, as specified under 9.3.3, develop and document procedures for implementing a regular monitoring program after building occupancy. At a minimum:

(a) For *densely occupied spaces*, a procedure shall be in place to react to the elevated CO_2 levels by temporarily increasing the outdoor air flow for the conditioning or air handling unit. The procedure shall include also the definition to be used for elevated

CO_2 levels, which shall be no more than 600 ppm_v above normal ambient CO_2 levels at the building *site* or the steady-state concentrations based the air quantities in 9.3.1 determined in accordance with the equations in Normative Appendix E. The CO_2 concentration data shall be reviewed on a regular basis, but no less frequently than monthly. If CO_2 levels do not meet the concentration requirements as specified in 9.3.3.1(a), then adjustments to the ventilation system equipment shall be made and the CO_2 levels checked daily for a minimum of one week to ensure the system is back in compliance. In addition, check operation all CO_2 sensors annually and recalibrate or replace sensing elements for all CO_2 sensors at the manufacturer's recommended interval or a minimum of every 5 years, whichever is shorter.

(b) For each mechanical ventilation system serving *non-densely occupied spaces* or a combination of *densely occupied spaces* and *non-densely occupied spaces*, verify that the device which senses outdoor air flow is actually measuring the flow rate within ±10% of the sensor output reading at the minimum outdoor air flow rates specified in Section 9.3.1. If the sensor is not within ±10%, then recalibrate the sensor. This verification shall be done on a quarterly basis and records maintained on-site. Recalibrate direct outdoor airflow measurement device at the manufacturer's recommended interval or a minimum of annually.

(c) For naturally ventilated spaces, CO_2 monitoring shall be done and recorded. The levels shall be checked on a minimum of a monthly basis and referenced to concentration requirements as specified in 9.3.3.1 (a) to verify natural ventilation system has the capability to properly ventilate spaces. If excessive concentration levels are found, verify with building occupants (for manual natural ventilation systems) and/or through EMS that natural ventilation strategies are being followed per design intent. If, when operated properly, spaces are found that cannot be ventilated sufficiently to lower concentration levels, retain the services of a *commissioning agent* to review system operations and provide recommendations for needed modifications. Check all CO_2 sensors functioning annually and recalibrate or replace sensing elements at the manufacturer's recommended interval or a minimum of every five years, whichever is shorter

(d) Owner shall maintain following documentation for IEQ M&V:

1. IEQ M&V Plan, including:

    i. List of each zone or building space that requires CO_2 monitoring, as defined in 9.3.3.1(a) and each air system with outdoor air flow measuring station as defined in 9.3.3.1(b), and each natural ventilated space with CO_2 monitoring as defined in 9.3.3.2.

    ii. Monitoring procedures and monitoring frequencies for each monitored sensing device, including a description of the specific response measures to be taken if needed.

2. Dated records of CO2 concentrations and airflow rates measured and reviewed as part of the above listed requirements, along with dated documentation of any corrective actions taken and any sensor recalibrations or replacements.

All IEQ M&V data and documentation shall be made available to local, state and federal agencies, or their representatives, that may request it.

10.3.4 Energy Use Reporting. The project owner shall enter the building's annual energy use into the Environmental Protection Agency's Energy Star Portfolio Manager Tool every third year after initial *building commissioning* has been completed and either the occupancy certificate has been issued or a minimum occupancy of 80% is reached for the life of the building. Owner shall print and retain input and summary report pages from Portfolio Manager for their building on each occasion when annual energy use data is entered. This documentation shall be made available to local, state or federal agencies, or their representatives, that may request it.

Exception to 10.3.4: Building types not included in Energy Star Portfolio Manager are excluded from this reporting requirement.

10.3.5 Durability Plan. A durability plan that is consistent with the *owner's project requirements* shall be developed to estimate structural, *building envelope* (but not mechanical and electrical), and *hardscape* materials that need to be replaced during the life of the building. The service life of the building shall be no less than that determined using Table 10.3.5. The expected service life shall be specified for building assemblies and materials that need to be inspected and/or replaced during the service life of the building. *Site* improvements and *hardscape* shall also be included. Documentation in the durability plan shall include the project design service life and basis for determination, and the following for each assembly or component:

(a) Building assembly description

(b) Material

(c) Design service life, years

(d) Predicted service life, years

(e) Failure category

(f) Effects of failure

(g) Maintenance frequency

(h) Maintenance access

The durability plan shall be submitted to the owner for approval prior to the completion of design development. Owner shall retain a copy of the durability plan for use during life of building and for local, state and federal agencies or their representatives that may request this data.

TABLE 10.3.5 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

10.3.6 Transportation Management Plan (TMP). Owner shall prepare a management plan with the intent to reduce gasoline- and diesel-powered vehicle trips.

All owners of buildings shall prepare and implement within a 5 year period, a transportation management plan that demonstrates a reduction of 15% of estimated vehicle trips to the facility. This plan shall be submitted to the *authority having jurisdiction* as part of the building permit application.

(a) An assessment of the expected number of vehicle trips (baseline) for all travelers to the building shall be developed and included in the plan.
The baseline for the TMP, except as outlined below for high rise *residential* and retail, shall be developed by determining traveler means of transportation to the building location by mode. Current mode rates for all means of transportation including single occupancy vehicle (SOV) shall be attained from the local municipal planning organization and/or air quality planning board and/or state department of transportation. Current mode rates shall be attained for the zip code, or the smallest geographic area in which the building is located when zip code data is not available.

(b) High rise *residential* baseline is determined as no more than 1.25 parking spaces provided for each housing unit.

(c) For retail, the baseline is determined by the maximum number of parking spaces allowed by the municipal ordinance.

(d) Based upon the baseline assessment of means of transportation, the TMP shall identify a list of activities to be implemented within the 5-year period that will achieve a 15% reduction in gasoline- and diesel-powered vehicle travel and increase or develop alternative transportation activities in those areas where there are opportunities for new, or already existing alternative transportation activities. These activities shall include only those identified as in use by travelers within the *building project's* zip code or geographic area, as identified in the baseline. For example, if the baseline shows no activity in the "bicycle" means of transportation, the provisions of the TMP is not allowed to be met by establishing bike storage and shower facilities. However, if there is enough existing activity by travelers to demonstrate that providing these facilities will significantly address the measurable goal, these accommodations are allowed to be included in the TMP. Establishment of carpools, vanpools, and shuttle buses where they current do not exist is considered an allowable

activity to decrease vehicle trips.

(e) A methodology for monitoring, reporting and evaluation.

(f) Implementation and verification of the TMP completed within 5 years of building occupancy. Compliance documentation shall be kept by the owner and the TMP and this compliance documentation shall be made available to local, state or federal agencies or their representatives that may request it.

Exceptions to 10.3.6:

(a) Where the building is located within 800 m (½ mi) of a public transit system (commuter rail and/or subway) and it is demonstrated by the TMP baseline calculations that a minimum of 25% of travelers within the projects' zip code or geographic area use public transit.

(b) Where the baseline demonstrates that 25% of travelers within the project's zip code or geographic area use existing alternative transportation modes.

(c) Parking provisions are included that do not exceed the Maximum Parking Capacity in Table 10.3.6.

Table 10.3.6 Maximum Parking Capacity

Use	**Maximum Parking Spaces**	
Eating/Drinking Uses	1 per 25 m^2 (250 ft^2)	
Entertainment and Public Assembly	1 for every 8 fixed seats or 1 per 10 m^2 (100 ft^2) for venues without fixed seats	
Hospital and Health Care	1 per 50 m^2 (500 ft^2)	
Lodging	1 for every eight rooms if located downtown or within 5 miles of an airport, or 1 for every 4 rooms	
Manufacturing and Agricultural	1 per 200 m^2 (2,000 ft^2)	
Office	1 per 100 m^2 (1,000 ft^2)	
Residential	1 per dwelling	
Retail (including Customer Service Offices)	1 per 50 m^2 (500 ft^2)	
School	1 per 50 m^2 (500 ft^2)	
Warehouse	1 per 150 m^2 (1,500 ft^2)	

For uses not shown or if the jurisdiction's minimum parking requirements exceed those listed in the table, parking supply shall not exceed 50% of the estimated peak average demand for the use. Calculations shall be done in accordance with *generally accepted engineering standards* and handbooks acceptable to the *authority having jurisdiction*. (Informative note: See example such as the Institute of Transportation Engineers'

Parking Generation, 3rd Edition, in Informative Appendix F.) (Informative note: See example in Informative Appendix K.)

10.3.7 Erosion and Sediment Control (ESC) Plan. Prepare 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.

10.3.8 Indoor Air Quality (IAQ) Construction Management Plan. An Indoor Air Quality (IAQ) Management Plan shall be developed and implemented as follows:

(a) The plan for IAQ during construction shall be in accordance with *generally accepted engineering practice* acceptable to the *authority having jurisdiction*. (Informative note: See example such as the SMACNA IAQ Guidelines for Occupied Buildings under Construction in Informative Appendix F.)

(b) Cleanliness standards for all HVAC air conveyance elements shall be followed during construction. A cleanliness specification—based on the cleanliness requirements of the building—shall provide details for the storage and covering of air conveyance elements. Permanent HVAC shall never be used during construction and shall be operated for the first time during building "flush-out" and then only after all filters and controls are in place and operational.

(c) After construction ends, prior to occupancy and with all interior finishes installed, a building flush-out shall be performed by one of the following methods:

1. Supplying a total air volume of 4,300 m^3 of outdoor air per m^2 of floor area (14,000 ft^3 of outdoor air per ft^2 of floor area) while maintaining an internal temperature of a minimum of 15 C (60 ºF) and relative humidity no higher than 60% or as in 10.3.8.1(d) or 10.3.8.1(e).

2. If occupancy is desired prior to completion of the flush-out, the space is allowed to be occupied following delivery of a minimum of 1,100 m^3 of outdoor air per m^2 of floor area (3,500 ft^3 of outdoor air per ft^2 of floor area) to the space. Once a space is occupied, it shall be ventilated at a minimum rate of 1.5 L/s per m^2 (0.30 cfm per ft^2) of outside air or the design minimum outside air rate determined in 9.3.1(a), whichever is greater. During each day of the flush-out period, ventilation shall begin a minimum of three hours prior to occupancy and continue during occupancy. These conditions shall be maintained until a total of 4,300 m^3 of outdoor air per m^2 of floor area (14,000 ft^3 of outdoor air per ft^2 of floor area) has been delivered to the space.

3. Baseline IAQ testing shall be conducted after construction ends and prior to occupancy using testing protocols consistent with the USEPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air. The testing shall demonstrate that the contaminant maximum concentrations listed in Table 10.3.8 are not exceeded. 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 indicate 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.

(d) The IAQ Management Plan shall include a list of each zone or building space that requires CO_2 monitoring, as defined in 9.3.3.1(a). The plan shall contain a description of the response measures to be taken when CO_2 levels exceed those specified in 9.3.3, and require recalibration of the CO_2 sensors at a frequency based on manufacturer's recommendations.

(e) The IAQ Management Plan shall include a description of the specific response measures to be taken when the outdoor airflow rate fails to meet that specified in 9.3.3.1(b).

(f) The IAQ Management Plan shall include a description of the specific response measures when CO_2 levels exceed those specified in 9.3.3 for naturally ventilated spaces.

TABLE 10.3.8 Maximum Concentration of Air Pollutants

Contaminant	Maximum Concentration
Formaldehyde	50 parts per billion
Particulates (PM10)	50 mcg/m^3 (50 ppb)
Total Volatile Organic Compounds (TVOC)	500 mcg/m^3 (500 ppb)
4-Phenylcyclohexene (4-PCH)[a]	6.5 mcg/m^3 (6.5 ppb)
Carbon Monoxide (CO)	9 ppm and no greater than 2 ppm above outdoor levels

[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.

10.3.9 Construction. The following shall be adhered to during project construction.

10.3.9.1 Construction Activity Pollution Prevention: No-idling of Construction Vehicles. The purpose of this provision is to reduce diesel emissions of vehicles during construction. Operators of diesel construction vehicles are not allowed to idle their vehicles' engines during any part of the building's construction. No load/unload location owner shall cause vehicles covered by this provision to idle for a period greater than 30 minutes while waiting to load or unload at a location under their control. No owner or operator of a vehicle shall cause or permit vehicles covered by this provision to idle for more than 5 minutes in any 60 minute period except in the case of a load/unload location.

Exceptions to 10.3.9.1:

(a) a vehicle idles while forced to remain motionless at the direction of a law

enforcement official.

(b) a vehicle idles when operating defrosters, heaters, air conditioners, or installing equipment solely to prevent a safety or health emergency, and not as part of a rest period.

(c) the primary propulsion engine idles for maintenance, servicing, repairing, or diagnostic purposes if idling is required for such activity.

(d) idling of the primary propulsion engine is necessary to power work-related mechanical or electrical operations other than propulsion (e.g., mixing or processing cargo or straight truck refrigeration). This exemption does not apply when idling for cabin comfort or to operate non-essential on-board equipment.

(e) an occupied vehicle idles for purposes of air conditioning or heating while waiting to load or unload.

(f) a vehicle idles due to mechanical difficulties over which the driver has no control.

(g) idling of a vehicle is required to meet an applicable existing local, state or federal safety, health, environmental, or trade union requirement.

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

(a) Materials stored on-site or materials installed that are absorptive shall be protected from moisture damage.

(b) Immediately remove and discard building construction material which shows visual evidence of biological growth due to the presence of moisture. Replace the moisture damaged materials with undamaged materials.

(c) Landscaping sprinklers shall not be permitted to spray water on a building and within 1 m (3 feet) of a building.

10.4 Prescriptive Option. There are no prescriptive criteria.

10.5 Performance Option. There are no performance criteria.

10.6 Submittal Requirements

10.6.1 General. The *authority having jurisdiction* is allowed to require submittal of compliance documentation and supplemental information, in accordance with 10.2 of this standard.

10.6.2 Prior to Building Permit. Include as part of building permit submission, the following documentation, as applicable to the project:

(a) Under Section 10.3.1:

1. Signed certification by owner that *owner's project requirements* have been

generated and distributed to all project team members and an independent and qualified CxA has been retained for the project to provide commissioning services in accordance with all requirements in 10.3.1. Include full contact information for the CxA.

2. Signed certification by Design team leader and sub-consultants that commissioning requirements have been incorporated into Construction Documents.
3. The *Commissioning Plan*.

(b) Under Section 10.3.2:

1. Signed certification by owner that a qualified Acceptance Agent has been retained for the project to provide services in accordance with all requirements in 10.3.1. Include full contact information for the Acceptance Agent.
2. Signed certification by Design team leader that Acceptance testing requirements have been incorporated into specifications and other Construction Documents.

(c) Under Section 10.3.3:

1. The measurement and verification plan.
2. Signed certification by Design team leader that measurement and verification requirements have been incorporated into specifications and other Construction Documents.

(d) Under Section 10.3.5:

1. The durability plan. (Informative note: See example in Informative Appendix K.)

(e) Under Section 10.3.6:

1. The TMP.

(f) Under Section 10.3.7:

1. A copy of the ESC plan.

10.6.3 Prior to Issuance of Certificate of Occupancy. Provide, as a requirement before certificate of occupancy is issued, the following documentation as applicable to project:

(a) Under Section 10.3.1:

1. Preliminary summary commissioning report commissioning
2. Signed certification by owner and CxA that all commissioning requirements outlined above, including full implementation of *commissioning plan* (except for trend logging and off-season testing) have been met to the full satisfaction of owner. For systems that require off-season testing verification, the certification shall include a listing of formal contractual arrangements in place for conducting the required off-season testing as well as plans for correcting any deficiencies that

are found.

(b) Under Section 10.3.2:

1. Signed certification by owner and Acceptance Agent that acceptance testing requirements outlined above, including full implementation of acceptance testing (except for trend logging and off-season testing), have been met to the full satisfaction of owner. Final Certificate of Occupancy shall not be issued unless the submitted Certificate of Acceptance demonstrates that the specified systems, equipment and controls have been shown to all be performing in accordance with construction documentation requirements, or, for systems that require off-season testing verification, that a formal contractual arrangement is in place for conducting this testing as well as plans for correcting any deficiencies that are found.

(c) Under Section 10.3.8:

1. Signed certification by Contractor that they have complied with all provisions of Section 10.3.8 during construction.
2. A copy of the IAQ Construction Management plan.

> **Exception to 10.6.3(c)**: If 10.3.8(c)2 building flush strategy is being employed in some or all spaces, then in addition to contractor certification, owner shall submit certification that includes a listing of formal contractual arrangements that are in place for contractor to complete the required provisions of 10.3.8(c)2 subsequent to building occupancy in all spaces where 10.3.8(c)2 applies.

(d) Under Section 10.3.9:

1. Signed certification by Contractor that they have complied with all provisions of Section 10.3.9 during construction.

11. NORMATIVE REFERENCES

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		
ASHRAE Standard 55-2004	Thermal Comfort Conditions for Human Occupancy	9.3.4, 9.6.4
ASHRAE Standard 62.1-2007	Ventilation for Acceptable Indoor Air Quality	3.2, 9.3.1, 9.6.1, Appendix E
ASHRAE/IESNA Standard 90.1-2007 (90.1-2004 plus addenda a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, x, y, aa, ab, ac, ad, ae, ag, ah, ai, aj, ak, al, am, an, ao, ap, aq, ar, as, at, av)	Energy Standard for Buildings Except Low-Rise Residential Buildings	3.1, 3.2, 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, 7.6.1, 7.6.5, 7.6.6, 7.6.7, 7.6.8, 7.6.9, 7.6.10, 7.6.11, 7.6.12, Appendix A, Appendix C, Appendix D
ASHRAE Standard 140-2004	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs	Appendix D
ASHRAE Standard 169-2006	Weather Data for Building Design Standards	Appendix A
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 A112.19.2-2003	Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals	6.3.2.1
ASME A112.19.19-2006	Vitreous China Nonwater Urinals	6.3.2.1
American Society for Testing and Materials 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	5.3.3, Appendix D
ASTM C1549-04	Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer	5.3.3, Appendix D
ASTM D1003-00	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics	9.3.7, 9.4.1.2
ASTM E90-04	Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements	9.3.6
ASTM E408-71(2002)	Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques	5.3.3, Appendix D
ASTM E413-04	Classification for Rating Sound Insulation	9.3.6
ASTM E779-03	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	Appendix B
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, 5.6.1
ASTM E1918-06	Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field	5.3.3, Appendix D
ASTM E1980-01	*Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces*	5.3.3, 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

California Department of Health Services (CDHS)
P. O. Box 997413
Sacramento, CA 95899-7413
United States
1-916-445-4171; www.dhs.ca.gov

California Specification 01350 - July 15, 2004	Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers	9.4.2.3, 9.5.2

CITES Secretariat **International Environment House** **Chemin des Anémones** **CH-1219 Châtelaine, Geneva** **Switzerland** **41-(0)22-917-81-39/40; www.cites.org**		
3 March 1973 Amended at Bonn, on 22 June 1979, with Appendices I, II and III valid from 4 March 2007	Convention on International Trade in Endangered Species of Wild Fauna and Flora	8.3.2
Green Seal **1001 Connecticut Avenue, NW, Suite 827** **Washington, DC 20036-5525** **United States** **1-202-872-6400; www.greenseal.org**		
GS-11, May 20, 1993	Standard for Paints	9.4.2.2
GS-36, October 19, 2000	Standard for Commercial Adhesives	9.4.2.1
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 Standards Organization (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 14044 – 2006	Environmental management — Life cycle assessment — Requirements and guidelines	8.5.1
ISO/IEC Guide 59-1994	Code of Good Practice for Standardization	8.4.1.3
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 7th Draft Testing Protocol – November 2006	Smart Water Application Technology (SWAT), Turf and Landscape Irrigation Equipment Climatologically Based Controllers	6.3.1.3
Scientific Certification Systems (SCS) **2000 Powell Street, Suite 1350** **Emeryville, CA 94608** **United States** **1-510-452-8000; www.scscertified.com**		
SCS-EC10-2004	Environmental Certification Program, Indoor Air Quality Performance	9.4.2.3

Solar Rating and Certification Council (SRCC) **c/o Florida Solar Energy Center (FSEC)** **1679 Clearlake Rd** **Cocoa FL 32922-5703** **United States** **1-321-638-1537; 1-321-638-1010; www.solar-rating.org**		
SRCC Document OG-100	Operating Guidelines for Certifying Solar Collectors	7.3.3
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 1113- Amended June 9, 2006	Architectural Coatings	9.4.2.2
SCAQMD 1168 - amended January 7, 2005	Adhesive and Sealant Applications	9.4.2.1
United States Department of Agriculture (USDA) **BioPreferred** **2272 Howe Hall, Suite 2620** **Ames, Iowa 50011-2272** **United States** **1-877-251-6522; 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	8.4.1.3
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**		
2003	Commercial Building Energy Consumption Survey (CBECS)	10.3.3.3
	State and U.S. Historical Data	Appendix D
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**		
1970 and as amended in 1990	Clean Air Act	8.5.1.2
January 21, 2005	NPDES General Permit for Stormwater Discharges From Construction Activities	10.3.7
Version 3.0, July 1, 1999	Energy Star Computer Memorandum of Understanding	7.3.2.1

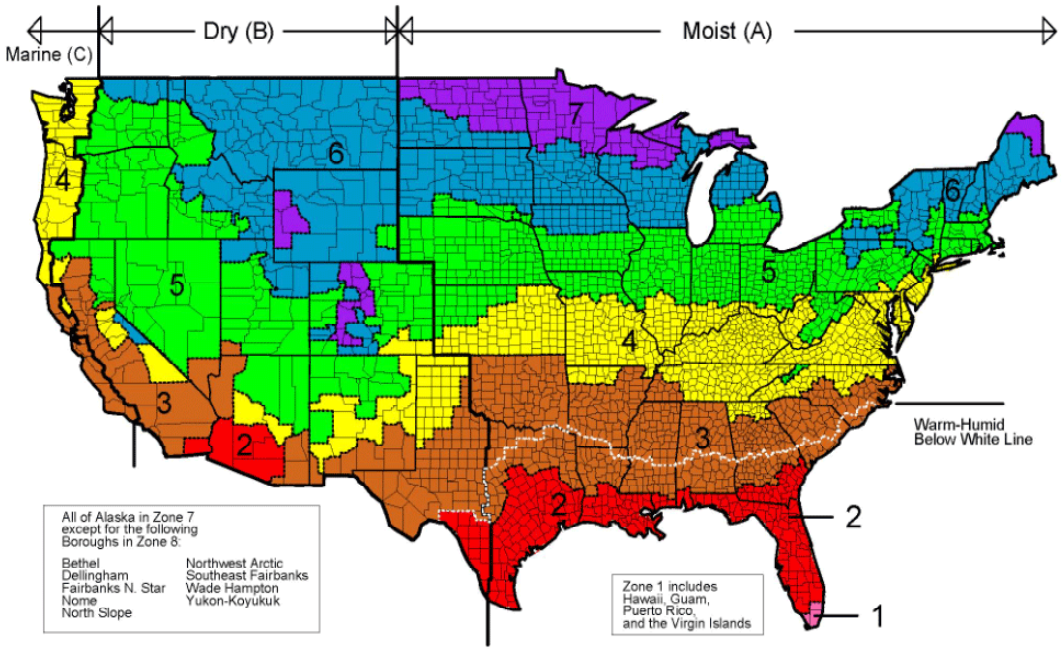
Version 2.0	Energy Star Copier Memorandum of Understanding	7.3.2.1
Amendment October 23, 1998	Energy Star Memorandum of Understanding for Multifunction Devices	7.3.2.1
Version 3.0, November 1 2000	Energy Star Printer, Fax, Printer/Fax, and Mailing Machine Memorandum of Understanding	7.3.2.1
November 16, 2005	Energy Star Program Requirements and Criteria for Room Air Conditioners	7.3.2.1
Version 4.0	Energy Star Program Requirements for ASHPs and Central Air Conditioners	7.3.2.1
Version 2	Energy Star Program Requirements for Boilers	7.3.2.1
Version 1.1	Energy Star Program Requirements for Bottled Water Coolers	7.3.2.1
Version 3.0, January 1, 2004	Energy Star Program Requirements for CFLs	7.3.2.1
December 20, 2005	Energy Star Program Requirements for Clothes Washers	6.3.2.2, 7.3.2.1
	Energy Star Program Requirements for Commercial and Industrial Transformers	7.3.2.1
Version 1.0, August 15, 2003	Energy Star Program Requirements for Commercial Fryers	7.3.2.1
Version 1.0, August 1, 2003	Energy Star Program Requirements for Commercial Steam Cookers	7.3.2.1
Version 4.1, January 1, 2006	Energy Star Program Requirements for Computer Monitors	7.3.2.1
Version 1.0	Energy Star Program Requirements for Consumer Audio and DVD	7.3.2.1
Version 2.0, October 1 2006	Energy Star Program Requirements for Dehumidifiers	7.3.2.1
February 24, 2004	Energy Star Program Requirements for Dishwashers	6.3.2.2, 7.3.2.1
Version 2.0	Energy Star Program Requirements for Furnaces	7.3.2.1
April 1, 2001	Energy Star Program Requirements for Geothermal Heat Pumps	7.3.2.1
Version 1.0, August 15, 2003	Energy Star Program Requirements for Hot Food Holding Cabinets	7.3.2.1
January 1, 2004	Energy Star Program Requirements for Light Commercial HVAC	7.3.2.1
January 1 2006	Energy Star Program Requirements for Products with Battery Charger Systems (BCSs)	7.3.2.1
	Energy Star Program Requirements for Programmable Thermostats	7.3.2.1
Version 2.0	Energy Star Program Requirements for Refrigerated Beverage Vending Machines	7.3.2.1
September 1 2001	Energy Star Program Requirements for Refrigerators and Freezers	7.3.2.1

Version 2.1, September 1, 2006	Energy Star Program Requirements for Residential Ceiling Fans	7.3.2.1
Version 1.2	Energy Star Program Requirements for Roof Products	5.3.3.3
Version 1, July 1 2004	Energy Star Program Requirements for Room Air Cleaners	7.3.2.1
Version 4.0, October 1, 2005	Energy Star Program Requirements for Residential Light Fixtures	7.3.2.1
Version 2.0 January 1, 2005	Energy Star Program Requirements for Residential Ventilating Fans	7.3.2.1
Version 1.1	Energy Star Program Requirements for Single-Voltage Ac-Dc and Ac-Ac Power Supplies	7.3.2.1
Version 1.0, September 1, 2001	Energy Star Program Requirements for Solid Door Refrigerators and Freezers	7.3.2.1
Version 2.0, November 1, 2006	Energy Star Program Requirements for Telephony	7.3.2.1
Version 1.1	Energy Star Program Requirements for Traffic Signals	7.3.2.1
Version 2.2	Energy Star Program Requirements for TVs, VCRs, DCR TVs with POD Slots, Combination Units, Television Monitors, and Component Television Units	7.3.2.1
Version 1.0 April 1, 1997	Energy Star Scanner Memorandum of Understanding	7.3.2.1
Version 1.0, January 24, 2007	WaterSense Tank-Type High-Efficiency Toilet Specification	6.3.2.1
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 600/4-90-010, April 1990	Compendium of Methods for the Determination of Air Pollutants in Indoor Air	10.3.8
U. S. Government Printing Office **Washington, D.C. 20401** **United States** **+1 (202) 512-0000; www.access.gpo.gov** **http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf**		
2005	Energy Policy Act (EPAct)	7.3.2.1
World Trade Organization (WTO) **Centre William Rappard,** **Rue de Lausanne 154,** **CH-1211 Geneva 21,** **Switzerland** **41-22-739-51-11; www.wto.org**		
1994	WTO Technical Barriers to Trade (TBT) Agreement Annex 3	8.4.1.3

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

NORMATIVE APPENDIX A
PRESCRIPTIVE BUILDING ENVELOPE TABLES

(Informative note: The first 8 tables are in SI units, then followed by the 8 tables in I-P.)



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

(a) For the United States, the 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 ASHRAE Standard 169.

(b) For Canada, see Table B2 in ASHRAE Standard 169.

(c) For available international locations (outside the U.S. and Canada), see Table B3 in ASHRAE Standard 169.

(d) For locations not provided in Table B2 or B3, see Table B4 (reproduced below) in ASHRAE Standard 169 for the international *climate zone* definitions.

Table B-4 International Climate Zone Definitions

Climate Zone Number	Name	Thermal Criteria (SI)	Thermal Criteria (IP)
1	Very Hot – Humid (1A), Dry (1B)	5000 < CDD10 C	9000 < CDD50ºF
2	Hot – Humid (2A), Dry (2B)	3500 < CDD10 C ≤ 5000	6300 < CDD50ºF ≤ 9000
3A, 3B	Warm – Humid (3A), Dry (3B)	2500 < CDD10 C ≤ 3500	4500 < CDD50ºF ≤ 6300
3C	Warm – Marine (3C)	CDD10 C ≤ 2500 AND HDD18 C ≤ 2000	CDD50ºF ≤ 4500 AND HDD65ºF ≤ 3600
4A, 4B	Mixed – Humid (4A), Dry (4B)	2500 ≤ CDD10 C AND 2000 < HDD18 C ≤ 3000	CDD50ºF ≤ 4500 AND 3600 < HDD65ºF ≤ 5400
4C	Mixed – Marine (4C)	2000 < HDD18 C ≤ 3000	3600 < HDD65ºF ≤ 5400
5A, 5B, 5C	Cool– Humid (5A), Dry (5B), Marine (5C)	3000 < HDD18 C ≤ 4000	5400 < HDD65ºF ≤ 7200
6A, 6B	Cold – Humid (6A), Dry (6B)	4000 < HDD18 C ≤ 5000	7200 < HDD65ºF ≤ 9000
7	Very Cold	5000 < HDD18 C ≤ 7000	9000 < HDD65ºF ≤ 12600
8	Subarctic	7000 < HDD18 C	12600 < HDD65ºF

Table A-1 (supersedes Table 5.5-1 in 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[d]	U-0.28	R-2.3 + R-3.3	U-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.95	R-1.1
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-0.41	R-2.3 + R-0.9 ci	U-0.41	R-2.3 + R-0.9 ci	U-0.64	R-2.3
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%	$U_{all}^{-3.24}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-3.24}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-7.72}$	$SHGC_{all}^{-NR}$

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-2 (supersedes Table 5.5-2 in 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-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.55	R-1.8
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-0.41	R-2.3 + R-0.9 ci	U-0.30	R-2.3 + R-1.8 ci	U-0.48	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-0.50	R-1.5 ci	U-0.42	R-1.8 ci	U-0.78	R-0.7 ci
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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-3 (supersedes Table 5.5-3 in 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-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.41	R-2.8
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-0.41	R-2.3 + R-0.9 ci	U-0.30	R-2.3 + R-1.8 ci	U-0.48	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-0.42	R-1.8 ci	U-0.42	R-1.8 ci	U-0.78	R-0.7 ci
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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-4 (supersedes Table 5.5-4 in 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-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.41	R-2.8
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-1.8 ci	U-0.30	R-2.3 + R-1.8 ci	U-0.48	R-3.3
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

[a] Mass walls with a heat capacity greater than 245 kJ/m²·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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-5 (supersedes Table 5.5-5 in 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-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.23	R-3.3 + R-1.8 filled cavity w/tb	U-0.41	R-2.8
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-1.8 ci	U-0.30	R-2.3 + R-1.8 ci	U-0.48	R-3.3
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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-6 (supersedes Table 5.5-6 in 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-5.3 + R-1.1 ci, filled cavity w/tb	U-0.18	R-5.3 + R-1.1 ci, filled cavity w/tb	U-0.37	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-1.8 ci	U-0.30	R-2.3 + R-1.8 ci	U-0.48	R-3.3
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

[a] Mass walls with a heat capacity greater than 245 kJ/m²·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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-7 (supersedes Table 5.5-7 in 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-1.8 ci, filled cavity w/tb	U-0.16	R-5.3 + R-1.8 ci, filled cavity w/tb	U-0.37	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-1.8 ci	U-0.21	R-2.3 + R-3.3 ci	U-0.48	R-3.3
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

[a] Mass walls with a heat capacity greater than 245 kJ/m²·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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-8 (supersedes Table 5.5-8 in 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-1.8 ci, filled cavity w/tb	U-0.16	R-5.3 + R-1.8 ci, filled cavity w/tb	U-0.28	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-0.24	R-5.5 ci	U-0.45	R-2.3 ci
Metal Building	U-0.30	R-2.3 + R-1.8 ci	U-0.18	R-2.3 + R-3.9 ci	U-0.35	R-2.3 + R-1.3 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-0.18	R-2.3 + R-3.3 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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-1 (supersedes Table 5.5-1 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 1 (A,B) (IP)

	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-0.049	R-13.0 + R-19.0	U-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.167	R-6.0
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-0.072	R-13.0 + R-5.0 ci	U-0.072	R-13.0 + R-5.0 ci	U-0.113	R-13.0
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%	$U_{all}^{-0.57}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-0.57}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.36}$	$SHGC_{all}^{-NR}$

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-2 (supersedes Table 5.5-2 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 2 (A,B) (IP)

	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-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.097	R-10.0
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-0.072	R-13.0 + R-5.0 ci	U-0.053	R-13.0 + R-10.0 ci	U-0.084	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-0.087	R-8.3 ci	U-0.074	R-10.4 ci	U-0.137	R-4.2 ci
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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-3 (supersedes Table 5.5-3 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 3 (A,B,C) (IP)

	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-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.072	R-16.0
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-0.072	R-13.0 + R-5.0 ci	U-0.053	R-13.0 + R-10.0 ci	U-0.084	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-0.074	R-10.4 ci	U-0.074	R-10.4 ci	U-0.137	R-4.2 ci
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-0.45	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%	$U_{all}^{-0.45}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-0.45}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.36}$	$SHGC_{all}^{-NR}$

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-4 (supersedes Table 5.5-4 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 4 (A,B,C) (IP)

	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-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.072	R-16.0
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-0.053	R-13.0 + R-10.0 ci	U-0.053	R-13.0 + R-10.0 ci	U-0.084	R-19.0
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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-5 (supersedes Table 5.5-5 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 5 (A,B,C) (IP)

	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-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.041	R-19.0 + R-10.0 filled cavity w/tb	U-0.072	R-16.0
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-0.053	R-13.0 + R-10.0 ci	U-0.053	R-13.0 + R-10.0 ci	U-0.084	R-19.0
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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-6 (supersedes Table 5.5-6 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 6 (A,B) (IP)

	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-0.032	R-30.0 + R-6.0 ci, filled cavity w/tb	U-0.032	R-30.0 + R-6.0 ci, filled cavity w/tb	U-0.065	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-0.053	R-13.0 + R-10.0 ci	U-0.053	R-13.0 + R-10.0 ci	U-0.084	R-19.0
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%	$U_{all}^{-0.45}$	$SHGC_{all}^{-0.46}$	$U_{all}^{-0.45}$	$SHGC_{all}^{-0.39}$	$U_{all}^{-1.36}$	$SHGC_{all}^{-NR}$

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-7 (supersedes Table 5.5-7 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 7 (IP)

	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-0.028	R-30.0 + R-10.0 ci, filled cavity w/tb	U-0.028	R-30.0 + R-10.0 ci, filled cavity w/tb	U-0.065	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-0.053	R-13.0 + R-10.0 ci	U-0.036	R-13.0 + R-18.8 ci	U-0.084	R-19.0
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

[a] Mass walls with a heat capacity greater than 12 Btu/ft²·°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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

Table A-8 (supersedes Table 5.5-8 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 8 (IP)

	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-0.028	R-30.0 + R-10.0 ci, filled cavity w/tb	U-0.028	R-30.0 + R-10.0 ci, filled cavity w/tb	U-0.049	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-0.043	R-31.3 ci	U-0.080	R-13.3 ci
Metal Building	U-0.053	R-13.0 + R-10.0 ci	U-0.032	R-13.0 + R-22.4 ci	U-0.061	R-13.0 + R-7.5 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-0.032	R-13.0 + R-18.8 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]	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}-0.58	$SHGC_{all}$-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

[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 nonentrance doors.
[d] Filled cavity with thermal block is as shown in Table A3.2.of Standard 90.1.

(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 0.02 $L/s \cdot m^2$ under a pressure differential of 75 Pa (0.004 cfm/ft^2 under a pressure differential of 0.3 in. water (1.57 lb/ft^2)) when tested in accordance with ASTM E2178. These materials meet this requirement when all joints are sealed and the above section on characteristics are met:

1. Plywood - minimum 10 mm (3/8 in)
2. Oriented strand board - minimum 10 mm (3/8 in)
3. Extruded polystyrene insulation board - minimum 19 mm (3/4 in)
4. Foil-back urethane insulation board - minimum 19 mm (3/4 in)
5. Exterior or interior gypsum board - minimum 12 mm (1/2 in)
6. Cement board - minimum 12 mm (1/2 in)

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 16 mm (5/8 in) 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 0.2 L/s·m^2 @ 75 Pa (0.04 cfm/ft^2 under a pressure differential of 0.3" w.g. (1.57psf)) when tested in accordance with ASTM E2357 or ASTM E1677. These assemblies meet this requirement when all joints are sealed and the above section on characteristics are met:

1. Concrete masonry walls coated with:
    i. One application of block filler and two applications of a paint or sealer coating, or
    ii. A Portland cement/sand parge, stucco or plaster minimum 12 mm (1/2 in) thick.

(c) Building. Testing the completed building and demonstrating that the air leakage rate of the *building envelope* does not exceed 2.0 L/s·m^2 @ 75 Pa (0.40 cfm/ft^2 at a pressure differential of 0.3" w.g. (1.57 psf)) 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 REQUIREMENTS

(Informative note: The first 25 tables are in SI units, followed by the 25 tables in I-P.)

Table C-1 (supersedes Table 6.8.1A in 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 (SI)	Test Procedure
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	ARI 210/240
Through-the-wall Air Cooled	<9 kW	All	Split Systems	3.52 SCOP	ARI 210/240
			Single Packaged	3.52 SCOP	ARI 210/240
Small-Duct High Velocity, Air-Cooled	<19kW	All	Split Systems	2.93 SCOP	ARI 210/240
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	ARI 340/360
	≥40 kW and < 70 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	ARI 340/360
	≥70 kW and < 223 kW	Electric Resistance (or None)	Split Systems and Single Package	2.93 COP 3.08 ICOP	ARI 340/360
		All other	Split Systems and Single Package	2.87 COP 3.02 ICOP	ARI 340/360
	≥223 kW	Electric Resistance (or None)	Split Systems and Single Package	2.84 COP 2.99 ICOP	ARI 340/360
		All other	Split Systems and Single Package	2.78 COP 2.93 ICOP	ARI 340/360

Table C-1 (supersedes Table 6.8.1A in ASHRAE/IESNA Standard 90.1) – Electrical Operated Unitary Air Conditioners and Condensing Units (SI) (continued)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency (SI)	Test Procedure
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	ARI 340/360
	≥40 kW and < 70 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	3.81 COP 4.13 ICOP	ARI 340/360
	≥70 kW Btu/h	Electric Resistance (or None)	Split Systems and Single Package	4.10 COP 4.10 ICOP	ARI 340/360
		All other	Split Systems and Single Package	3.81 COP 3.81 ICOP	ARI 340/360
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	ARI 365

Table C-2 (supersedes Table 6.8.1B in 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 (SI)	Test Procedure
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	3.37 COP_C 3.52 $ICOP_C$	ARI 340/360
		All other	Split Systems and Single Package	3.31 COP_C 3.46 $ICOP_C$	
	≥40 kW and < 70 kW	Electric Resistance (or None)	Split Systems and Single Package	3.37 COP_C 3.52 $ICOP_C$	
		All other	Split Systems and Single Package	3.31 COP_C 3.46 $ICOP_C$	
	≥70 kW	Electric Resistance (or None)	Split Systems and Single Package	2.93 COP_C 2.93 $ICOP_C$	
		All other	Split Systems and Single Package	2.87 COP_C 2.87 $ICOP_C$	
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	

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

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency (SI)	Test Procedure
Air Conditioners, Air Cooled (Heating Mode)	<19 kW	All	Split Systems	2.49 $SCOP_H$	ARI210/240
			Single Packaged	2.34 $SCOP_H$	
Through-the-wall Air Cooled (Heating Mode)	<9 kW	All	Split Systems	2.17 $SCOP_H$	
			Single Packaged	2.17 $SCOP_H$	
Small-Duct High Velocity, Air-Cooled (Heating Mode)	<19 kW	All	Split Systems	1.99 $SCOP_H$	
Air Cooled (Heating Mode)	≥19 kW and <40 kW (Cooling Capacity)	–	8C db/6C wb Outdoor Air	3.3 COP_H	ARI 340/360
			-8 C db/-9 C wb Outdoor Air	2.2 COP_H	
	≥40 kW (Cooling Capacity)	–	47 F db/43 Fwb Outdoor Air	3.2 COP_H	
			-8 C db/-9 C wb Outdoor Air	2.0 COP_H	
Water-Source (Heating Mode)	< 40 kW (Cooling Capacity)	–	68 F Entering Water	4.2 COP_H	ISO-13256-1
Groundwater-Source (Heating Mode)	< kW (Cooling Capacity)	–	50 F Entering Water	3.6 COP_H	
			0 C Entering Fluid	3.1 COP_H	

Table C-3 (supersedes Table 6.8.1C in ASHRAE/IESNA Standard 90.1)
Water Chilling Packages – Minimum Efficiency Requirements (SI)

Equipment Type	Size Category	Units	Minimum Efficiency (SI)				Test Procedure
			Path A		Path B		
			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 must 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 Absoprtion Single Effect	All Capacities	COP	0.600[h]	NR	NA	NA	ARI 560
Water-Cooled Absorption Single Effect	All Capacities	COP	0.700[h]	NR	NA	NA	
Absorption Double Effect Indirect-Fired	All Capacities	COP	1.000	3.350	NA	NA	
Absorption Double Effect Direct Fired	All Capacities	COP	1.200	NR	NA	NA	

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is <4.4 F
b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure
c. Where there is a Column A and Column B requirement either column can be used for compliance, but both the full and IPLV values must be meet
d. Path A is intended for applications where significant operating time is expected at full load and design ambient
e. Path B is intended for applications with significant operating time at part load. All path B machines must be equipped with demand limiting capable controls
f. NA means that this requirement is not applicable and can not be used for compliance
g. NR means that for this category there are no minimum requirements
h. Only can be used in heat recover applications

Table C-4 (supersedes Table 6.2.1H in ASHRAE/IESNA Standard 90.1) Column A Minimum Efficiencies for Centrifugal Chillers <527 kW (SI)

full load COP std = 5.547									IPLV COP std = 5.901					
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temp (C)	Entering Condenser Water Temp (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	5.674	6.036	5.918	6.296	6.077	6.464	6.287	6.688	6.427	6.837	6.529	6.945
4.4	26.7	22.2	5.121	5.448	5.458	5.806	5.644	6.004	5.852	6.225	5.970	6.351	6.049	6.435
4.4	29.4	25.0	4.256	4.527	4.791	5.097	5.077	5.401	5.371	5.714	5.522	5.874	5.614	5.972
5.0	23.9	18.9	5.764	6.131	6.003	6.385	6.164	6.557	6.385	6.792	6.536	6.953	6.647	7.070
5.0	26.7	21.7	5.251	5.585	5.560	5.915	5.735	6.101	5.936	6.315	6.055	6.441	6.136	6.527
5.0	29.4	24.4	4.463	4.747	4.950	5.266	5.210	5.543	5.480	5.830	5.620	5.978	5.707	6.070
5.6	23.9	18.3	5.850	6.223	6.088	6.476	6.255	6.654	6.491	6.905	6.655	7.079	6.776	7.208
5.6	26.7	21.1	5.369	5.711	5.656	6.017	5.823	6.194	6.020	6.404	6.141	6.533	6.225	6.622
5.6	29.4	23.9	4.652	4.948	5.095	5.420	5.332	5.672	5.581	5.937	5.712	6.077	5.795	6.164
6.1	23.9	17.8	5.935	6.313	6.175	6.569	6.351	6.756	6.605	7.027	6.784	7.217	6.917	7.358
6.1	26.7	20.6	5.478	5.827	5.747	6.113	5.908	6.284	6.106	6.495	6.231	6.628	6.320	6.722
6.1	29.4	23.3	4.823	5.131	5.227	5.560	5.444	5.791	5.676	6.037	5.801	6.170	5.881	6.255
6.7	23.9	17.2	6.019	6.403	6.267	6.666	6.454	6.866	6.730	7.160	6.926	7.368	7.072	7.523
6.7	26.7	20.0	5.579	5.935	5.834	6.205	5.992	6.374	6.194	6.589	6.326	6.729	6.420	6.830
6.7	29.4	22.8	4.979	5.297	5.347	5.688	5.548	5.901	5.765	6.133	5.886	6.261	5.965	6.345
7.2	23.9	16.7	6.104	6.493	6.364	6.770	6.565	6.984	6.867	7.305	7.082	7.534	7.243	7.704
7.2	26.7	19.4	5.674	6.036	5.918	6.296	6.077	6.464	6.287	6.688	6.427	6.837	6.529	6.945
7.2	29.4	22.2	5.121	5.448	5.458	5.806	5.644	6.004	5.852	6.225	5.970	6.351	6.049	6.435
7.8	23.9	16.1	6.192	6.587	6.468	6.880	6.687	7.113	7.018	7.465	7.254	7.717	7.430	7.904
7.8	26.7	18.9	5.764	6.131	6.003	6.385	6.164	6.557	6.385	6.792	6.536	6.953	6.647	7.070
7.8	29.4	21.7	5.251	5.585	5.560	5.915	5.735	6.101	5.936	6.315	6.055	6.441	6.136	6.527
8.3	23.9	15.6	6.285	6.686	6.580	7.000	6.819	7.254	7.183	7.641	7.443	7.917	7.636	8.123
8.3	26.7	18.3	5.850	6.223	6.088	6.476	6.255	6.654	6.491	6.905	6.655	7.079	6.776	7.208
8.3	29.4	21.1	5.369	5.711	5.656	6.017	5.823	6.194	6.020	6.404	6.141	6.533	6.225	6.622
8.9	23.9	15.0	6.383	6.790	6.703	7.130	6.965	7.409	7.364	7.834	7.650	8.138	7.863	8.364
8.9	26.7	17.8	5.935	6.313	6.175	6.569	6.351	6.756	6.605	7.027	6.784	7.217	6.917	7.358
8.9	29.4	20.6	5.478	5.827	5.747	6.113	5.908	6.284	6.106	6.495	6.231	6.628	6.320	6.722
Condenser DT[b]			7.80		6.24		5.20		3.90		3.12		2.60	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-5 (supersedes Table 6.2.1I in ASHRAE/IESNA Standard 90.1) Column A Minimum Efficiencies for Centrifugal Chillers ≥527 kW, <1055 kW (SI)

Column A Centrifugal Chillers > 150 tons and < 300 tons														
full load COP std = 5.547							IPLV COP std = 5.901							
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temperature (C)	Entering Condenser Water Temperature (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	5.674	6.036	5.918	6.296	6.077	6.464	6.287	6.688	6.427	6.837	6.529	6.945
4.4	26.7	22.2	5.121	5.448	5.458	5.806	5.644	6.004	5.852	6.225	5.970	6.351	6.049	6.435
4.4	29.4	25.0	4.256	4.527	4.791	5.097	5.077	5.401	5.371	5.714	5.522	5.874	5.614	5.972
5.0	23.9	18.9	5.764	6.131	6.003	6.385	6.164	6.557	6.385	6.792	6.536	6.953	6.647	7.070
5.0	26.7	21.7	5.251	5.585	5.560	5.915	5.735	6.101	5.936	6.315	6.055	6.441	6.136	6.527
5.0	29.4	24.4	4.463	4.747	4.950	5.266	5.210	5.543	5.480	5.830	5.620	5.978	5.707	6.070
5.6	23.9	18.3	5.850	6.223	6.088	6.476	6.255	6.654	6.491	6.905	6.655	7.079	6.776	7.208
5.6	26.7	21.1	5.369	5.711	5.656	6.017	5.823	6.194	6.020	6.404	6.141	6.533	6.225	6.622
5.6	29.4	23.9	4.652	4.948	5.095	5.420	5.332	5.672	5.581	5.937	5.712	6.077	5.795	6.164
6.1	23.9	17.8	5.935	6.313	6.175	6.569	6.351	6.756	6.605	7.027	6.784	7.217	6.917	7.358
6.1	26.7	20.6	5.478	5.827	5.747	6.113	5.908	6.284	6.106	6.495	6.231	6.628	6.320	6.722
6.1	29.4	23.3	4.823	5.131	5.227	5.560	5.444	5.791	5.676	6.037	5.801	6.170	5.881	6.255
6.7	23.9	17.2	6.019	6.403	6.267	6.666	6.454	6.866	6.730	7.160	6.926	7.368	7.072	7.523
6.7	26.7	20.0	5.579	5.935	5.834	6.205	5.992	6.374	6.194	6.589	6.326	6.729	6.420	6.830
6.7	29.4	22.8	4.979	5.297	5.347	5.688	5.548	5.901	5.765	6.133	5.886	6.261	5.965	6.345
7.2	23.9	16.7	6.104	6.493	6.364	6.770	6.565	6.984	6.867	7.305	7.082	7.534	7.243	7.704
7.2	26.7	19.4	5.674	6.036	5.918	6.296	6.077	6.464	6.287	6.688	6.427	6.837	6.529	6.945
7.2	29.4	22.2	5.121	5.448	5.458	5.806	5.644	6.004	5.852	6.225	5.970	6.351	6.049	6.435
7.8	23.9	16.1	6.192	6.587	6.468	6.880	6.687	7.113	7.018	7.465	7.254	7.717	7.430	7.904
7.8	26.7	18.9	5.764	6.131	6.003	6.385	6.164	6.557	6.385	6.792	6.536	6.953	6.647	7.070
7.8	29.4	21.7	5.251	5.585	5.560	5.915	5.735	6.101	5.936	6.315	6.055	6.441	6.136	6.527
8.3	23.9	15.6	6.285	6.686	6.580	7.000	6.819	7.254	7.183	7.641	7.443	7.917	7.636	8.123
8.3	26.7	18.3	5.850	6.223	6.088	6.476	6.255	6.654	6.491	6.905	6.655	7.079	6.776	7.208
8.3	29.4	21.1	5.369	5.711	5.656	6.017	5.823	6.194	6.020	6.404	6.141	6.533	6.225	6.622
8.9	23.9	15.0	6.383	6.790	6.703	7.130	6.965	7.409	7.364	7.834	7.650	8.138	7.863	8.364
8.9	26.7	17.8	5.935	6.313	6.175	6.569	6.351	6.756	6.605	7.027	6.784	7.217	6.917	7.358
8.9	29.4	20.6	5.478	5.827	5.747	6.113	5.908	6.284	6.106	6.495	6.231	6.628	6.320	6.722
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-6 (supersedes Table 6.2.1J in ASHRAE/IESNA Standard 90.1) Column A Minimum Efficiencies for Centrifugal Chillers ≥1055 kW tons, <2108 kW (SI)

full load COP std = 6.106														
			IPLV COP std = 6.406											
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temperature (C)	Entering Condenser Water Temperature (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	6.245	6.552	6.514	6.835	6.689	7.018	6.920	7.260	7.074	7.422	7.186	7.540
4.4	26.7	22.2	5.637	5.914	6.007	6.303	6.212	6.518	6.441	6.758	6.571	6.895	6.658	6.986
4.4	29.4	25.0	4.684	4.915	5.274	5.533	5.588	5.863	5.912	6.203	6.078	6.377	6.179	6.483
5.0	23.9	18.9	6.344	6.656	6.607	6.932	6.785	7.118	7.028	7.374	7.194	7.548	7.316	7.676
5.0	26.7	21.7	5.779	6.063	6.120	6.421	6.313	6.623	6.534	6.855	6.664	6.992	6.753	7.086
5.0	29.4	24.4	4.912	5.154	5.449	5.717	5.735	6.017	6.032	6.329	6.186	6.490	6.281	6.590
5.6	23.9	18.3	6.439	6.756	6.701	7.030	6.885	7.223	7.145	7.496	7.325	7.685	7.458	7.825
5.6	26.7	21.1	5.910	6.200	6.226	6.532	6.409	6.724	6.627	6.953	6.760	7.092	6.852	7.189
5.6	29.4	23.9	5.120	5.372	5.608	5.884	5.869	6.158	6.143	6.445	6.288	6.597	6.378	6.692
6.1	23.9	17.8	6.532	6.853	6.797	7.131	6.991	7.334	7.271	7.628	7.467	7.835	7.613	7.988
6.1	26.7	20.6	6.030	6.326	6.325	6.636	6.502	6.822	6.721	7.051	6.859	7.196	6.956	7.298
6.1	29.4	23.3	5.309	5.570	5.753	6.036	5.992	6.287	6.247	6.554	6.385	6.699	6.473	6.791
6.7	23.9	17.2	6.625	6.951	6.898	7.237	7.104	7.453	7.408	7.772	7.624	7.999	7.784	8.167
6.7	26.7	20.0	6.141	6.443	6.421	6.737	6.595	6.919	6.818	7.153	6.963	7.305	7.067	7.414
6.7	29.4	22.8	5.480	5.750	5.885	6.175	6.106	6.406	6.346	6.658	6.479	6.797	6.565	6.888
7.2	23.9	16.7	6.719	7.049	7.005	7.349	7.227	7.582	7.559	7.930	7.796	8.179	7.972	8.364
7.2	26.7	19.4	6.245	6.552	6.514	6.835	6.689	7.018	6.920	7.260	7.074	7.422	7.186	7.540
7.2	29.4	22.2	5.637	5.914	6.007	6.303	6.212	6.518	6.441	6.758	6.571	6.895	6.658	6.986
7.8	23.9	16.1	6.816	7.151	7.119	7.469	7.360	7.722	7.724	8.104	7.985	8.377	8.178	8.581
7.8	26.7	18.9	6.344	6.656	6.607	6.932	6.785	7.118	7.028	7.374	7.194	7.548	7.316	7.676
7.8	29.4	21.7	5.779	6.063	6.120	6.421	6.313	6.623	6.534	6.855	6.664	6.992	6.753	7.086
8.3	23.9	15.6	6.918	7.258	7.243	7.599	7.506	7.875	7.906	8.295	8.192	8.595	8.405	8.819
8.3	26.7	18.3	6.439	6.756	6.701	7.030	6.885	7.223	7.145	7.496	7.325	7.685	7.458	7.825
8.3	29.4	21.1	5.910	6.200	6.226	6.532	6.409	6.724	6.627	6.953	6.760	7.092	6.852	7.189
8.9	23.9	15.0	7.026	7.371	7.378	7.741	7.666	8.043	8.106	8.505	8.421	8.835	8.654	9.080
8.9	26.7	17.8	6.532	6.853	6.797	7.131	6.991	7.334	7.271	7.628	7.467	7.835	7.613	7.988
8.9	29.4	20.6	6.030	6.326	6.325	6.636	6.502	6.822	6.721	7.051	6.859	7.196	6.956	7.298
Condenser DT[b]			7.80		6.24		5.20		3.90		3.12		2.60	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-7 (supersedes Table 6.2.1K in ASHRAE/IESNA Standard 90.1) Column A Minimum Efficiencies for Centrifugal Chillers ≥2108 kW (SI)

full load COP std = 6.170														
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temperature (C)	Entering Condenser Water Temperature (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	6.311	6.674	6.583	6.961	6.759	7.148	6.993	7.395	7.149	7.560	7.262	7.680
4.4	26.7	22.2	5.696	6.024	6.071	6.420	6.278	6.639	6.509	6.883	6.641	7.022	6.729	7.116
4.4	29.4	25.0	4.734	5.006	5.329	5.636	5.647	5.972	5.974	6.318	6.142	6.495	6.244	6.603
5.0	23.9	18.9	6.411	6.779	6.677	7.061	6.856	7.250	7.102	7.511	7.270	7.688	7.393	7.818
5.0	26.7	21.7	5.840	6.176	6.185	6.540	6.379	6.746	6.603	6.982	6.735	7.122	6.825	7.217
5.0	29.4	24.4	4.964	5.250	5.506	5.823	5.795	6.129	6.095	6.446	6.251	6.610	6.347	6.712
5.6	23.9	18.3	6.507	6.881	6.771	7.161	6.957	7.357	7.220	7.635	7.402	7.828	7.536	7.970
5.6	26.7	21.1	5.972	6.315	6.291	6.653	6.476	6.849	6.696	7.082	6.831	7.224	6.924	7.322
5.6	29.4	23.9	5.174	5.471	5.667	5.993	5.931	6.272	6.208	6.565	6.354	6.719	6.446	6.816
6.1	23.9	17.8	6.601	6.981	6.869	7.264	7.064	7.470	7.347	7.770	7.546	7.980	7.693	8.136
6.1	26.7	20.6	6.093	6.444	6.392	6.759	6.571	6.949	6.792	7.182	6.931	7.329	7.029	7.433
6.1	29.4	23.3	5.365	5.673	5.813	6.148	6.055	6.404	6.313	6.676	6.452	6.823	6.541	6.917
6.7	23.9	17.2	6.695	7.080	6.970	7.371	7.179	7.592	7.486	7.917	7.704	8.147	7.866	8.318
6.7	26.7	20.0	6.206	6.562	6.489	6.862	6.665	7.048	6.890	7.286	7.036	7.441	7.141	7.552
6.7	29.4	22.8	5.538	5.857	5.947	6.289	6.170	6.525	6.413	6.781	6.547	6.923	6.635	7.016
7.2	23.9	16.7	6.790	7.180	7.078	7.485	7.303	7.723	7.638	8.078	7.878	8.331	8.056	8.519
7.2	26.7	19.4	6.311	6.674	6.583	6.961	6.759	7.148	6.993	7.395	7.149	7.560	7.262	7.680
7.2	29.4	22.2	5.696	6.024	6.071	6.420	6.278	6.639	6.509	6.883	6.641	7.022	6.729	7.116
7.8	23.9	16.1	6.888	7.284	7.194	7.608	7.437	7.865	7.805	8.254	8.069	8.533	8.265	8.740
7.8	26.7	18.9	6.411	6.779	6.677	7.061	6.856	7.250	7.102	7.511	7.270	7.688	7.393	7.818
7.8	29.4	21.7	5.840	6.176	6.185	6.540	6.379	6.746	6.603	6.982	6.735	7.122	6.825	7.217
8.3	23.9	15.6	6.991	7.393	7.319	7.740	7.585	8.021	7.989	8.449	8.279	8.755	8.494	8.982
8.3	26.7	18.3	6.507	6.881	6.771	7.161	6.957	7.357	7.220	7.635	7.402	7.828	7.536	7.970
8.3	29.4	21.1	5.972	6.315	6.291	6.653	6.476	6.849	6.696	7.082	6.831	7.224	6.924	7.322
8.9	23.9	15.0	7.100	7.508	7.456	7.884	7.747	8.192	8.191	8.662	8.509	8.999	8.745	9.248
8.9	26.7	17.8	6.601	6.981	6.869	7.264	7.064	7.470	7.347	7.770	7.546	7.980	7.693	8.136
8.9	29.4	20.6	6.093	6.444	6.392	6.759	6.571	6.949	6.792	7.182	6.931	7.329	7.029	7.433
Condenser DT[b]			7.80		6.24		5.20		3.90		3.12		2.60	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-8 (supersedes Table 6.2.1L in ASHRAE/IESNA Standard 90.1) Column B Minimum Efficiencies for Centrifugal Chillers <527kW (SI)

			full load COP std =	5.504				IPLV COP std =	7.816					
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temperature (C)	Entering Condenser Water Temperature (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	5.629	7.994	5.872	8.338	6.029	8.561	6.238	8.857	6.377	9.055	6.478	9.198
4.4	26.7	22.2	5.081	7.215	5.415	7.689	5.600	7.952	5.806	8.244	5.924	8.411	6.002	8.523
4.4	29.4	25.0	4.222	5.996	4.754	6.751	5.037	7.153	5.329	7.568	5.479	7.780	5.570	7.909
5.0	23.9	18.9	5.718	8.120	5.956	8.457	6.116	8.684	6.335	8.996	6.485	9.209	6.595	9.364
5.0	26.7	21.7	5.209	7.397	5.517	7.834	5.690	8.080	5.890	8.363	6.007	8.531	6.088	8.644
5.0	29.4	24.4	4.428	6.288	4.912	6.974	5.170	7.341	5.437	7.721	5.576	7.918	5.662	8.040
5.6	23.9	18.3	5.804	8.242	6.040	8.577	6.206	8.812	6.440	9.145	6.603	9.376	6.723	9.546
5.6	26.7	21.1	5.327	7.564	5.612	7.969	5.777	8.203	5.973	8.482	6.093	8.652	6.176	8.771
5.6	29.4	23.9	4.615	6.554	5.055	7.178	5.290	7.512	5.537	7.863	5.668	8.048	5.750	8.164
6.1	23.9	17.8	5.888	8.361	6.127	8.700	6.301	8.948	6.554	9.306	6.731	9.558	6.863	9.745
6.1	26.7	20.6	5.435	7.718	5.702	8.096	5.861	8.323	6.058	8.603	6.182	8.779	6.270	8.904
6.1	29.4	23.3	4.785	6.795	5.186	7.364	5.401	7.670	5.631	7.996	5.755	8.172	5.835	8.285
6.7	23.9	17.2	5.972	8.480	6.218	8.829	6.404	9.093	6.678	9.482	6.872	9.758	7.017	9.964
6.7	26.7	20.0	5.535	7.860	5.788	8.219	5.945	8.442	6.146	8.727	6.276	8.912	6.370	9.045
6.7	29.4	22.8	4.940	7.015	5.305	7.533	5.504	7.816	5.720	8.123	5.840	8.293	5.918	8.404
7.2	23.9	16.7	6.057	8.600	6.314	8.966	6.514	9.250	6.814	9.675	7.027	9.978	7.186	10.204
7.2	26.7	19.4	5.629	7.994	5.872	8.338	6.029	8.561	6.238	8.857	6.377	9.055	6.478	9.198
7.2	29.4	22.2	5.081	7.215	5.415	7.689	5.600	7.952	5.806	8.244	5.924	8.411	6.002	8.523
7.8	23.9	16.1	6.144	8.725	6.417	9.112	6.634	9.421	6.963	9.887	7.197	10.220	7.372	10.468
7.8	26.7	18.9	5.718	8.120	5.956	8.457	6.116	8.684	6.335	8.996	6.485	9.209	6.595	9.364
7.8	29.4	21.7	5.209	7.397	5.517	7.834	5.690	8.080	5.890	8.363	6.007	8.531	6.088	8.644
8.3	23.9	15.6	6.236	8.855	6.529	9.271	6.766	9.608	7.127	10.120	7.385	10.486	7.577	10.759
8.3	26.7	18.3	5.804	8.242	6.040	8.577	6.206	8.812	6.440	9.145	6.603	9.376	6.723	9.546
8.3	29.4	21.1	5.327	7.564	5.612	7.969	5.777	8.203	5.973	8.482	6.093	8.652	6.176	8.771
8.9	23.9	15.0	6.333	8.993	6.651	9.444	6.910	9.813	7.307	10.376	7.590	10.778	7.801	11.078
8.9	26.7	17.8	5.888	8.361	6.127	8.700	6.301	8.948	6.554	9.306	6.731	9.558	6.863	9.745
8.9	29.4	20.6	5.435	7.718	5.702	8.096	5.861	8.323	6.058	8.603	6.182	8.779	6.270	8.904
Condenser DT[b]			7.80		6.24		5.20		3.90		3.12		2.60	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-9 (supersedes Table 6.2.1M in ASHRAE/IESNA Standard 90.1)
Column B Minimum Efficiencies for Centrifugal Chillers ≥527 kW, and <1055 kW (SI)

full load COP std = 5.504														
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temp (C)	Entering Condenser Water Temp (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	5.629	7.994	5.872	8.338	6.029	8.561	6.238	8.857	6.377	9.055	6.478	9.198
4.4	26.7	22.2	5.081	7.215	5.415	7.689	5.600	7.952	5.806	8.244	5.924	8.411	6.002	8.523
4.4	29.4	25.0	4.222	5.996	4.754	6.751	5.037	7.153	5.329	7.568	5.479	7.780	5.570	7.909
5.0	23.9	18.9	5.718	8.120	5.956	8.457	6.116	8.684	6.335	8.996	6.485	9.209	6.595	9.364
5.0	26.7	21.7	5.209	7.397	5.517	7.834	5.690	8.080	5.890	8.363	6.007	8.531	6.088	8.644
5.0	29.4	24.4	4.428	6.288	4.912	6.974	5.170	7.341	5.437	7.721	5.576	7.918	5.662	8.040
5.6	23.9	18.3	5.804	8.242	6.040	8.577	6.206	8.812	6.440	9.145	6.603	9.376	6.723	9.546
5.6	26.7	21.1	5.327	7.564	5.612	7.969	5.777	8.203	5.973	8.482	6.093	8.652	6.176	8.771
5.6	29.4	23.9	4.615	6.554	5.055	7.178	5.290	7.512	5.537	7.863	5.668	8.048	5.750	8.164
6.1	23.9	17.8	5.888	8.361	6.127	8.700	6.301	8.948	6.554	9.306	6.731	9.558	6.863	9.745
6.1	26.7	20.6	5.435	7.718	5.702	8.096	5.861	8.323	6.058	8.603	6.182	8.779	6.270	8.904
6.1	29.4	23.3	4.785	6.795	5.186	7.364	5.401	7.670	5.631	7.996	5.755	8.172	5.835	8.285
6.7	23.9	17.2	5.972	8.480	6.218	8.829	6.404	9.093	6.678	9.482	6.872	9.758	7.017	9.964
6.7	26.7	20.0	5.535	7.860	5.788	8.219	5.945	8.442	6.146	8.727	6.276	8.912	6.370	9.045
6.7	29.4	22.8	4.940	7.015	5.305	7.533	5.504	7.816	5.720	8.123	5.840	8.293	5.918	8.404
7.2	23.9	16.7	6.057	8.600	6.314	8.966	6.514	9.250	6.814	9.675	7.027	9.978	7.186	10.204
7.2	26.7	19.4	5.629	7.994	5.872	8.338	6.029	8.561	6.238	8.857	6.377	9.055	6.478	9.198
7.2	29.4	22.2	5.081	7.215	5.415	7.689	5.600	7.952	5.806	8.244	5.924	8.411	6.002	8.523
7.8	23.9	16.1	6.144	8.725	6.417	9.112	6.634	9.421	6.963	9.887	7.197	10.220	7.372	10.468
7.8	26.7	18.9	5.718	8.120	5.956	8.457	6.116	8.684	6.335	8.996	6.485	9.209	6.595	9.364
7.8	29.4	21.7	5.209	7.397	5.517	7.834	5.690	8.080	5.890	8.363	6.007	8.531	6.088	8.644
8.3	23.9	15.6	6.236	8.855	6.529	9.271	6.766	9.608	7.127	10.120	7.385	10.486	7.577	10.759
8.3	26.7	18.3	5.804	8.242	6.040	8.577	6.206	8.812	6.440	9.145	6.603	9.376	6.723	9.546
8.3	29.4	21.1	5.327	7.564	5.612	7.969	5.777	8.203	5.973	8.482	6.093	8.652	6.176	8.771
8.9	23.9	15.0	6.333	8.993	6.651	9.444	6.910	9.813	7.307	10.376	7.590	10.778	7.801	11.078
8.9	26.7	17.8	5.888	8.361	6.127	8.700	6.301	8.948	6.554	9.306	6.731	9.558	6.863	9.745
8.9	29.4	20.6	5.435	7.718	5.702	8.096	5.861	8.323	6.058	8.603	6.182	8.779	6.270	8.904
Condenser DT[b]			7.80		6.24		5.20		3.90		3.12		2.60	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-10 (supersedes Table 6.2.1N in ASHRAE/IESNA Standard 90.1) Column B Minimum Efficiencies for Centrifugal Chillers ≥1055 kW and < 2108 kW (SI)

full load COP std = 5.862									IPLV COP std = 8.792					
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temperature (C)	Entering Condenser Water Temperature (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	5.995	8.993	6.254	9.381	6.421	9.632	6.643	9.965	6.791	10.187	6.899	10.348
4.4	26.7	22.2	5.411	8.117	5.767	8.651	5.964	8.946	6.183	9.275	6.309	9.463	6.392	9.588
4.4	29.4	25.0	4.497	6.745	5.063	7.594	5.365	8.047	5.676	8.513	5.835	8.752	5.932	8.898
5.0	23.9	18.9	6.090	9.135	6.343	9.514	6.513	9.770	6.747	10.121	6.906	10.360	7.023	10.535
5.0	26.7	21.7	5.548	8.322	5.875	8.813	6.060	9.090	6.273	9.409	6.398	9.597	6.483	9.725
5.0	29.4	24.4	4.716	7.074	5.231	7.846	5.506	8.258	5.791	8.686	5.938	8.908	6.030	9.045
5.6	23.9	18.3	6.181	9.272	6.433	9.649	6.609	9.914	6.859	10.288	7.032	10.548	7.159	10.739
5.6	26.7	21.1	5.673	8.510	5.977	8.965	6.153	9.229	6.362	9.542	6.489	9.734	6.578	9.867
5.6	29.4	23.9	4.915	7.373	5.384	8.075	5.634	8.452	5.897	8.846	6.036	9.054	6.123	9.185
6.1	23.9	17.8	6.271	9.406	6.525	9.788	6.711	10.066	6.980	10.470	7.169	10.753	7.309	10.963
6.1	26.7	20.6	5.788	8.683	6.072	9.108	6.242	9.364	6.452	9.678	6.584	9.876	6.678	10.017
6.1	29.4	23.3	5.096	7.645	5.523	8.284	5.753	8.629	5.997	8.996	6.129	9.194	6.214	9.321
6.7	23.9	17.2	6.360	9.540	6.622	9.933	6.820	10.230	7.112	10.668	7.319	10.978	7.473	11.209
6.7	26.7	20.0	5.895	8.843	6.164	9.246	6.331	9.497	6.545	9.818	6.684	10.026	6.784	10.176
6.7	29.4	22.8	5.261	7.892	5.650	8.475	5.862	8.793	6.092	9.138	6.219	9.329	6.303	9.454
7.2	23.9	16.7	6.450	9.675	6.724	10.087	6.937	10.406	7.256	10.885	7.484	11.226	7.653	11.480
7.2	26.7	19.4	5.995	8.993	6.254	9.381	6.421	9.632	6.643	9.965	6.791	10.187	6.899	10.348
7.2	29.4	22.2	5.411	8.117	5.767	8.651	5.964	8.946	6.183	9.275	6.309	9.463	6.392	9.588
7.8	23.9	16.1	6.543	9.815	6.834	10.251	7.066	10.598	7.415	11.123	7.665	11.498	7.851	11.777
7.8	26.7	18.9	6.090	9.135	6.343	9.514	6.513	9.770	6.747	10.121	6.906	10.360	7.023	10.535
7.8	29.4	21.7	5.548	8.322	5.875	8.813	6.060	9.090	6.273	9.409	6.398	9.597	6.483	9.725
8.3	23.9	15.6	6.641	9.962	6.953	10.430	7.206	10.809	7.590	11.385	7.865	11.797	8.069	12.104
8.3	26.7	18.3	6.181	9.272	6.433	9.649	6.609	9.914	6.859	10.288	7.032	10.548	7.159	10.739
8.3	29.4	21.1	5.673	8.510	5.977	8.965	6.153	9.229	6.362	9.542	6.489	9.734	6.578	9.867
8.9	23.9	15.0	6.745	10.117	7.083	10.624	7.360	11.039	7.782	11.673	8.084	12.126	8.308	12.462
8.9	26.7	17.8	6.271	9.406	6.525	9.788	6.711	10.066	6.980	10.470	7.169	10.753	7.309	10.963
8.9	29.4	20.6	5.788	8.683	6.072	9.108	6.242	9.364	6.452	9.678	6.584	9.876	6.678	10.017
Condenser DT[b]			7.80		6.24		5.20		3.90		3.12		2.60	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-11 (supersedes Table 6.2.1O in ASHRAE/IESNA Standard 90.1) Column B Minimum Efficiencies for Centrifugal Chillers ≥2108 kW (SI)

full load COP std = 5.961									IPLV COP std = 8.792					
			Condenser Flow Rate											
			10.2 l/min-kW		12.7 l/min-kW		15.3 l/min-kW		20.4 l/min-kW		25.5 l/min-kW		30.6 l/min-kW	
Leaving Chilled Water Temperature (C)	Entering Condenser Water Temperature (C)	Lift[a] (F)	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP	FL COP	NPLV COP
4.4	23.9	19.4	6.097	8.993	6.360	9.381	6.530	9.632	6.756	9.965	6.906	10.187	7.016	10.348
4.4	26.7	22.2	5.503	8.117	5.865	8.651	6.065	8.946	6.288	9.275	6.415	9.463	6.500	9.588
4.4	29.4	25.0	4.573	6.745	5.149	7.594	5.456	8.047	5.772	8.513	5.934	8.752	6.032	8.898
5.0	23.9	18.9	6.193	9.135	6.450	9.514	6.624	9.770	6.861	10.121	7.023	10.360	7.142	10.535
5.0	26.7	21.7	5.642	8.322	5.975	8.813	6.163	9.090	6.379	9.409	6.506	9.597	6.593	9.725
5.0	29.4	24.4	4.796	7.074	5.319	7.846	5.599	8.258	5.889	8.686	6.039	8.908	6.132	9.045
5.6	23.9	18.3	6.286	9.272	6.542	9.649	6.721	9.914	6.975	10.288	7.151	10.548	7.281	10.739
5.6	26.7	21.1	5.769	8.510	6.078	8.965	6.257	9.229	6.469	9.542	6.599	9.734	6.689	9.867
5.6	29.4	23.9	4.998	7.373	5.475	8.075	5.730	8.452	5.997	8.846	6.138	9.054	6.227	9.185
6.1	23.9	17.8	6.377	9.406	6.636	9.788	6.825	10.066	7.098	10.470	7.290	10.753	7.433	10.963
6.1	26.7	20.6	5.887	8.683	6.175	9.108	6.348	9.364	6.561	9.678	6.696	9.876	6.791	10.017
6.1	29.4	23.3	5.183	7.645	5.616	8.284	5.850	8.629	6.099	8.996	6.233	9.194	6.319	9.321
6.7	23.9	17.2	6.468	9.540	6.734	9.933	6.935	10.230	7.232	10.668	7.443	10.978	7.599	11.209
6.7	26.7	20.0	5.995	8.843	6.269	9.246	6.439	9.497	6.656	9.818	6.798	10.026	6.899	10.176
6.7	29.4	22.8	5.350	7.892	5.746	8.475	5.961	8.793	6.195	9.138	6.325	9.329	6.410	9.454
7.2	23.9	16.7	6.560	9.675	6.838	10.087	7.055	10.406	7.379	10.885	7.611	11.226	7.783	11.480
7.2	26.7	19.4	6.097	8.993	6.360	9.381	6.530	9.632	6.756	9.965	6.906	10.187	7.016	10.348
7.2	29.4	22.2	5.503	8.117	5.865	8.651	6.065	8.946	6.288	9.275	6.415	9.463	6.500	9.588
7.8	23.9	16.1	6.654	9.815	6.950	10.251	7.185	10.598	7.541	11.123	7.795	11.498	7.984	11.777
7.8	26.7	18.9	6.193	9.135	6.450	9.514	6.624	9.770	6.861	10.121	7.023	10.360	7.142	10.535
7.8	29.4	21.7	5.642	8.322	5.975	8.813	6.163	9.090	6.379	9.409	6.506	9.597	6.593	9.725
8.3	23.9	15.6	6.754	9.962	7.071	10.430	7.328	10.809	7.718	11.385	7.998	11.797	8.206	12.104
8.3	26.7	18.3	6.286	9.272	6.542	9.649	6.721	9.914	6.975	10.288	7.151	10.548	7.281	10.739
8.3	29.4	21.1	5.769	8.510	6.078	8.965	6.257	9.229	6.469	9.542	6.599	9.734	6.689	9.867
8.9	23.9	15.0	6.859	10.117	7.203	10.624	7.484	11.039	7.914	11.673	8.221	12.126	8.449	12.462
8.9	26.7	17.8	6.377	9.406	6.636	9.788	6.825	10.066	7.098	10.470	7.290	10.753	7.433	10.963
8.9	29.4	20.6	5.887	8.683	6.175	9.108	6.348	9.364	6.561	9.678	6.696	9.876	6.791	10.017
Condenser DT[b]			7.80		6.24		5.20		3.90		3.12		2.60	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (C) - Entering Condenser Water Temperature ©
c All NPLV values shown are NPLV except at conditions of 15.3 L/MIN-Kw Condenser Flow Rate with 6.7°C Leaving Chilled Water Temperature and 29.4 C Entering Condenser Water Temperature which is IPLV
Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = COP * Kadj

Table C-12 (supersedes Table 6.8.1D in 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 (SI)	Test Procedure
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

Table C-12 (supersedes Table 6.8.1D in ASHRAE/IESNA Standard 90.1) (continued)
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 (SI)	Test Procedure
SPVAC (Cooling Mode)	<19 kW	35 C db/23.9 C wb Outdoor Air	3.81 $SCOP_C$	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	3.81 $SCOP_C$	
	≥ 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 12 contains a complete specification of the referenced test procedure, including the referenced 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 40.6 cm high and less than 106.7 cm wide."
c Cap means the rated cooling capacity of the product in Btu/h. If the unit’s capacity is less than 2.05 kW, use 2.05 kW in the calculation. If the unit’s capacity is greater than 4.39 kW, use 4.39 kW in the calculation."

TABLE C-13 (supersedes Table 6.8.1E in 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
Warm Air Furnace, Gas-Fired (Outdoor Installation)	<65.9 kW		DOE 10 CFR Part 430 or ANSI Z21.47	78% AFUE or 80% E_t[d]
	≥65.9 kW	Maximum Capacity[d]	ANSI Z21.47	80% E_c[c]
Warm Air Furnace, Gas-Fired (Indoor Installation)	<65.9 kW		DOE 10 CFR Part 430 or ANSI Z21.47	90% AFUE or 92% E_t[d]
	≥65.9 kW	Maximum Capacity[d]	ANSI Z21.47	92% E_t[f]
Warm Air Furnace, Oil Fired (outdoor installation)	<65.9 kW		DOE 10 CFR Part 430 or UL 727	78% AFUE or 80% E_t[d]
	≥65.9 kW	Maximum Capacity[c]	UL 727	81% E_t[f]
Warm Air Furnace, Oil Fired (indoor installation)	<65.9 kW		DOE 10 CFR Part 430 or UL 727	90% AFUE or 92% E_t[d]
	≥65.9 kW	Maximum Capacity[c]	UL 727	92% E_t[f]
Warm Air duct Furnaces, Gas-Fired (indoor installation)	All Capacities	Maximum Capacity[c]	ANSI Z83.9	90% E_c[g]
Warm Air Unit Heaters, Gas Fired (indoor installation)	All Capacities	Maximum Capacity[c]	ANSI Z83.8	90% E_c[g]
Warm Air Unit Heaters, Oil Fired (indoor installation)	All Capacities	Maximum Capacity[c]	UL 731	90% E_c[g]

a Et = thermal efficiency. See test procedure for detailed discussions
b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure
"c Ec = combustion efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or 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*."
d 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
e Minimum and maximum ratings as provided for and allowed by the unit's controls
"f Et = combustion efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or 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*."
g Ec = combustion efficiency (100% less flue losses) See test procedures for detailed discussion

Table C-14 (supersedes Table 6.8.1F in ASHRAE/IESNA Standard 90.1)
Gas and Oil Fired Boilers - Minimum Efficiency Requirements (SI)

Equipment Type[a]	Size Category (Input)	Subcategory or Rating Condition	Test Procedure[c]	Minimum Efficiency
Boilers, Gas-Fired	<87.9 kW	Hot Water	DOE 10 CFR Part 430	90% E_t
		Steam		89% E_t
	≥87.9 kW and <732.7 kW	Maximum Capacity[d]	DOE 10 CFR Part 431	89% E_t
	>732.7 kW Btu/h[a]	Hot Water		90% E_t
	>732.7 kW Btu/h[a]	Steam		89% E_t
Boilers, Oil-Fired	<300,000 Btu/h		DOE 10 CFR Part 430	90% E_t
	>300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum Capacity[d]	DOE 10 CFR Part 431	90% E_t
	>2,500,000 Btu/h[a]	Hot Water		90% E_t
	>2,500,000 Btu/h[a]	Steam		90% E_t
Oil-Fired (Residual)	>300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum Capacity[d]	DOE 10 CFR Part 431	90% E_t
	>2,500,000 Btu/h[a]	Hot Water		90% E_t
		Steam		90% E_t

"a These requirements apply to boilers with rated input of 2345 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 Et = thermal efficiency. Ec = combustion efficiency. See reference document for detailed information.
c Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
d Minimum and maximum ratings as provided for and allowed by the unit's controls.

Table C-15 (supersedes Table 6.8.1G in 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]	Full Load Maximum Approach [c]
Open loop Propeller or Axial Fan Cooling Towers	All	CTI ATC-105	1% ASHRAE city wb temperature	≥3.38 L/s kW	3.3 C above 1% wb temperature
Closed Loop Propeller or Axial Fan Cooling Towers	All			future	future
Open Loop Centrifugal Fan Cooling Towers	All	CTI ATC-105	1% ASHRAE city wb temperature	≥1.87 L/s kW	3.3 C above 1% wb temperature
Closed Loop Centrifugal Fan Cooling Towers	All			future	future
Air-Cooled Condensers	All	ARI 460		not applicable, air cooled condenser must be matched to the HVAC system and rated per tables C3	

A For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided by the fan nameplate rated motor power.
B For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.
C The approach is the design tower leaving water temperature - the building 1% design wb temperature as per the ASHRAE Handbook requirements

Table C-16 (supersedes Table 6.8.2A in 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	**Heating Ducts Only**						
1, 2	none	none	none	none	none	none	none
3	R-1.06	none	none	none	none	none	none
4	R-1.06	none	none	none	none	none	none
5	R-1.41	R-1.06	none	none	none	none	R-1.06
6	R-1.41	R-1.41	R-1.06	none	none	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	**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	**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 6.4.4.2 or Section 5. 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-17 (supersedes Table 6.8.2B in 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-1.06	none	R-1.06
3	R-1.41	R-1.41	R-1.41	R-1.06	R-1.06	none	R-1.06
4	R-1.41	R-1.41	R-1.41	R-1.06	R-1.06	none	R-1.06
5	R-1.41	R-1.41	R-1.41	R-0.62	R-1.06	none	R-1.06
6	R-1.76	R-1.41	R-1.41	R-0.62	R-1.06	none	R-1.06
7	R-1.76	R-1.41	R-1.41	R-0.62	R-1.06	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 6.4.4.2 or Section 5. 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-18 (supersedes Table 6.8.3 in 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-m2 °K)	Mean Rating Temp. °C	<25	25 to < 38	38 to < 102	38 to <203	≥203
Heating Systems (Steam, Steam Condensate, and Hot Water)b,c							
>176.7	1.82-1.93	121.1	17.0	19.9	19.9	25.6	25.6
121.7-176.7	1.65-1.82	200	11.4	17.0	19.9	19.9	19.9
93.9-121.1	1.53-1.70	150	11.4	11.4	14.2	14.2	14.2
60.6-93.3	1.42-1.65	125	8.5	8.5	8.5	11.4	11.4
40.6-60.0	1.25-1.59	100	5.7	5.7	8.5	8.5	8.5
Domestic and Service Hot Water Systems							
40.6+	1.25-1.59	100	5.7	5.7	8.5	8.5	8.5
Cooling Systems (Chilled Water, Brine, and Refrigerant)d							
4.4-15.6	1.25-1.59	100	5.7	5.7	8.5	8.5	8.5
<4.4	1.25-1.59	100	5.7	8.5	8.5	8.5	11.4

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 (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 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-19 (supersedes Table 7.8 in 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	0.93-0.00132V EF	DOE 10 CFR Part 430
	>12 kW	Resistance ≥ 75.7L	20 + 35 $V^{.5}$ SL, Btu/h	ANSI Z21.10.3
	24 Amps and ≤ 250 volts	Heat Pump	0.93-0.00132V EF	DOE 10 CFR Part 430
Gas Storage Water Heaters	≤75,000 Btu/h	Resistance ≥ 75.7L	0.62-0.0019V EF	DOE 10 CFR Part 430
	>75,000 Btu/h	<310.1 (kW/L)	80% E_t (Q/800 + 110 $V^{.5}$) SL, Btu/h	ANSI Z21.10.3
Gas Instantaneous Water Heaters	>50,000 Btu/h and <2000,000 Btu/h	≥ 310.1 kWQ/L and < 7.56 L	0.62-0.0019V EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h[c]	≥ 310.1 kWQ/L and < 37.8 L	80% E_t	ANSI Z21.10.3
	≥200,000 Btu/h	≥ 310.1 kWQ/L and < 37.8 L	80% E_t (Q/800 + 110 $V^{.5}$) SL, Btu/h	
Oil Storage Water Heaters	≤105,000 Btu/h	Resistance ≥ 75.7L	0.59-0.0019V EF	DOE 10 CFR Part 430
	>105,000 Btu/h	<310.1 (kW/L)	78% Et (Q/800 + 110 $V^{.5}$) SL, Btu/h	ANSI Z21.10.3
Oil Instantaneous Water Heaters	≤ 210,000 Btu/h	≥ 310.1 kWQ/L and < 7.56 L	0.59-0.0019V EF	DOE 10 CFR Part 430
	>210,000 Btu/h	≥ 310.1 kWQ/L and < 37.8 L	80% E_t	ANSI Z21.10.3
	>210,000 Btu/h	≥ 310.1 kWQ/L and < 37.8 L	78% Et (Q/800 + 110 $V^{.5}$) SL, Btu/h	
Hot Water Supply Boilers, Gas and Oil	300,000 Btu/h and <12,500,000 Btu/h	≥ 310.1 kWQ/L and < 37.8 L	80% E_t	ANSI Z21.10.3
Hot Water Supply Boilers, Gas		≥ 310.1 kWQ/L and < 37.8 L	80% E_t (Q/800 + 110 $V^{.5}$) SL, Btu/h	
Hot Water Supply Boilers, Oil		≥ 310.1 kWQ/L and < 37.8 L	78% Et (Q/800 + 110 $V^{.5}$) SL, Btu/h	
Pool Heaters OIl and Gas	All		78% E_t	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 kW 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 12 contains a complete specification, including the year version, of the referenced test procedure.

c Instantaneous water heaters with input rates below 58.6 kW must comply with these requirements if the water heater is
designed to heat water to temperatures 82.2°C or higher."

TABLE C-20 Minimum Nominal Efficiency for General Purpose Design A and Design B Motors[a] (SI)

	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 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-21 – Transformer Minimum Efficiences (SI)

ASHRAE 189				
Rated Capacity (kVA)	**Low Voltage**	**Medium Voltage**		
		Dry		**Liquid**
		≤60 kV BIL	**>60 kV BIL**	
Single Phase				
10	--	--		98.4
15	97.7	97.6	97.6	98.6
25	98.0	97.9	97.9	98.7
37.5	98.2	98.1	98.1	98.8
50	98.3	98.2	98.2	98.9
75	98.5	98.4	98.4	99.0
100	98.6	98.5	98.5	99.0
167	98.7	98.8	98.7	99.1
250	98.8	98.9	98.8	99.2
333	98.9	99.0	98.9	99.2
500	--	99.1	99.0	99.3
667	--	99.2	99.0	99.4
833	--	99.2	99.1	99.4
3 Phase				
15	97.0	96.8	96.8	98.1
30	97.5	97.3	97.3	98.4
45	97.7	97.6	97.6	98.6
75	98.0	97.9	97.9	98.7
112.5	98.2	98.1	98.1	98.8
150	98.3	98.2	98.2	98.9
225	98.5	98.4	98.4	99.0
300	98.6	98.6	98.5	99.0
500	98.7	98.8	98.7	99.1
750	98.8	98.9	98.8	99.2
1000	98.9	99.0	98.9	99.2
1500	--	99.1	99.0	99.3
2000	--	99.2	99.0	99.4
2500	--	99.2	99.1	99.4

Low Voltage rating temperature = 75 C
Medium Voltage rating temperature = 75 C
Low Voltage% of Nameplate Load = 35%
Medium Voltage % of nameplate load = 50%

Table C-22 Air-Cooled Ice Cube Machine Efficiency Requirements (SI)

Equipment Type	Harvest Rate	Energy Use Limit kWh/mg of ice	Portable Water Use Limit L/mg Ice	Test Procedure
Ice-Cube Marker Head	<450	203.48-0.1697H	≤2084	ARI 810-2003
	≥450	136.68-0.02204H	≤1667	
Remote-Condensing without remote compressor	<1000	177.47-0.00772H	≤2918	
	≥1000	102.29	≤1667	
Remote-Condensing with remote compressor	<934	177.47-0.07716H	≤2084	
	≥934	106.26	≤1667	
Self-Contained	<175	1392.58-3.636H	≤2918[a]	
	≥175	759.67	≤2501[a]	

H = Ice Harvest Rate (lbs kg/day)

Table C-23 Water Cooled Ice Cube Machine Efficiency Requirements (SI)

Equipment Type	Harvest Rate	Energy Use Limit kWh/mg of ice	Portable Water Use Limit gal./100 mg Ice	Test Procedure
Ice-Maker Head	<500	154.7-0.1102H	--	ARI 810-2003
	≥500	113.1-.0.2204H	≤2084	
	≥1436	81.57	≤1667	
Self Contained	<200	233.6-0.3902H	≤2918	
	≥200	155.9	≤2501	

H = Ice Harvest Rate (kg ice/day)

a. All condenser water loops shall be closed loop or remote evaporative condenser systems Once-through cooling is not allowed.

Table C-24 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-25 Commercial Clothes Washers (SI)

Product	MER	WF
All Commercial Clothes Washers	48.6932	30.28

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.

Table C-1 (supersedes Table 6.8.1A in ASHRAE/IESNA Standard 90.1) – Electrical Operated Unitary Air Conditioners and Condensing Units (IP)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency (IP)	Test Procedure
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	ARI 210/240
Through-the-wall Air Cooled	<30,000 Btu/h	All	Split Systems	12.0 SEER	ARI 210/240
			Single Packaged	12.0 SEER	ARI 210/240
Small-Duct High Velocity, Air-Cooled	<65,000 Btu/h	All	Split Systems	10 SEER	ARI 210/240
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	ARI 340/360
	≥135,000 Btu/h and < 240,000 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	ARI 340/360
	≥240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split Systems and Single Package	10.0 EER 10.5 IEER	ARI 340/360
		All other	Split Systems and Single Package	9.8 EER 10.3 IEER	ARI 340/360
	≥760,000 Btu/h	Electric Resistance (or None)	Split Systems and Single Package	9.7 EER 10.2 IEER	ARI 340/360
		All other	Split Systems and Single Package	9.5 EER 10.0 IEER	ARI 340/360

Table C-1 (supersedes Table 6.8.1A in ASHRAE/IESNA Standard 90.1) – Electrical Operated Unitary Air Conditioners and Condensing Units (IP) (continued)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency (IP)	Test Procedure
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	ARI 340/360
	≥135,000 Btu/h and < 240,000 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	ARI 340/360
	≥240,000 Btu/h	Electric Resistance (or None)	Split Systems and Single Package	14.0 EER 14.0 IEER	ARI 340/360
		All other	Split Systems and Single Package	13.8 EER 13.8 IEER	ARI 340/360
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	ARI 365

Table C-2 (supersedes Table 6.8.1B in ASHRAE/IESNA Standard 90.1) – Electrically Operated Unitary and Applied Heat Pumps Minimum Efficiency Requirements (IP)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency (IP)	Test Procedure
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	11.5 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	Electric Resistance (or None)	Split Systems and Single Package	10.0 EER 10.0 IEER	
		All other	Split Systems and Single Package	9.8 EER 9.8 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	

Table C-2 (supersedes Table 6.8.1B in ASHRAE/IESNA Standard 90.1) – Electrically Operated Unitary and Applied Heat Pumps Minimum Efficiency Requirements (IP) (continued)

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Conditions	Minimum Efficiency (IP)	Test Procedure
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 Fwb 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 Fwb 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	

Table C-3 (supersedes Table 6.8.1C in ASHRAE/IESNA Standard 90.1)
Water Chilling Packages – Minimum Efficiency Requirements (IP)

Equipment Type	Size Category	Units	Minimum Efficiency (IP)				Test Procedure
			Path A		Path B		
			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 must 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	<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 Absoprtion Single Effect	All Capacities	COP	0.600[h]	NR	NA	NA	ARI 560
Water-Cooled Absorption Single Effect	All Capacities	COP	0.700[h]	NR	NA	NA	
Absorption Double Effect Indirect-Fired	All Capacities	COP	1.000	1.050	NA	NA	
Absorption Double Effect Direct Fired	All Capacities	COP	1.200	NR	NA	NA	

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 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure
c. Where there is a Column A and Column B requirement either column can be used for compliance, but both the full and IPLV values must be meet
d. Path A is intended for applications where significant operating time is expected at full load and design ambient
e. Path B is intended for applications with significant operating time at part load. All path B machines must be equipped with demand limiting capable controls
f. NA means that this requirement is not applicable and can not be used for compliance
g. NR means that for this category there are no minimum requirements
h. Only can be used in heat recover applications

Table C-4 (supersedes Table 6.2.1H in ASHRAE/IESNA Standard 90.1)
Column A Minimum Efficiencies for Centrifugal Chillers <150 tons (IP)

full load kw/ton std = 0.634														
			Condenser Flow Rate											
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temp.(F)	Entering Cond Water Temp. (F)	Lift[a] (F)	FL kW/Ton	NPLV kW/ton	FL kW/Ton	NPLV kW/ton	FL kW/Ton	NPLV kW/ton	FL kW/Ton	NPLV kW/ton	FL kW/Ton	NPLV kW/ton	FL kW/Ton	NPLV kW/ton
40	75	35	0.620	0.583	0.594	0.559	0.579	0.544	0.559	0.526	0.547	0.514	0.539	0.506
40	80	40	0.687	0.646	0.644	0.606	0.623	0.586	0.601	0.565	0.589	0.554	0.581	0.547
40	85	45	0.826	0.777	0.734	0.690	0.693	0.651	0.655	0.616	0.637	0.599	0.626	0.589
41	75	34	0.610	0.574	0.586	0.551	0.571	0.536	0.551	0.518	0.538	0.506	0.529	0.497
41	80	39	0.670	0.630	0.633	0.595	0.613	0.576	0.592	0.557	0.581	0.546	0.573	0.539
41	85	44	0.788	0.741	0.710	0.668	0.675	0.635	0.642	0.603	0.626	0.588	0.616	0.579
42	75	33	0.601	0.565	0.578	0.543	0.562	0.529	0.542	0.509	0.529	0.497	0.519	0.488
42	80	38	0.655	0.616	0.622	0.585	0.604	0.568	0.584	0.549	0.573	0.538	0.565	0.531
42	85	43	0.756	0.711	0.690	0.649	0.660	0.620	0.630	0.592	0.616	0.579	0.607	0.571
43	75	32	0.593	0.557	0.570	0.535	0.554	0.521	0.532	0.501	0.518	0.487	0.508	0.478
43	80	37	0.642	0.604	0.612	0.575	0.595	0.560	0.576	0.541	0.564	0.531	0.557	0.523
43	85	42	0.729	0.685	0.673	0.633	0.646	0.607	0.620	0.583	0.606	0.570	0.598	0.562
44	75	31	0.584	0.549	0.561	0.528	0.545	0.512	0.523	0.491	0.508	0.477	0.497	0.468
44	80	36	0.630	0.593	0.603	0.567	0.587	0.552	0.568	0.534	0.556	0.523	0.548	0.515
44	85	41	0.706	0.664	0.658	0.618	0.634	0.596	0.610	0.573	0.598	0.562	0.590	0.554
45	75	30	0.576	0.542	0.553	0.520	0.536	0.504	0.512	0.481	0.497	0.467	0.486	0.456
45	80	35	0.620	0.583	0.594	0.559	0.579	0.544	0.559	0.526	0.547	0.514	0.539	0.506
45	85	40	0.687	0.646	0.644	0.606	0.623	0.586	0.601	0.565	0.589	0.554	0.581	0.547
46	75	29	0.568	0.534	0.544	0.511	0.526	0.494	0.501	0.471	0.485	0.456	0.473	0.445
46	80	34	0.610	0.574	0.586	0.551	0.571	0.536	0.551	0.518	0.538	0.506	0.529	0.497
46	85	39	0.670	0.630	0.633	0.595	0.613	0.576	0.592	0.557	0.581	0.546	0.573	0.539
47	75	28	0.560	0.526	0.534	0.502	0.516	0.485	0.490	0.460	0.473	0.444	0.461	0.433
47	80	33	0.601	0.565	0.578	0.543	0.562	0.529	0.542	0.509	0.529	0.497	0.519	0.488
47	85	38	0.655	0.616	0.622	0.585	0.604	0.568	0.584	0.549	0.573	0.538	0.565	0.531
48	75	27	0.551	0.518	0.525	0.493	0.505	0.475	0.478	0.449	0.460	0.432	0.447	0.420
48	80	32	0.593	0.557	0.570	0.535	0.554	0.521	0.532	0.501	0.518	0.487	0.508	0.478
48	85	37	0.642	0.604	0.612	0.575	0.595	0.560	0.576	0.541	0.564	0.531	0.557	0.523
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)
c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = (kw/ton)/Kadj

Table C-5 (supersedes Table 6.2.1I in ASHRAE/IESNA Standard 90.1)
Column A Minimum Efficiencies for Centrifugal Chillers ≥150 tons, <300 tons (IP)

full load kw/ton std =	0.634	IPLV kw/ton std	0.596

			Condenser Flow Rate											
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temp (F)	Entering Cond Water Temp (F)	Lift[a] (F)	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton
40	75	35	0.620	0.583	0.594	0.559	0.579	0.544	0.559	0.526	0.547	0.514	0.539	0.506
40	80	40	0.687	0.646	0.644	0.606	0.623	0.586	0.601	0.565	0.589	0.554	0.581	0.547
40	85	45	0.826	0.777	0.734	0.690	0.693	0.651	0.655	0.616	0.637	0.599	0.626	0.589
41	75	34	0.610	0.574	0.586	0.551	0.571	0.536	0.551	0.518	0.538	0.506	0.529	0.497
41	80	39	0.670	0.630	0.633	0.595	0.613	0.576	0.592	0.557	0.581	0.546	0.573	0.539
41	85	44	0.788	0.741	0.710	0.668	0.675	0.635	0.642	0.603	0.626	0.588	0.616	0.579
42	75	33	0.601	0.565	0.578	0.543	0.562	0.529	0.542	0.509	0.529	0.497	0.519	0.488
42	80	38	0.655	0.616	0.622	0.585	0.604	0.568	0.584	0.549	0.573	0.538	0.565	0.531
42	85	43	0.756	0.711	0.690	0.649	0.660	0.620	0.630	0.592	0.616	0.579	0.607	0.571
43	75	32	0.593	0.557	0.570	0.535	0.554	0.521	0.532	0.501	0.518	0.487	0.508	0.478
43	80	37	0.642	0.604	0.612	0.575	0.595	0.560	0.576	0.541	0.564	0.531	0.557	0.523
43	85	42	0.729	0.685	0.673	0.633	0.646	0.607	0.620	0.583	0.606	0.570	0.598	0.562
44	75	31	0.584	0.549	0.561	0.528	0.545	0.512	0.523	0.491	0.508	0.477	0.497	0.468
44	80	36	0.630	0.593	0.603	0.567	0.587	0.552	0.568	0.534	0.556	0.523	0.548	0.515
44	85	41	0.706	0.664	0.658	0.618	0.634	0.596	0.610	0.573	0.598	0.562	0.590	0.554
45	75	30	0.576	0.542	0.553	0.520	0.536	0.504	0.512	0.481	0.497	0.467	0.486	0.456
45	80	35	0.620	0.583	0.594	0.559	0.579	0.544	0.559	0.526	0.547	0.514	0.539	0.506
45	85	40	0.687	0.646	0.644	0.606	0.623	0.586	0.601	0.565	0.589	0.554	0.581	0.547
46	75	29	0.568	0.534	0.544	0.511	0.526	0.494	0.501	0.471	0.485	0.456	0.473	0.445
46	80	34	0.610	0.574	0.586	0.551	0.571	0.536	0.551	0.518	0.538	0.506	0.529	0.497
46	85	39	0.670	0.630	0.633	0.595	0.613	0.576	0.592	0.557	0.581	0.546	0.573	0.539
47	75	28	0.560	0.526	0.534	0.502	0.516	0.485	0.490	0.460	0.473	0.444	0.461	0.433
47	80	33	0.601	0.565	0.578	0.543	0.562	0.529	0.542	0.509	0.529	0.497	0.519	0.488
47	85	38	0.655	0.616	0.622	0.585	0.604	0.568	0.584	0.549	0.573	0.538	0.565	0.531
48	75	27	0.551	0.518	0.525	0.493	0.505	0.475	0.478	0.449	0.460	0.432	0.447	0.420
48	80	32	0.593	0.557	0.570	0.535	0.554	0.521	0.532	0.501	0.518	0.487	0.508	0.478
48	85	37	0.642	0.604	0.612	0.575	0.595	0.560	0.576	0.541	0.564	0.531	0.557	0.523
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)
c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = (kw/ton)/Kadj

Table C-6 (supersedes Table 6.2.1J in ASHRAE/IESNA Standard 90.1)
Column A Minimum Efficiencies for Centrifugal Chillers >300 tons, <600 tons (IP)

full load kw/ton std = 0.576													
			Condenser Flow Rate										
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temp (F)	Entering Cond Water Temp (F)	Lift[a] (F)	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton
40	75	35	0.563	0.537	0.540	0.515	0.526	0.501	0.508	0.484	0.497	0.474	0.489	0.466
40	80	40	0.624	0.595	0.585	0.558	0.566	0.540	0.546	0.520	0.535	0.510	0.528	0.503
40	85	45	0.751	0.716	0.667	0.636	0.629	0.600	0.595	0.567	0.579	0.552	0.569	0.542
41	75	34	0.554	0.528	0.532	0.507	0.518	0.494	0.500	0.477	0.489	0.466	0.481	0.458
41	80	39	0.609	0.580	0.575	0.548	0.557	0.531	0.538	0.513	0.528	0.503	0.521	0.496
41	85	44	0.716	0.682	0.645	0.615	0.613	0.585	0.583	0.556	0.569	0.542	0.560	0.534
42	75	33	0.546	0.521	0.525	0.500	0.511	0.487	0.492	0.469	0.480	0.458	0.472	0.449
42	80	38	0.595	0.567	0.565	0.538	0.549	0.523	0.531	0.506	0.520	0.496	0.513	0.489
42	85	43	0.687	0.655	0.627	0.598	0.599	0.571	0.573	0.546	0.559	0.533	0.551	0.526
43	75	32	0.538	0.513	0.517	0.493	0.503	0.480	0.484	0.461	0.471	0.449	0.462	0.440
43	80	37	0.583	0.556	0.556	0.530	0.541	0.516	0.523	0.499	0.513	0.489	0.506	0.482
43	85	42	0.662	0.631	0.611	0.583	0.587	0.559	0.563	0.537	0.551	0.525	0.543	0.518
44	75	31	0.531	0.506	0.510	0.486	0.495	0.472	0.475	0.452	0.461	0.440	0.452	0.431
44	80	36	0.573	0.546	0.548	0.522	0.533	0.508	0.516	0.492	0.505	0.481	0.498	0.474
44	85	41	0.642	0.612	0.598	0.570	0.576	0.549	0.554	0.528	0.543	0.517	0.536	0.511
45	75	30	0.523	0.499	0.502	0.479	0.487	0.464	0.465	0.443	0.451	0.430	0.441	0.420
45	80	35	0.563	0.537	0.540	0.515	0.526	0.501	0.508	0.484	0.497	0.474	0.489	0.466
45	85	40	0.624	0.595	0.585	0.558	0.566	0.540	0.546	0.520	0.535	0.510	0.528	0.503
46	75	29	0.516	0.492	0.494	0.471	0.478	0.455	0.455	0.434	0.440	0.420	0.430	0.410
46	80	34	0.554	0.528	0.532	0.507	0.518	0.494	0.500	0.477	0.489	0.466	0.481	0.458
46	85	39	0.609	0.580	0.575	0.548	0.557	0.531	0.538	0.513	0.528	0.503	0.521	0.496
47	75	28	0.508	0.485	0.486	0.463	0.469	0.447	0.445	0.424	0.429	0.409	0.418	0.399
47	80	33	0.546	0.521	0.525	0.500	0.511	0.487	0.492	0.469	0.480	0.458	0.472	0.449
47	85	38	0.595	0.567	0.565	0.538	0.549	0.523	0.531	0.506	0.520	0.496	0.513	0.489
48	75	27	0.501	0.477	0.477	0.454	0.459	0.437	0.434	0.414	0.418	0.398	0.406	0.387
48	80	32	0.538	0.513	0.517	0.493	0.503	0.480	0.484	0.461	0.471	0.449	0.462	0.440
48	85	37	0.583	0.556	0.556	0.530	0.541	0.516	0.523	0.499	0.513	0.489	0.506	0.482
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = (kw/ton)/Kadj

Table C-7 (supersedes Table 6.2.1K in ASHRAE/IESNA Standard 90.1) Column A Minimum Efficiencies for Centrifugal Chillers >600 tons (IP)

full load kw/ton std = 0.570									IPLV kw/ton std = 0.539					
			Condenser Flow Rate											
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temp (F)	Entering Cond Water Temp (F)	Lift[a] (F)	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton
40	75	35	0.557	0.527	0.534	0.505	0.520	0.492	0.503	0.476	0.492	0.465	0.484	0.458
40	80	40	0.617	0.584	0.579	0.548	0.560	0.530	0.540	0.511	0.530	0.501	0.523	0.494
40	85	45	0.743	0.703	0.660	0.624	0.623	0.589	0.589	0.557	0.573	0.541	0.563	0.533
41	75	34	0.549	0.519	0.527	0.498	0.513	0.485	0.495	0.468	0.484	0.457	0.476	0.450
41	80	39	0.602	0.569	0.569	0.538	0.551	0.521	0.533	0.504	0.522	0.494	0.515	0.487
41	85	44	0.708	0.670	0.639	0.604	0.607	0.574	0.577	0.546	0.563	0.532	0.554	0.524
42	75	33	0.541	0.511	0.519	0.491	0.506	0.478	0.487	0.461	0.475	0.449	0.467	0.441
42	80	38	0.589	0.557	0.559	0.529	0.543	0.514	0.525	0.497	0.515	0.487	0.508	0.480
42	85	43	0.680	0.643	0.621	0.587	0.593	0.561	0.567	0.536	0.554	0.523	0.546	0.516
43	75	32	0.533	0.504	0.512	0.484	0.498	0.471	0.479	0.453	0.466	0.441	0.457	0.432
43	80	37	0.577	0.546	0.550	0.520	0.535	0.506	0.518	0.490	0.507	0.480	0.500	0.473
43	85	42	0.656	0.620	0.605	0.572	0.581	0.549	0.557	0.527	0.545	0.515	0.538	0.508
44	75	31	0.525	0.497	0.505	0.477	0.490	0.463	0.470	0.444	0.457	0.432	0.447	0.423
44	80	36	0.567	0.536	0.542	0.513	0.528	0.499	0.510	0.483	0.500	0.473	0.492	0.466
44	85	41	0.635	0.601	0.591	0.559	0.570	0.539	0.548	0.519	0.537	0.508	0.530	0.501
45	75	30	0.518	0.490	0.497	0.470	0.482	0.455	0.460	0.435	0.446	0.422	0.437	0.413
45	80	35	0.557	0.527	0.534	0.505	0.520	0.492	0.503	0.476	0.492	0.465	0.484	0.458
45	85	40	0.617	0.584	0.579	0.548	0.560	0.530	0.540	0.511	0.530	0.501	0.523	0.494
46	75	29	0.511	0.483	0.489	0.462	0.473	0.447	0.451	0.426	0.436	0.412	0.426	0.402
46	80	34	0.549	0.519	0.527	0.498	0.513	0.485	0.495	0.468	0.484	0.457	0.476	0.450
46	85	39	0.602	0.569	0.569	0.538	0.551	0.521	0.533	0.504	0.522	0.494	0.515	0.487
47	75	28	0.503	0.476	0.481	0.454	0.464	0.438	0.440	0.416	0.425	0.402	0.414	0.392
47	80	33	0.541	0.511	0.519	0.491	0.506	0.478	0.487	0.461	0.475	0.449	0.467	0.441
47	85	38	0.589	0.557	0.559	0.529	0.543	0.514	0.525	0.497	0.515	0.487	0.508	0.480
48	75	27	0.495	0.468	0.472	0.446	0.454	0.429	0.429	0.406	0.413	0.391	0.402	0.380
48	80	32	0.533	0.504	0.512	0.484	0.498	0.471	0.479	0.453	0.466	0.441	0.457	0.432
48	85	37	0.577	0.546	0.550	0.520	0.535	0.506	0.518	0.490	0.507	0.480	0.500	0.473
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = (kw/ton)/Kadj

Table C-8 (supersedes Table 6.2.1L in ASHRAE/IESNA Standard 90.1)
Column B Minimum Efficiencies for Centrifugal Chillers <150 tons (IP)

full load kw/ton std = 0.639														
			Condenser Flow Rate											
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temp (F)	Entering Condenser Water Temp (F)	Lift[a] (F)	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton
40	75	35	0.625	0.440	0.599	0.422	0.583	0.411	0.564	0.397	0.552	0.388	0.543	0.382
40	80	40	0.692	0.487	0.649	0.457	0.628	0.442	0.606	0.427	0.594	0.418	0.586	0.413
40	85	45	0.833	0.587	0.740	0.521	0.698	0.492	0.660	0.465	0.642	0.452	0.631	0.445
41	75	34	0.615	0.433	0.591	0.416	0.575	0.405	0.555	0.391	0.542	0.382	0.533	0.376
41	80	39	0.675	0.475	0.638	0.449	0.618	0.435	0.597	0.421	0.585	0.412	0.578	0.407
41	85	44	0.794	0.559	0.716	0.504	0.680	0.479	0.647	0.456	0.631	0.444	0.621	0.437
42	75	33	0.606	0.427	0.582	0.410	0.567	0.399	0.546	0.385	0.533	0.375	0.523	0.368
42	80	38	0.660	0.465	0.627	0.441	0.609	0.429	0.589	0.415	0.577	0.406	0.569	0.401
42	85	43	0.762	0.537	0.696	0.490	0.665	0.468	0.635	0.447	0.621	0.437	0.612	0.431
43	75	32	0.597	0.421	0.574	0.404	0.558	0.393	0.537	0.378	0.523	0.368	0.512	0.361
43	80	37	0.647	0.456	0.617	0.434	0.600	0.423	0.581	0.409	0.569	0.401	0.561	0.395
43	85	42	0.735	0.518	0.678	0.478	0.651	0.459	0.625	0.440	0.611	0.430	0.603	0.425
44	75	31	0.589	0.415	0.566	0.398	0.549	0.387	0.527	0.371	0.512	0.360	0.501	0.353
44	80	36	0.635	0.447	0.608	0.428	0.592	0.417	0.572	0.403	0.560	0.395	0.552	0.389
44	85	41	0.712	0.501	0.663	0.467	0.639	0.450	0.615	0.433	0.602	0.424	0.594	0.419
45	75	30	0.581	0.409	0.557	0.392	0.540	0.380	0.516	0.364	0.500	0.352	0.489	0.345
45	80	35	0.625	0.440	0.599	0.422	0.583	0.411	0.564	0.397	0.552	0.388	0.543	0.382
45	85	40	0.692	0.487	0.649	0.457	0.628	0.442	0.606	0.427	0.594	0.418	0.586	0.413
46	75	29	0.572	0.403	0.548	0.386	0.530	0.373	0.505	0.356	0.489	0.344	0.477	0.336
46	80	34	0.615	0.433	0.591	0.416	0.575	0.405	0.555	0.391	0.542	0.382	0.533	0.376
46	85	39	0.675	0.475	0.638	0.449	0.618	0.435	0.597	0.421	0.585	0.412	0.578	0.407
47	75	28	0.564	0.397	0.539	0.379	0.520	0.366	0.494	0.348	0.476	0.335	0.464	0.327
47	80	33	0.606	0.427	0.582	0.410	0.567	0.399	0.546	0.385	0.533	0.375	0.523	0.368
47	85	38	0.660	0.465	0.627	0.441	0.609	0.429	0.589	0.415	0.577	0.406	0.569	0.401
48	75	27	0.555	0.391	0.529	0.372	0.509	0.358	0.481	0.339	0.463	0.326	0.451	0.317
48	80	32	0.597	0.421	0.574	0.404	0.558	0.393	0.537	0.378	0.523	0.368	0.512	0.361
48	85	37	0.647	0.456	0.617	0.434	0.600	0.423	0.581	0.409	0.569	0.401	0.561	0.395
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)
c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = (kw/ton)/Kadj

Table C-9 (supersedes Table 6.2.1M in ASHRAE/IESNA Standard 90.1)
Column B Minimum Efficiencies for Centrifugal Chillers ≥150 tons, <300 tons (IP)

full load kw/ton std = 0.639 **IPLV kw/ton std = 0.450**

			Condenser Flow Rate											
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temp (F)	Entering Condenser Water Temp (F)	Lift[a] (F)	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton
40	75	35	0.625	0.440	0.599	0.422	0.583	0.411	0.564	0.397	0.552	0.388	0.543	0.382
40	80	40	0.692	0.487	0.649	0.457	0.628	0.442	0.606	0.427	0.594	0.418	0.586	0.413
40	85	45	0.833	0.587	0.740	0.521	0.698	0.492	0.660	0.465	0.642	0.452	0.631	0.445
41	75	34	0.615	0.433	0.591	0.416	0.575	0.405	0.555	0.391	0.542	0.382	0.533	0.376
41	80	39	0.675	0.475	0.638	0.449	0.618	0.435	0.597	0.421	0.585	0.412	0.578	0.407
41	85	44	0.794	0.559	0.716	0.504	0.680	0.479	0.647	0.456	0.631	0.444	0.621	0.437
42	75	33	0.606	0.427	0.582	0.410	0.567	0.399	0.546	0.385	0.533	0.375	0.523	0.368
42	80	38	0.660	0.465	0.627	0.441	0.609	0.429	0.589	0.415	0.577	0.406	0.569	0.401
42	85	43	0.762	0.537	0.696	0.490	0.665	0.468	0.635	0.447	0.621	0.437	0.612	0.431
43	75	32	0.597	0.421	0.574	0.404	0.558	0.393	0.537	0.378	0.523	0.368	0.512	0.361
43	80	37	0.647	0.456	0.617	0.434	0.600	0.423	0.581	0.409	0.569	0.401	0.561	0.395
43	85	42	0.735	0.518	0.678	0.478	0.651	0.459	0.625	0.440	0.611	0.430	0.603	0.425
44	75	31	0.589	0.415	0.566	0.398	0.549	0.387	0.527	0.371	0.512	0.360	0.501	0.353
44	80	36	0.635	0.447	0.608	0.428	0.592	0.417	0.572	0.403	0.560	0.395	0.552	0.389
44	85	41	0.712	0.501	0.663	0.467	0.639	0.450	0.615	0.433	0.602	0.424	0.594	0.419
45	75	30	0.581	0.409	0.557	0.392	0.540	0.380	0.516	0.364	0.500	0.352	0.489	0.345
45	80	35	0.625	0.440	0.599	0.422	0.583	0.411	0.564	0.397	0.552	0.388	0.543	0.382
45	85	40	0.692	0.487	0.649	0.457	0.628	0.442	0.606	0.427	0.594	0.418	0.586	0.413
46	75	29	0.572	0.403	0.548	0.386	0.530	0.373	0.505	0.356	0.489	0.344	0.477	0.336
46	80	34	0.615	0.433	0.591	0.416	0.575	0.405	0.555	0.391	0.542	0.382	0.533	0.376
46	85	39	0.675	0.475	0.638	0.449	0.618	0.435	0.597	0.421	0.585	0.412	0.578	0.407
47	75	28	0.564	0.397	0.539	0.379	0.520	0.366	0.494	0.348	0.476	0.335	0.464	0.327
47	80	33	0.606	0.427	0.582	0.410	0.567	0.399	0.546	0.385	0.533	0.375	0.523	0.368
47	85	38	0.660	0.465	0.627	0.441	0.609	0.429	0.589	0.415	0.577	0.406	0.569	0.401
48	75	27	0.555	0.391	0.529	0.372	0.509	0.358	0.481	0.339	0.463	0.326	0.451	0.317
48	80	32	0.597	0.421	0.574	0.404	0.558	0.393	0.537	0.378	0.523	0.368	0.512	0.361
48	85	37	0.647	0.456	0.617	0.434	0.600	0.423	0.581	0.409	0.569	0.401	0.561	0.395
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)

c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3

where X = Condenser DT + LIFT

kw/tonadj = (kw/ton)/Kadj

Table C-10 (supersedes Table 6.2.1N in ASHRAE/IESNA Standard 90.1)
Column B Minimum Efficiencies for Centrifugal Chillers ≥300 tons, <600 tons (IP)

full load kw/ton std = 0.600													
			IPLV kw/ton std = 0.400										
			Condenser Flow Rate										
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temp (F)	Entering Condenser Water Temp (F)	Lift[a] (F)	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton
40	75	35	0.587	0.391	0.562	0.375	0.548	0.365	0.529	0.353	0.518	0.345	0.510	0.340
40	80	40	0.650	0.433	0.610	0.407	0.590	0.393	0.569	0.379	0.557	0.372	0.550	0.367
40	85	45	0.782	0.521	0.695	0.463	0.656	0.437	0.620	0.413	0.603	0.402	0.593	0.395
41	75	34	0.577	0.385	0.554	0.370	0.540	0.360	0.521	0.348	0.509	0.339	0.501	0.334
41	80	39	0.634	0.423	0.599	0.399	0.580	0.387	0.561	0.374	0.550	0.366	0.542	0.362
41	85	44	0.746	0.497	0.672	0.448	0.639	0.426	0.607	0.405	0.592	0.395	0.583	0.389
42	75	33	0.569	0.379	0.547	0.364	0.532	0.355	0.513	0.342	0.500	0.333	0.491	0.327
42	80	38	0.620	0.413	0.588	0.392	0.572	0.381	0.553	0.369	0.542	0.361	0.535	0.356
42	85	43	0.716	0.477	0.653	0.436	0.624	0.416	0.596	0.398	0.583	0.388	0.574	0.383
43	75	32	0.561	0.374	0.539	0.359	0.524	0.349	0.504	0.336	0.491	0.327	0.481	0.321
43	80	37	0.608	0.405	0.579	0.386	0.563	0.376	0.545	0.363	0.534	0.356	0.527	0.351
43	85	42	0.690	0.460	0.637	0.425	0.611	0.408	0.586	0.391	0.574	0.383	0.566	0.377
44	75	31	0.553	0.369	0.531	0.354	0.516	0.344	0.495	0.330	0.481	0.320	0.471	0.314
44	80	36	0.597	0.398	0.571	0.380	0.555	0.370	0.537	0.358	0.526	0.351	0.518	0.346
44	85	41	0.668	0.446	0.622	0.415	0.600	0.400	0.577	0.385	0.565	0.377	0.558	0.372
45	75	30	0.545	0.364	0.523	0.349	0.507	0.338	0.485	0.323	0.470	0.313	0.460	0.306
45	80	35	0.587	0.391	0.562	0.375	0.548	0.365	0.529	0.353	0.518	0.345	0.510	0.340
45	85	40	0.650	0.433	0.610	0.407	0.590	0.393	0.569	0.379	0.557	0.372	0.550	0.367
46	75	29	0.537	0.358	0.515	0.343	0.498	0.332	0.474	0.316	0.459	0.306	0.448	0.299
46	80	34	0.577	0.385	0.554	0.370	0.540	0.360	0.521	0.348	0.509	0.339	0.501	0.334
46	85	39	0.634	0.423	0.599	0.399	0.580	0.387	0.561	0.374	0.550	0.366	0.542	0.362
47	75	28	0.530	0.353	0.506	0.337	0.488	0.325	0.463	0.309	0.447	0.298	0.436	0.291
47	80	33	0.569	0.379	0.547	0.364	0.532	0.355	0.513	0.342	0.500	0.333	0.491	0.327
47	85	38	0.620	0.413	0.588	0.392	0.572	0.381	0.553	0.369	0.542	0.361	0.535	0.356
48	75	27	0.521	0.348	0.497	0.331	0.478	0.319	0.452	0.301	0.435	0.290	0.423	0.282
48	80	32	0.561	0.374	0.539	0.359	0.524	0.349	0.504	0.336	0.491	0.327	0.481	0.321
48	85	37	0.608	0.405	0.579	0.386	0.563	0.376	0.545	0.363	0.534	0.356	0.527	0.351
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)
c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = (kw/ton)/Kadj

Table C-11 (supersedes Table 6.2.1O in ASHRAE/IESNA Standard 90.1) Column B Minimum Efficiencies for Centrifugal Chillers ≥600 tons (IP)

full load kw/ton std = 0.590														
			IPLV kw/ton std 0.400											
			Condenser Flow Rate											
			2 gpm/ton		2.5 gpm/ton		3 gpm/ton		4 gpm/ton		5 gpm/ton		6 gpm/ton	
Leaving Chilled Water Temperature (F)	Entering Con-denser Water Temperature (F)	Lift[a] (F)	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton	FL kW/Ton	IPLV kW/ton
40	75	35	0.577	0.391	0.553	0.375	0.539	0.365	0.521	0.353	0.509	0.345	0.501	0.340
40	80	40	0.639	0.433	0.600	0.407	0.580	0.393	0.559	0.379	0.548	0.372	0.541	0.367
40	85	45	0.769	0.521	0.683	0.463	0.645	0.437	0.609	0.413	0.593	0.402	0.583	0.395
41	75	34	0.568	0.385	0.545	0.370	0.531	0.360	0.513	0.348	0.501	0.339	0.492	0.334
41	80	39	0.623	0.423	0.589	0.399	0.571	0.387	0.551	0.374	0.541	0.366	0.533	0.362
41	85	44	0.733	0.497	0.661	0.448	0.628	0.426	0.597	0.405	0.582	0.395	0.574	0.389
42	75	33	0.559	0.379	0.538	0.364	0.523	0.355	0.504	0.342	0.492	0.333	0.483	0.327
42	80	38	0.610	0.413	0.579	0.392	0.562	0.381	0.544	0.369	0.533	0.361	0.526	0.356
42	85	43	0.704	0.477	0.642	0.436	0.614	0.416	0.586	0.398	0.573	0.388	0.565	0.383
43	75	32	0.552	0.374	0.530	0.359	0.515	0.349	0.495	0.336	0.482	0.327	0.473	0.321
43	80	37	0.597	0.405	0.570	0.386	0.554	0.376	0.536	0.363	0.525	0.356	0.518	0.351
43	85	42	0.679	0.460	0.626	0.425	0.601	0.408	0.577	0.391	0.564	0.383	0.557	0.377
44	75	31	0.544	0.369	0.522	0.354	0.507	0.344	0.486	0.330	0.473	0.320	0.463	0.314
44	80	36	0.587	0.398	0.561	0.380	0.546	0.370	0.528	0.358	0.517	0.351	0.510	0.346
44	85	41	0.657	0.446	0.612	0.415	0.590	0.400	0.568	0.385	0.556	0.377	0.549	0.372
45	75	30	0.536	0.364	0.514	0.349	0.499	0.338	0.477	0.323	0.462	0.313	0.452	0.306
45	80	35	0.577	0.391	0.553	0.375	0.539	0.365	0.521	0.353	0.509	0.345	0.501	0.340
45	85	40	0.639	0.433	0.600	0.407	0.580	0.393	0.559	0.379	0.548	0.372	0.541	0.367
46	75	29	0.529	0.358	0.506	0.343	0.489	0.332	0.466	0.316	0.451	0.306	0.440	0.299
46	80	34	0.568	0.385	0.545	0.370	0.531	0.360	0.513	0.348	0.501	0.339	0.492	0.334
46	85	39	0.623	0.423	0.589	0.399	0.571	0.387	0.551	0.374	0.541	0.366	0.533	0.362
47	75	28	0.521	0.353	0.497	0.337	0.480	0.325	0.456	0.309	0.440	0.298	0.429	0.291
47	80	33	0.559	0.379	0.538	0.364	0.523	0.355	0.504	0.342	0.492	0.333	0.483	0.327
47	85	38	0.610	0.413	0.579	0.392	0.562	0.381	0.544	0.369	0.533	0.361	0.526	0.356
48	75	27	0.513	0.348	0.488	0.331	0.470	0.319	0.444	0.301	0.428	0.290	0.416	0.282
48	80	32	0.552	0.374	0.530	0.359	0.515	0.349	0.495	0.336	0.482	0.327	0.473	0.321
48	85	37	0.597	0.405	0.570	0.386	0.554	0.376	0.536	0.363	0.525	0.356	0.518	0.351
Condenser DT[b]			14.04		11.23		9.36		7.02		5.62		4.68	

a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature
b Condenser DT = Leaving Condenser Water Temperature (°F) - Entering Condenser Water Temperature (°F)
c All NPLV values shown are NPLV except at conditions of 3 gpm/ton Condenser Flow Rate with 44°F Leaving Chilled Water Temperature and 85°F Entering Condenser Water Temperature which is IPLV

Kadj = 6.17568 - 0.303668(X) + 0.00629466(X)2 - 0.000045780(X)3
where X = Condenser DT + LIFT
kw/tonadj = (kw/ton)/Kadj

Table C-12 (supersedes Table 6.8.1D in 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 (IP)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency (IP)	Test Procedure
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

Table C-12 (supersedes Table 6.8.1D in ASHRAE/IESNA Standard 90.1) (continued) 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 (IP)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency (IP)	Test Procedure
SPVAC (Cooling Mode)	<65,000 Btu/h	95 F db/75 F wb Outdoor Air	13.0 SEER	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	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	95 F db/75 F wb Outdoor Air	11.5 EER	
	≥135,000 Btu/hr 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/hr 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 12 contains a complete specification of the referenced test procedure, including the referenced 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."

c Cap means the rated cooling capacity of the product in Btu/h. If the unit’s capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit’s capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation."

TABLE C-13 (supersedes Table 6.8.1E in ASHRAE/IESNA Standard 90.1)
Warm Air Furnace and Combustion Warm Air Furnaces/Air Conditioning Units, Warm Air Duct Furnaces and Unit Heaters (IP)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Test Procedure[b]	Minimum Efficiency
Warm Air Furnace, Gas-Fired (Outdoor Installation)	<225,000 Btu/h		DOE 10 CFR Part 430 or ANSI Z21.47	78% AFUE or 80% E_t[d]
	≥225,000 Btu/h	Maximum Capacity[d]	ANSI Z21.47	80% E_c[c]
Warm Air Furnace, Gas-Fired (Indoor Installation)	<225,000 Btu/h		DOE 10 CFR Part 430 or ANSI Z21.47	90% AFUE or 92% E_t[d]
	≥225,000 Btu/h	Maximum Capacity[d]	ANSI Z21.47	92% E_t[f]
Warm Air Furnace, Oil Fired (outdoor installation)	<225,000 Btu/h		DOE 10 CFR Part 430 or UL 727	78% AFUE or 80% E_t[d]
	≥225,000 Btu/h	Maximum Capacity[c]	UL 727	81% E_t[f]
Warm Air Furnace, Oil Fired (indoor installation)	<225,000 Btu/h		DOE 10 CFR Part 430 or UL 727	90% AFUE or 92% E_t[d]
	≥225,000 Btu/h	Maximum Capacity[c]	UL 727	92% E_t[f]
Warm Air duct Furnaces, Gas-Fired (indoor installation)	All Capacities	Maximum Capacity[c]	ANSI Z83.9	90% E_c[g]
Warm Air Unit Heaters, Gas Fired (indoor installation)	All Capacities	Maximum Capacity[c]	ANSI Z83.8	90% E_c[g]
Warm Air Unit Heaters, Oil Fired (indoor installation)	All Capacities	Maximum Capacity[c]	UL 731	90% E_c[g]

a Et = thermal efficiency. See test procedure for detailed discussions
b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure
c Ec = combustion efficiency. 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*.
d 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
e Minimum and maximum ratings as provided for and allowed by the unit's controls
f Et = combustion efficiency. 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*.
g Ec = combustion efficiency (100% less flue losses) See test procedures for detailed discussion

Table C-14 (supersedes Table 6.8.1F in ASHRAE/IESNA Standard 90.1)
Gas and Oil Fired Boilers - Minimum Efficiency Requirements (IP)

Equipment Type[a]	Size Category (Input)	Subcategory or Rating Condition	Test Procedure	Minimum Efficiency
Boilers, Gas-Fired	<300,000 Btu/h	Hot Water	DOE 10 CFR Part 430	90% E_t
		Steam		89% E_t
	≥300,000 Btu/h and <2,500,000 Btu/h	Maximum Capacity[d]	DOE 10 CFR Part 431	89% E_t
	>2,500,000 Btu/h[a]	Hot Water		90% E_t
	>2,500,000 Btu/h[a]	Steam		89% E_t
Boilers, Oil-Fired	<300,000 Btu/h		DOE 10 CFR Part 430	90% E_t
	>300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum Capacity[d]	DOE 10 CFR Part 431	90% E_t
	>2,500,000 Btu/h[a]	Hot Water		90% E_t
	>2,500,000 Btu/h[a]	Steam		90% E_t
Oil-Fired (Residual)	>300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum Capacity[d]	DOE 10 CFR Part 431	90% E_t
	>2,500,000 Btu/h[a]	Hot Water		90% E_t
		Steam		90% 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 Et = thermal efficiency. Ec = combustion efficiency. See reference document for detailed information.
c Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
d Minimum and maximum ratings as provided for and allowed by the unit's controls.

Table C-15 (supersedes Table 6.8.1G in ASHRAE/IESNA Standard 90.1)
Performance Requirements for Heat Rejection Equipment (IP)

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Rating Standard	Rating Conditions	Performance Required[a,b]	Full Load Maximum Approach [c]
Open loop Propeller or Axial Fan Cooling Towers	All	CTI ATC-105	1% ASHRAE city wb temperature	≥40 gpm/hp	6 F above 1% wb temperature
Closed Loop Propeller or Axial Fan Cooling Towers	All			future	future
Open Loop Centrifugal Fan Cooling Towers	All	CTI ATC-105	1% ASHRAE city wb temperature	≥22.0 gpm/hp	6 F above 1% wb temperature
Closed Loop Centrifugal Fan Cooling Towers	All			future	future
Air-Cooled Condensers	All	ARI 460		not applicable, air cooled condenser must be matched to the HVAC system and rated per tables C3	

A For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided by the fan nameplate rated motor power.
B For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.
C The approach is the design tower leaving water temperature - the building 1% design wb temperature as per the ASHRAE Handbook requirements

Table C-16 (supersedes Table 6.8.2A in ASHRAE/IESNA Standard 90.1)
Minimum Duct Insulation R-Value[a]
Cooling and Heating Only Supply Ducts and Return Ducts (IP)

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	Heating Ducts Only						
1, 2	none	none	none	none	none	none	none
3	R-6	none	none	none	none	none	none
4	R.6	none	none	none	none	none	none
5	R-8	R-6	none	none	none	none	R-6
6	R-8	R-8	R-6	none	none	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	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	Return Ducts						
1 to 8	R-6	R-6	R-6	none	none	none	none

a Insulation R-values, measured in (h·ft2·°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 6.4.4.2 or Section 5. 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-17 (supersedes Table 6.8.2B in ASHRAE/IESNA Standard 90.1)
Minimum Duct Insulation R-Value[a],
Combined Heating and Cooling Supply Ducts and Return Ducts (IP)

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-6	none	R-6
3	R-8	R-8	R-8	R-6	R-6	none	R-6
4	R-8	R-8	R-8	R-6	R-6	none	R-6
5	R-8	R-8	R-8	R-3.5	R-6	none	R-6
6	R-10	R-8	R-8	R-3.5	R-6	none	R-6
7	R-10	R-8	R-8	R-3.5	R-6	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·ft2·°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 6.4.4.2 or Section 5. 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-18 (supersedes Table 6.8.3 in ASHRAE/IESNA Standard 90.1)
Minimum Pipe Insulation Thickness[a] (IP)

Fluid Design Operating Temp. Range (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
	Conductivity Btu·in./(h·ft2·°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-19 (supersedes Table 7.8 in ASHRAE/IESNA Standard 90.1)
Performance Requirements for Water Heating Equipment (IP)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required [a]	Test Procedure [b]
Electric Water Heaters	12 kW	Resistance ≥ 20 gal	0.93-0.00132V EF	DOE 10 CFR Part 430
	>12 kW	Resistance ≥ 20 gal	20 + 35 $V^{.5}$ SL, Btu/h	ANSI Z21.10.3
	24 Amps and ≤ 250 volts	Heat Pump	0.93-0.00132V EF	DOE 10 CFR Part 430
Gas Storage Water Heaters	≤75,000 Btu/h	≥20 gal	0.62-0.0019V EF	DOE 10 CFR Part 430
	>75,000 Btu/h	<4000 (Btu/h)/gal	80% E_t (Q/800 + 110 $V^{.5}$) SL, Btu/h	ANSI Z21.10.3
Gas Instantaneous Water Heaters	>50,000 Btu/h and <2000,000 Btu/h	≥ 4000 (Btu/h)/gal and < 2 gal	0.62-0.0019V EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h[c]	≥ 4000 (Btu/h)/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥200,000 Btu/h	4000 (Btu/h)/gal and ≥ 10 gal	80% E_t (Q/800 + 110 $V^{.5}$) SL, Btu/h	
Oil Storage Water Heaters	≤105,000 Btu/h	≥ 20 gal	0.59-0.0019V EF	DOE 10 CFR Part 430
	>105,000 Btu/h	<4000 (Btu/h)/gal	78% Et (Q/800 + 110 $V^{.5}$) SL, Btu/h	ANSI Z21.10.3
Oil Instantaneous Water Heaters	≤ 210,000 Btu/h	≥ 4000 (Btu/h)/gal and < 2 gal	0.59-0.0019V EF	DOE 10 CFR Part 430
	>210,000 Btu/h	≥ 4000 (Btu/h)/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	>210,000 Btu/h	≥ 4000 (Btu/h)/gal and ≥ 10 gal	78% Et (Q/800 + 110 $V^{.5}$) SL, 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	80% E_t	ANSI Z21.10.3
Hot Water Supply Boilers, Gas		≥ 4000 (Btu/h)/gal and ≥ 10 gal	80% E_t (Q/800 + 110 $V^{.5}$) SL, Btu/h	
Hot Water Supply Boilers, Oil		≥ 4000 (Btu/h)/gal and ≥ 10 gal	78% Et (Q/800 + 110 $V^{.5}$) SL, Btu/h	
Pool Heaters Oil and Gas	All		78% E_t	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 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 12 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-20 Minimum Nominal Efficiency for General Purpose Design A and Design B Motors[a] (IP)

	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-21 – Transformer Minimum Efficiences (IP)

ASHRAE 189				
Rated Capacity (kVA)	**Low Voltage**	**Medium Voltage**		
		Dry		**Liquid**
		≤60 kV BIL	**>60 kV BIL**	
Single Phase				
10	--	--		98.4
15	97.7	97.6	97.6	98.6
25	98.0	97.9	97.9	98.7
37.5	98.2	98.1	98.1	98.8
50	98.3	98.2	98.2	98.9
75	98.5	98.4	98.4	99.0
100	98.6	98.5	98.5	99.0
167	98.7	98.8	98.7	99.1
250	98.8	98.9	98.8	99.2
333	98.9	99.0	98.9	99.2
500	--	99.1	99.0	99.3
667	--	99.2	99.0	99.4
833	--	99.2	99.1	99.4
3 Phase				
15	97.0	96.8	96.8	98.1
30	97.5	97.3	97.3	98.4
45	97.7	97.6	97.6	98.6
75	98.0	97.9	97.9	98.7
112.5	98.2	98.1	98.1	98.8
150	98.3	98.2	98.2	98.9
225	98.5	98.4	98.4	99.0
300	98.6	98.6	98.5	99.0
500	98.7	98.8	98.7	99.1
750	98.8	98.9	98.8	99.2
1000	98.9	99.0	98.9	99.2
1500	--	99.1	99.0	99.3
2000	--	99.2	99.0	99.4
2500	--	99.2	99.1	99.4

Low Voltage rating temperature = 167 F
Medium Voltage rating temperature = 167 F
Low Voltage% of Nameplate Load = 35%
Medium Voltage % of nameplate load = 50%

Table C-22 Air-Cooled Ice Cube Machine Efficiency Requirements (IP)

Equipment Type	Harvest Rate	Energy Use Limit kWh/100lbs of ice	Portable Water Use Limit gal./100 lbs Ice	Test Procedure
Ice-Cube Marker Head	<450	9.23-.0077H	≤25	ARI 810-2003
	≥450	6.20-.0010H	≤20	
Remote-Condensing without remote compressor	<1000	8.05-.00035H	≤25	
	≥1000	4.64	≤20	
Remote-Condensing with remote compressor	<934	8.05-.0035H	≤25	
	≥934	4.82	≤20	
Self-Contained	<175	16.7-0.0436H	≤35[a]	
	≥175	9.11	≤30[a]	

H = Ice Harvest Rate (lbs ice/day)

Table C-23 Water Cooled Ice Cube Machine Efficiency Requirements (IP)

Equipment Type	Harvest Rate	Energy Use Limit kWh/100lbs of ice	Portable Water Use Limit gal./100 lbs Ice	Test Procedure
Ice-Maker Head	<500	7.02-0.005H	--	ARI 810-2003
	≥500	5.13-0.0010H	≤25	
	≥1436	3.7	≤20	
Self Contained	<200	10.6-0.0177H	≤35	
	≥200	7.07	≤30	

H = Ice Harvest Rate (lbs ice/day)

a. All condenser water loops shall be closed loop or remote evaporative condenser systems Once-through cooling is not allowed.

Table C-24 Commercial Refrigerator & Freezers (IP)

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-25 Commercial Clothes Washers (IP)

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.

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

NORMATIVE APPENDIX D

PERFORMANCE OPTION FOR ENERGY EFFICIENCY

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 ASHRAE/IESNA Standard 90.1 and Appendix G of ASHRAE/IESNA Standard 90.1. This appendix offers an alternative to 7.4 for compliance with ASHRAE/USGBC/IESNA Standard 189. Also, it is provided for those wishing to use the methodology developed for this standard to quantify performance that substantially exceeds the requirements of ASHRAE/USGBC/IESNA Standard 189. 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:

- All requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 of ASHRAE/IESNA Standard 90.1 and 7.3 are complied with. These sections contain the mandatory provisions of the standard, and are prerequisites.
- The proposed design shall only vary from requirements in 7.4 where those variations have been accurately and completely modeled. Where variations are not specifically analyzed (e.g. the requirements in 7.4.3(n) for pipe insulation), the proposed design shall comply with those requirements.
- The improved performance of the proposed building design is calculated in accordance with provisions of this appendix using the following formula:

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 ASHRAE/IESNA Standard 90.1 and 7.4.

D1.4 Documentation Requirements. Simulated performance shall be documented, and documentation shall be submitted to the *authority having jurisdiction*. 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 power 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:

- the same simulation program,
- the same weather data, and
- 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. (Informative Note: See examples such as EnergyPlus, or its predecessor programs DOE-2 or BLAST, listed in Informative Appendix F.) 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 *authority having jurisdiction*

and shall, at a minimum, have the ability to explicitly model all of the following:

a. 8,760 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. *on-site renewable energy power systems*;

i. baseline building design characteristics specified in 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. (Informative note: See examples such as the ASHRAE Handbook - Fundamentals listed in Informative Appendix F.)

D2.2.4 The simulation program shall be tested according to 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 *authority having jurisdiction*.

D2.4 Energy Rates. Annual energy costs shall be determined using either actual rates for purchased energy or state average energy prices published by USDOE's Energy Information Administration (EIA) 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 to D2.4: On-site renewable energy sources or site-recovered energy shall not be considered to be purchased energy and shall not be included in the proposed building performance. Where on-site renewable or site-recovered sources are used, the baseline building performance 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 *authority having jurisdiction* 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 and shall not be less stringent than the requirements in 7.3 and 7.4.

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 to D3.1.1:

a. Use additional system type(s) for non-predominant conditions (i.e., residential/nonresidential or heating source) if those conditions apply to more than 2,000 m^2 (20,000 ft^2) of conditioned floor area.

b. 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 30 W/m^2 (10 Btu/h-ft^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.

c. 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.

d. For laboratory spaces with a minimum of 2,500 L/s (5,000 cfm) 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.

D3.1.2 General Baseline HVAC System Requirements. HVAC systems in the baseline building design shall conform with 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 7.4.3(b). 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 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 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
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 *authority having jurisdiction*. **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:** a. 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. b. 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 nonstandard efficiency measures for those cases where the measures exceed the requirements in this standard, provided that the revised schedules have the approval of the *authority having jurisdiction*. 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 9.3.1, demand control ventilation 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, 7.3.2, and 7.4.4.

TABLE D3.1 *(Continued)* 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. a. 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: 1. Separate model of each of these assemblies within the energy simulation model. 2. 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. b. 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. c. For exterior roofs, the roof surface may 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. d. 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 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 solar heat gain coefficient* (SHGC) shall match the appropriate requirements in Tables A-1 through A-8 using the value for $SHGC_{all.}$ provided that the *vertical fenestration* complies with 7.4.3(i). If not, then the SHGC for west-facing and east-facing *fenestration* shall be uniformly reduced until the *vertical fenestration* complies with 7.4.3(i). 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 9.4.1. 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 7.4.3(e). 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 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 9.3.7. 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 9.3.7(b). **(e) Roof albedo.** Those *roof* surfaces subject to 5.3.3.3 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 *(Continued)* Modeling Requirements for Calculating Proposed and Baseline Building Performance

No.	Proposed Building Performance	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 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:** 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, 9.3.7, and 9.4.1 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 *authority having jurisdiction*. g. For automatic lighting controls in addition to those required for minimum code compliance under Section 9.2 of ASHRAE/IESNA Standard 90.1 and 7.4.6, 9.3.7, and 9.4.1, 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 *authority having jurisdiction*.	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 ASHRAE/IESNA Standard 90.1 and 7.4.6. Automatic lighting controls shall be modeled in accordance with 7.4.3(p) 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: a. The space use classification is the same throughout the thermal block. b. 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. c. 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 *(Continued)* Modeling Requirements for Calculating Proposed and Baseline Building Performance

No.	Proposed Building Performance	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 4.5 m (15 ft) from an exterior wall. Perimeter spaces shall be those located within 4.5 m (15 ft) 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 4.5 m (15 ft) or less from a glazed perimeter wall, except that floor area within 4.5 m (15 ft) of glazed perimeter walls having more than one orientation shall be divided proportionately between zones. c. Separate *thermal blocks* shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features. d. Separate *thermal blocks* shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.	Same as Proposed Design.
9.	**Thermal Blocks - Multifamily Residential Buildings** Residential spaces shall be modeled using at least one thermal block per 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(b) 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. d. 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 *(Continued)* 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. d. 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 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(b) and (c). 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(b) and (c) 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 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:** If a condenser heat recovery system complying with the requirements described in Section 6.5.6.2 of 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 ASHRAE/IESNA Standard 90.1. **Exceptions:** 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 *(Continued)* 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 *authority having jurisdiction*. 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 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 ASHRAE/IESNA Standard 90.1 and in 6.3.2, 6.4.2, 7.3.2, 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 *authority having jurisdiction* 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.

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 3 Floors or Less and < 2,500 m^2 (25,000 ft^2)	System 3 – PSZ-AC	System 4 – PSZ-HP
Nonresidential & 4 or 5 Floors and <2,500 m^2 (25,000 ft^2) or 5 Floors or Less and 7,500 m^2 to 15,000 m^2 (75,000 ft^2 to 150,000 ft^2)	System 5 - Packaged VAV w/ Reheat	System 6 - Packaged VAV w/PFP Boxes
Nonresidential and More than 5 Floors or >15,000 m^2 (150,000 ft^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 2,500 L/s (5000 cfm) 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 variable air volume with reheat	VAV	Direct Expansion	Hot Water Fossil Fuel Boiler
6. Packaged VAV w/PFP Boxes	Packaged rooftop variable air volume with reheat	VAV	Direct Expansion	Electric Resistance
7. VAV w/Reheat	Packaged rooftop variable air volume with reheat	VAV	Chilled Water	Hot Water Fossil Fuel Boiler
8. VAV w/PFP Boxes	Variable air volume with reheat	VAV	Chilled Water	Electric Resistance

Note: Reheat shall not exceed that specified in 7.4.3(g).

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 8,760 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 *authority having jurisdiction* 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 9.3.1.

Exception to D3.1.2.5: When modeling demand-control ventilation in the proposed design when its use is not required by 7.4.3(d).

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 7.4.3(f) and Table 7.4.3-1 and the total capacity of all systems without economizers in the *building project* does not exceed that specified in footnote a to Table 7.4.3-1. If an economizer is not required by 7.4.3(f) and Table 7.4.3-1 including footnote a, outdoor air economizers shall not be included in baseline HVAC Systems 1 and 2. If an economizer is not required by 7.4.3(f) and Table 7.4.3-1 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 to D3.1.2.6: Economizers shall not be included for systems complying with one or more of the exceptions listed below.

a. Systems that include gas-phase air cleaning to comply with the requirements of Section 6.1.2 of ANSI/ASHRAE Standard 62. This exception shall be used only if the system in the proposed design does not match building design.

b. 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.

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.

D3.1.2.7 Economizer High-Limit Shutoff. The high-limit shutoff shall be a dry-bulb switch with setpoint temperatures in accordance with the values in Table D3.1.2.7.

TABLE D3.1.2.7 Economizer High-Limit Shutoff

Climate Zone	High-Limit Shutoff
1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	75°F
5A, 6A, 7A	70°F
Others	65°F

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 11 C (20°F). 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 Supply Fan Power. System fan electrical power for supply, return, exhaust, and relief (excluding power to fan-powered VAV boxes) shall be calculated using the following formulas:

For Systems 1 and 2,

$$P_{fan} = CFM_S \cdot 0.3$$

For systems 3 through 8,

$$Pfan = bhp \times 746 / Fan\ Motor\ Efficiency$$

where
P_{fan} = electric power to fan motor (watts) and
bhp = brake horsepower of baseline fan motor from Table D3.1.2.9.
Fan Motor Efficiency = the efficiency from Table C-20 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

TABLE D3.1.2.9 Baseline Fan Brake Horsepower

Baseline Fan Motor Brake Horsepower	
Constant Volume Systems 1 – 4	**Variable Volume Systems 5 – 8**
$CFM_s \cdot 0.00085 + A$	$CFM_s \cdot 0.0012 + A$

Where *A* is calculated according to Section 6.5.3.1.1 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 G3.1.2.10.

D3.1.2.10 Exhaust Air Energy Recovery. Where required by 7.4.3(k), 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 to D3.1.2.10: If any of these exceptions apply, exhaust air energy recovery shall not be included in the baseline building design.

a. Systems serving spaces that are not cooled and that are heated to less than 16 C (60°F).

b. 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.

c. Heating operation for systems in *climate zones* 1 through 3.

d. Cooling operation for systems in *climate zones* 3C, 4C, 5B, 5C, 6B, 7, and 8.

e. 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.

f. 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.

g. Systems serving laboratories with exhaust rates of 2,500 L/s (5000 cfm) 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 4 C (40°F).

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 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 1,500 m^2 (15,000 ft^2) or less and as having two equally sized boilers for plants serving more than 1,500 m^2 (15,000 ft^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 82 C (180°F) and design return temperature as 54 C (130°F).

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: 82 C at -7 C(180°F at 20°F) and below, 66 C at 10 C (150°F at 50°F) and above, and ramped linearly between 82 C and 66 C (180°F and 150°F) at temperatures between -7 C and 10 C (20°F and 50°F).

D3.1.3.5 Hot Water Pumps (Systems 1, 5, and 7). The baseline building design hot water pump power shall be 300 kW/1000 L/s (19 W/gpm). The pumping system shall be modeled as primary-only with continuous variable flow. Hot water systems serving 12,000 m^2 (120,000 ft^2) or more shall be modeled with variable-speed drives, and systems serving less than 12,000 m^2 (120,000 ft^2) shall be modeled as riding the pump curve.

D3.1.3.6 Piping Losses (Systems 1, 5, 7, and 8). 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 type as indicated in Table D3.1.3.7 as a function of building peak cooling load.

TABLE D3.1.3.7 Type and Number of Chillers

Building Peak Cooling Load	Number and Type of Chiller(s)
≤ 1,050 kW (300 tons)	1 water-chilled screw chiller
> 1,050 kW (300 tons), < 2,100 kW (600 tons)	2 water-chilled screw chillers sized equally
≥ 2,100 kW (600 tons)	2 centrifugal chillers minimum with chillers added so that no chiller is larger than 2,800 kW (800 tons), all sized equally

D3.1.3.8 Chilled Water Design Supply Temperature (Systems 7 and 8). Chilled water design supply temperature shall be modeled at 7 C (44°F) and return water temperature at 13 C (56°F).

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: 7 C at 27 C (44°F at 80°F) and above, 12 C at 16 C (54°F at 60°F) and below, and ramped linearly between 7 C and 12 C (44°F and 54°F) at temperatures between 27 C and 16 C (80°F and 60°F).

D3.1.3.10 Chilled Water Pumps (Systems 7 and 8). The baseline building design pump power shall be 350 kW/1000 L/s (22 W/gpm). Chilled water systems with a cooling capacity of 1,050 kW (300 tons) 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 1,050 kW (300 tons) cooling capacity shall be modeled as primary/secondary systems with secondary pump riding the pump curve.

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 29 C (85°F) or 6 C (10°F) approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 6 C (10°F). The tower shall be controlled to maintain a 21 C (70°F) 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 300 kW/1000 L/s (19 W/gpm). 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). Supply air temperature shall be reset based on zone demand from the design temperature difference to a 6 C (10°F) temperature difference under minimum load conditions. Design air flow rates shall be sized for the reset supply air temperature, i.e., a 6 C (10°F) temperature difference.

D3.1.3.13 VAV Minimum Flow Setpoints (Systems 5 and 7). Minimum volume setpoints for VAV reheat boxes shall be 2 L/s·m^2 (0.4 cfm/ft^2) of floor area served. Reheat shall not exceed that specified in 7.4.3(g).

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 0.7 W/L/s (0.35 W/cfm) 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 D3.1.3.15 Part-Load Performance for VAV Fan Systems

Method 1 – Part-Load Fan Power Data	
Fan Part-Load Ratio	**Fraction of Full-Load Power**
0.00	0.00
0.10	0.03
0.20	0.07
0.30	0.13
0.40	0.21
0.50	0.30
0.60	0.41
0.70	0.54
0.80	0.68
0.90	0.83
1.00	1.00
Method 2 – Part-Load Fan Power Equation	
$P_{fan}= 0.0013 + 0.1470 \times PLR_{fan}+ 0.9506 \times (PLR_{fan})^2-0.0998 \times (PLR_{fan})^3$ Where P_{fan}= fraction of full-load fan power and PLR_{fan}= fan part-load ratio (current cfm/design cfm).	

TABLE D3.2 Power Adjustment Percentages for Automatic Lighting Controls

Automatic Control Devices(s)	**Non-24-hr and ≤ 500 m² (5,000ft²)**	**All Other**
(1) Programmable timing control	10%	0%
(2) Occupancy sensor (where not required by 7.4.6(b) or (c))	15%	10%
(3) Occupancy sensor and programmable timing control (where not required by 7.4.6(b) or (c))	15%	10%

Note: The 500 m^2 (5,000 ft^2) condition pertains to the total conditioned floor area of the building.

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

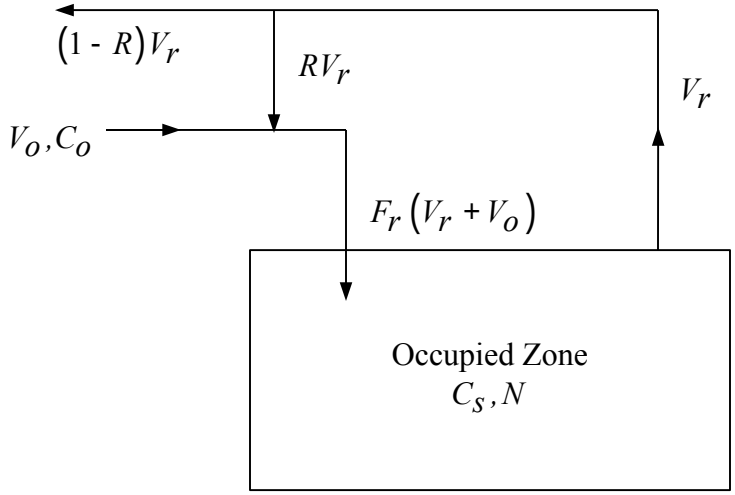
NORMATIVE APPENDIX E
SPACE CONTAMINANT CONCENTRATION EQUATIONS

System Type	Outdoor Airflow	Space Concentration
VAV	100%	$C_s = C_o + \frac{N}{E_v V_o}$
Constant	Constant	$C_s = \frac{N + E_v V_o C_o}{E_v \left(V_o + R V_r\right)}$
VAV	Constant	$C_s = \frac{N + E_v V_o C_o}{E_v \left(V_o + F_r R V_r\right)}$
VAV	Proportional *	$C_s = \frac{N + E_v F_r V_o C_o}{F_r E_v \left(V_o + R V_r\right)}$

* Variable air volume (VAV) systems reduce the circulation rate when the thermal load is satisfied. This is accounted for by a flow reduction factor. Proportional indicates that the outdoor airflow varies with the supply airflow, such that the outdoor airflow is equal to the design value times the flow reduction factor F_r.

Nomenclature

C = Contaminant (CO_2) Concentration
V_o = Volumetric flow
N = Contaminant (CO_2) generation rate
E_v = System ventilation efficiency (as defined in ASHRAE Standard 62.1)
F_r = Flow reduction factor
Subscripts
o = outdoor
r = return
s = space



(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX F
INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of this standard and to acknowledge source documents when appropriate.

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**		
ASHRAE Guideline 0-2005	The Commissioning Process	10.3.1.1
ASHRAE Guideline 1-1996	The HVAC Commissioning Process	10.3.1.1
ASHRAE Guideline 4-1994	Preparation of Operating and Maintenance Documentation for Building Systems	10.3.1.1
Fundamentals – 2005	ASHRAE Handbook	Appendix D
California Energy Commission (CEC) **1519 Ninth Street** **Sacramento, CA 95814** **United States** **1-800-772-3300 and 916-654-4287; www.energy.ca.gov**		
CEC-400-2005-006-CMF (April 2005)	Nonresidential Compliance Manual for California's 2005 Energy Efficiency Standards	10.3.2.1
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**		
		8.4.1.3
CSA S478-95 (R2001)	Guideline on Durability for Buildings	Appendix K
Carpet and Rug Institute **730 College Drive** **Dalton, Georgia 30720** **United States** **1-706-278-3176; www.carpet-rug.org**		

		9.4.2.3
Forest Stewardship Council (FSC) **1155 30th Street NW, Suite 300** **Washington, DC 20007** **United States** **1-202-342-0413; www.fsc.org**		
		8.4.1.3
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
Programme for the Endorsement of Forest Certification schemes (PEFC) **2éme Etage** **17 Rue des Girondins** **Merl-Hollerich** **L - 1626 Luxembourg** **352-26-25-90-59; www.pefc.org**		
		8.4.1.3
Resilient Floor Covering Institute **401 East Jefferson Street, Suite 102** **Rockville, Maryland 20850** **United States** **1-301-340-8580; www.rfci.com**		
		9.4.2.3
Sheet Metal and Air Conditioning Contractors National Association (SMACNA) **4201 Lafayette Center Drive** **Chantilly, VA 20151** **Unites States** **1-703-803-2980; www.smacna.org**		
SMACNA – 1995	IAQ Guidelines for Occupied Buildings under Construction	10.3.8
Sustainable Forestry Initiative, Inc. (SFI) **1655 North Fort Myer Drive, Suite 1300** **Arlington, VA 22209** **United States** **1-703 875 9500; www.aboutsfi.org**		
		8.4.1.3
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 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 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 G
INTEGRATED DESIGN

G1 Integrated Design. *Integrated Design* is a design process utilizing early and complete stakeholder and consultant participation by representatives of every issue. It is different from the conventional or linear design process where the architect is primarily responsible for the design and plan and there is limited stakeholder/consultant participation.

In an *Integrated Design* approach there is early stakeholder collaboration that allows both better control of all aspects of a project and the greatest opportunity for early sharing of expertise. *Integrated design* is in contrast to the traditional method, where an architect takes the lead and there is a limited role played by consultants, mechanical, structural and others at the Schematic Design Stage. While the traditional method may be appropriate for buildings designed to achieve relatively low levels of energy reduction, for buildings requiring significant energy reduction an *Integrated Design* Process shall be used.

The *Integrated Design* Process allows the greatest effectiveness in cost and environmental performance to be achieved by bringing all issues and participants into the project at the earliest point. As a general rule, the opportunities for creatively addressing solutions occur very early in the design process. Early team building and goal setting will save money for the total project – the later in the design process, the more expensive the implementation.

Good integration is a continuously iterative process. All issues need to be kept in play so that the connections and relationships can be optimized. A linear process approaches each problem directly and sequentially, while an integrated process approaches each problem from the different viewpoints of the participants and the issues they represent. It is a continuous circling process to make sure the project is exploring the best opportunities and adjusting responses as more understanding occurs.

The results of early collaboration lead to buildings that will reduce energy waste and achieve comfort and functionality with the minimum of support. This collaboration, by dealing with a unified strategy, can directly affect building form, the nature of the envelope, tailor mechanical, electrical and other systems.

There is an added dimension when *Integrated Design* is seen in relationship to Sustainable Design. This latter construct requires a different mindset or mental model and practice methodology that looks at systems in a more complex and integrated way. Instead of looking at just the physical elements of the building, the hidden connections

between the elements need to be understood. These hidden connections and patterns, for example, may be manifest in the downstream impact of toxins in building materials, the multiple efficiency and cost relationships between the many variables in an HVAC system and the *building envelope*, or the impact on social systems due to logging practices or any raw material extraction.

Through this integrative process, design optimization can more easily be achieved. Design optimization is the process by which the performance and cost effectiveness of all projects are refined and maximized.

The design team should use an *integrated design* process for the *building project*. This process shall be in accordance with generally accepted high performance green building design principles acceptable to the authority having jurisdiction. This process should include a design charrette.

G1.1 Design Charrette. At the initial stages of building design, a charrette process can be initiated and the members of the process should include all the stakeholders. The charrette process should be held for a minimum of three (3) days and a maximum of seven (7) days.

> **Exception to G1.1:** *Building projects* containing less than 10,000 gross square meters (100,000 gross square feet) can have a charrette design process of less than three days.

G1.2 Charrette Process. Experienced personnel with a minimum of 10 years of experience in their 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 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.

G1.3 Design Charrette Matrix. At the end of the charrette process, a matrix (Figure G1) 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 G1.2 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.

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INFORMATIVE APPENDIX H

EXAMPLE SITE WATER USE AND BUILDING WATER USE CALCULATIONS

In lieu of using the Prescriptive Path in Section 6.4, it is allowable to use the Performance Option in 6.5 for compliance with the requirements for *site* water use reduction, building water use reduction, or special water features. For those using the Performance Option in 6.5, the following sections provide the methodology and a sample calculation for the baseline. Note that the calculations shall include both the Mandatory Provisions in 6.3 as well as the Prescriptive measures in 6.4. The Mandatory Provisions shall always be complied with. It is only the Prescriptive measures that can be traded-off using the Performance Option. For components subject to the Mandatory Provisions (e.g. faucets, showers), it is acceptable to take credit for reductions in water use that exceed the requirements in the Mandatory Provisions.

6.5.1 Site Water Use Reduction

The following table provides a sample calculation for the site water use for a *building project*. The example uses *evapotranspiration* to establish base potable use, then deriving the amount of water that must come from alternate on-site sources. The calculations are based on monthly average *evapotranspiration* for the nearest site with ETo information available.

ETo = Total Evapotranspiration

ETr = Evapotranspiration adjusted for rainfall

ETp = Evapotranspiration adjusted for plant material

ETc = Combined ET based on planting area and plant material

Table H-1 Input Data

Location of Landscape (ETo data used)	Austin, Texas	
Evapotranspiration coefficients for plant material	Percent of ETo	
Turf Grass	70%	
All Other Plant Material	55%	
Irrigation efficiency	90%	

Table H-2 Building Project Areas (SI and IP)

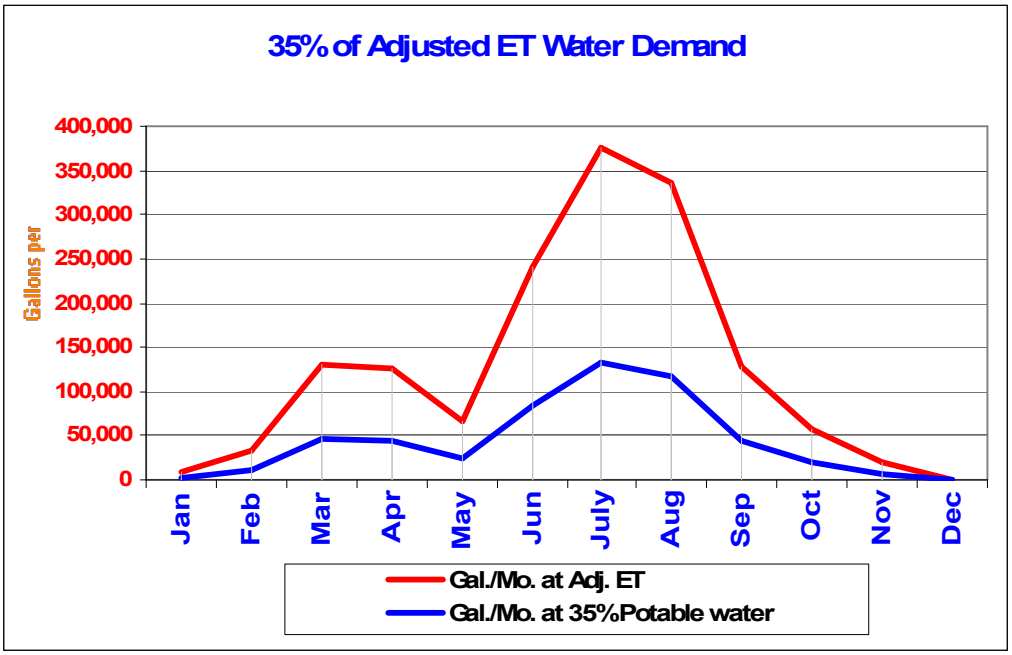
Overall Landscape Breakdown	**% of total area**	**Area m^2**	**Area ft^2**
Impervious Area	40%	20,000	200,000
Native	15%	7,500	75,000
Improved Landscape	45%	22,500	225,000
Total	100%	50,000	500,000
Improved Landscape Breakdown by Plant Material	**% of Impervious Landscape**	**Area m^2**	**Area ft^2**
Turf	40%	9,000	90,000
plant	60%	13,500	135,000
Total	100%	22,500	225,000
Combined adjusted ET	61%		

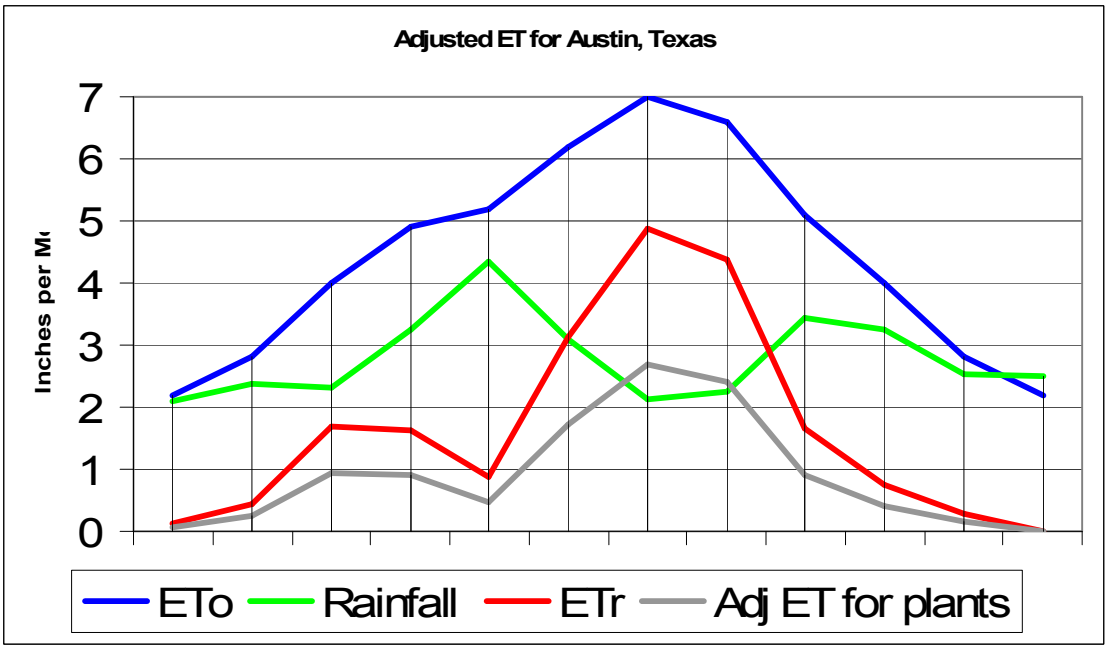
Table H-3 Site Potable Water Allowed and Alternate On-Site Water Required (SI)

					ET adjusted for irrigation efficiency	Total monthly water require-ment	Potable water allowed	Water from alternate on-site sources
Month	ETo	Rain fall	ETr	ETc	In. applied		35% of total	
	mm/ Mo.	mm/ Mo.	mm/ Mo.	mm/ Mo.	mm/Mo.	L/Month	L/Month	L/Month
Jan	56	53	3	2	2	100,796	35,279	65,517
Feb	71	60	11	7	7	394,020	137,907	256,113
Mar	102	59	43	26	29	1,539,426	538,799	1,000,627
Apr	124	83	42	25	28	1,502,773	525,970	976,802
May	132	110	22	13	15	788,039	275,814	512,226
Jun	157	78	79	48	54	2,858,934	1,000,627	1,858,307
July	178	54	124	76	84	4,471,665	1,565,083	2,906,582
Aug	168	57	111	68	75	3,995,176	1,398,312	2,596,865
Sep	130	87	42	26	29	1,521,099	532,385	988,715
Oct	102	83	19	12	13	687,244	240,535	446,708
Nov	71	64	7	4	5	247,408	86,593	160,815
Dec	56	64	0	0	0	0	0	0
TOTAL ANNUAL	1346	852	502	306	340	18,106,579	6,337,303	11,769,276

Table H-3 Site Potable Water Allowed and Alternate On-Site Water Required (IP)

					ET adjusted for irrigation efficiency	Total monthly water require-ment	Potable water allowed	Water from alternate on-site sources
Month	ETo	Rain fall	ETr	ETc	In. applied		35% of total	
	In/ Mo.	In/ Mo.	In/ Mo.	In/ Mo.	In/ Mo.	Gal/Mo	Gal/Mo	Gal/Mo
Jan	2.2	2.1	0.1	0.07	0.07	10,484	3,670	6,815
Feb	2.8	2.4	0.4	0.26	0.29	40,984	14,345	26,640
Mar	4.0	2.3	1.7	1.02	1.14	160,125	56,044	104,081
Apr	4.9	3.3	1.6	1.00	1.11	156,313	54,709	101,603
May	5.2	4.3	0.9	0.52	0.58	81,969	28,689	53,280
Jun	6.2	3.1	3.1	1.90	2.11	297,375	104,081	193,294
July	7.0	2.1	4.9	2.98	3.31	465,125	162,794	302,331
Aug	6.6	2.2	4.4	2.66	2.96	415,563	145,447	270,116
Sep	5.1	3.4	1.7	1.01	1.13	158,219	55,377	102,842
Oct	4.0	3.3	0.8	0.46	0.51	71,484	25,020	46,465
Nov	2.8	2.5	0.3	0.16	0.18	25,734	9,007	16,727
Dec	2.2	2.5	0.0	0.00	0.00	0	0	0
TOTAL ANNUAL	53	33.5	20	12.05	13.39	1,883,375	659,181	1,224,194





6.5.2 Building Water Use Reduction

The following table provides a sample calculation for the baseline for a 17-story mixed-use building with street level retail, ten floors of office, then six floors of multi-family *residential* on the top.

Table H-4 Building Water Use Input Data (SI)

PERFORMANCE EXAMPLE:						
	More efficient toilets to allow potable water use in fountain					
PROJECT DESCRIPTION:						
	17-story building (1,000 m^2/floor)					
	street-level retail, next 10 floors office, top 6 floors condominium					
NONRESIDENTIAL SPACES						
Building Use:	Retail					
Gross Building Area:	1,000	m^2		Area/Person:	25	m^2
Work Days/Year:	365	days		Number of People:	40	people
				Males:	20	males
				Females:	20	females
Building Use:	Office					
Gross Building Area:	10,000	m^2		Area/Person:	25	m^2
Work Days/Year:	260	days		Number of People:	400	people
				Males:	200	males
				Females:	200	females
RESIDENTIAL SPACES						
Building Use:	Apartments					
Gross Building Area:	6,000	m^2		Persons/Unit:	2.5	average
Dwelling Units:	40	units		Number of People:	100	people
Dwelling Unit Size:	150	m^2 (avg)		Males:	50	males
Days/Year:	365	days		Females:	50	females
FIXTURES AND FITTINGS						
Water Closets:	Uses/day – retail:		male:	1	Female:	3
	Uses/day - office:		male:	1	Female:	3
	Uses/day - apartment:		male:	5	Female:	5
Urinals:	Uses/day – retail:		male:	2	Female:	N.A.
	Uses/day - office:		male:	2	Female:	N.A.
	Uses/day - apartment:		male:	N.A.	Female:	N.A.
Lavatory Faucet:	Uses/day – retail:		all:	3	0.25	hr/use
	Uses/day - office:		all:	3	0.25	hr/use
Bathroom Faucet:	Uses/day - apartment:		all:	8	0.25	hr/use
Kitchen Faucet:	Uses/day - apartment:		all:	6	0.25	hr/use
Shower:	Uses/day – person:		all:	1	0.10	hr/use
APPLIANCES (within dwelling units)						
	Clothes washers:		392	USEPA cycles per year		
	Dishwashers:		215	USEPA cycles per year		
ORNAMENTAL FOUNTAIN						
Days/Year:	365	days		Hours/Day:	24	hours

Table H-4 Building Water Use Input Data (IP)

PERFORMANCE EXAMPLE:						
	More efficient toilets to allow potable water use in fountain					
PROJECT DESCRIPTION:						
	17-story building (10,000 ft^2/floor)					
	street-level retail, next 10 floors office, top 6 floors condominium					
NONRESIDENTIAL SPACES						
Building Use:	Retail					
Gross Building Area:	10,000	ft^2		Area/Person:	250	ft^2
Work Days/Year:	365	Days		Number of People:	40	people
				Males:	20	males
				Females:	20	females
Building Use:	Office					
Gross Building Area:	100,000	ft^2		Area/Person:	250	ft^2
Work Days/Year:	260	Days		Number of People:	400	people
				Males:	200	males
				Females:	200	females
RESIDENTIAL SPACES						
Building Use:	Apartments					
Gross Building Area:	60,000	ft^2		Persons/Unit:	2.5	average
Dwelling Units:	40	Units		Number of People:	100	people
Dwelling Unit Size:	1,500	ft^2 (avg)		Males:	50	males
Days/Year:	365	Days		Females:	50	females
FIXTURES AND FITTINGS						
Water Closets:	Uses/day – retail:		male:	1	Female:	3
	Uses/day - office:		male:	1	Female:	3
	Uses/day - apartment:		male:	5	Female:	5
Urinals:	Uses/day – retail:		male:	2	Female:	N.A.
	Uses/day - office:		male:	2	Female:	N.A.
	Uses/day - apartment:		male:	N.A.	Female:	N.A.
Lavatory Faucet:	Uses/day – retail:		all:	3	0.25	hr/use
	Uses/day - office:		all:	3	0.25	hr/use
Bathroom Faucet:	Uses/day - apartment:		all:	8	0.25	hr/use
Kitchen Faucet:	Uses/day - apartment:		all:	6	0.25	hr/use
Shower:	Uses/day – person:		all:	1	0.10	hr/use
APPLIANCES (within dwelling units)						
	Clothes washers:		392	USEPA cycles per year		
	Dishwashers:		215	USEPA cycles per year		
ORNAMENTAL FOUNTAIN						
Days/Year:	365	Days		Hours/Day:	24	hours

Table H-5 Building Water Use Performance Compliance Calculation (IP)

6.5.2 PERFORMANCE OPTION			**STANDARD 189**		**PROPOSED DESIGN**	
	Frequency of Use (per year)		**Gal/Use**	**Total gal/yr**	**Gal/Use**	**Total gal/yr**
MANDATORY PROVISIONS *(Every Proposed use shall be less than or equal to Std 189 use)*						
6.3.2.1 Plumbing Fixtures and Fittings						
6.3.2.1(a): Water Closets (Toilets) - flushometer valve (commercial)						
	Males	59300	4.8	284,640	3.8	225,340
	females	177900	4.8	853,920	3.8	676,020
6.3.2.1(b): Water Closets (Toilets) - tank type (residential)						
	males	91250	4.8	438,000	3.8	346,750
	females	91250	4.8	438,000	3.8	346,750
6.3.2.1(c): Urinals	water	118600	1.9	225,340	0.5	59,300
	non-water	N.A.		0		0
6.3.2.1(d): Public Lav'tory Faucets		88950	1.9	169,005	1.9	169,005
6.3.2.1(e): Public Self-Closing Fau		N.A.	1.0	0		0
6.3.2.1(f): Res. Bathroom Faucets		29200	5.7	166,440	3.8	110,960
6.3.2.1(g): Res. Kitchen Faucets		54750	8.3	454,425	8.3	454,425
6.3.2.1(h): Res. Showerhead		3650	7.6	27,740	6.8	24,820
6.3.2.1(i): Res. Shower Stall		N.A.		0		0
6.3.2.1 Appliances						
6.3.2.2(a) Clothes Washers and Dishwashers (within dwelling units)						
USEPA cycles/yr:	Clotheswas	43	23.0	360,640	23.0	360,640
USEPA cycles/yr:	Dishwasher	24	25.0	215,000	21.0	180,600
6.3.2.2(b) Clothes Washers (in multifamily and hotel common areas)						
	clothes washers	N.A.	32.0	0		0
PRESCRIPTIVE CRITERIA *(Proposed use allowed to exceed Std 189 use if made up for)*						
6.4.2.1 Cooling Towers 5 cycles		N.A.		0		0
6.4.2.2 Commercial Food Service Operations						
6.4.2.2(a): Pre-Rinse Spray Valve		N.A.		0		0
6.4.2.2(b): Dishwashers		N.A.		0		0
6.4.2.2(c): Food Steamers		N.A.		0		0
6.4.2.2(d): Ice Machines		N.A.		0		0
6.4.2.2(e): Garbage Disposers		N.A.		0		0
6.4.2.3 Medical and Laboratory Facilities						
6.4.2.3(a): Steam Sterilizers		N.A.		0		0
6.4.2.3(b): Film Processor Units		N.A.		0		0
6.4.2.3(c): Digital Imaging & Rad.		N.A.		0		0
6.4.2.3(d): Hood Scrubber Syst'm		N.A.		0		0
6.4.2.3(e): Dry Vacuum Pumps		N.A.		0		0
6.4.2.3(f): Water Treatment Syst.		N.A.		0		0
6.4.3 Special Water Features						
6.4.3(a): Ornamental Fountains		24	0.00	0	11.0	96,360
6.4.3(b): Pools and Spas		N.A.		0		0
		TOTAL	**Std 189:**	**3,633,150**	**Prop.:**	**3,050,970**
					Reduction from Std 189 =	**16.02%**

Table H-5 Building Water Use Performance Compliance Calculation (IP)

6.5.2 PERFORMANCE OPTION			**STANDARD 189**		**PROPOSED DESIGN**	
	Frequency of Use (per year)		**Gal/Use**	**Total gal/yr**	**Gal/Use**	**Total gal/yr**
MANDATORY PROVISIONS *(Every Proposed use shall be less than or equal to Std 189 use)*						
6.3.2.1 Plumbing Fixtures and Fittings						
6.3.2.1(a): Water Closets (Toilets) - flushometer valve (commercial)						
	Males	59300	1.28	75,904	1.00	59,300
	females	177900	1.28	227,712	1.00	177,900
6.3.2.1(b): Water Closets (Toilets) - tank type (residential)						
	males	91250	1.28	116,800	1.00	91,250
	females	91250	1.28	116,800	1.00	91,250
6.3.2.1(c): Urinals	water	118600	0.50	59,300	0.13	14,825
	non-water	N.A.		0		0
6.3.2.1(d): Public Lav'tory Faucets		88950	0.50	44,475	0.50	44,475
6.3.2.1(e): Public Self-Closing Fau		N.A.	0.25	0		0
6.3.2.1(f): Res. Bathroom Faucets		29200	1.50	43,800	1.00	29,200
6.3.2.1(g): Res. Kitchen Faucets		54750	2.20	120,450	2.20	120,450
6.3.2.1(h): Res. Showerhead		3650	2.00	7,300	1.75	6,388
6.3.2.1(i): Res. Shower Stall		N.A.		0		0
6.3.2.1 Appliances						
6.3.2.2(a) Clothes Washers and Dishwashers (within dwelling units)						
USEPA cycles/yr:	Clotheswas	43	6.00	94,080	6.00	94,080
USEPA cycles/yr:	Dishwasher	24	6.50	55,900	5.50	47,300
6.3.2.2(b) Clothes Washers (in multifamily and hotel common areas)						
clothes washers		N.A.	8.50	0		0
PRESCRIPTIVE CRITERIA *(Proposed use allowed to exceed Std 189 use if made up for)*						
6.4.2.1 Cooling Towers 5 cycles		N.A.		0		0
6.4.2.2 Commercial Food Service Operations						
6.4.2.2(a): Pre-Rinse Spray Valve		N.A.		0		0
6.4.2.2(b): Dishwashers		N.A.		0		0
6.4.2.2(c): Food Steamers		N.A.		0		0
6.4.2.2(d): Ice Machines		N.A.		0		0
6.4.2.2(e): Garbage Disposers		N.A.		0		0
6.4.2.3 Medical and Laboratory Facilities						
6.4.2.3(a): Steam Sterilizers		N.A.		0		0
6.4.2.3(b): Film Processor Units		N.A.		0		0
6.4.2.3(c): Digital Imaging & Rad.		N.A.		0		0
6.4.2.3(d): Hood Scrubber Syst'm		N.A.		0		0
6.4.2.3(e): Dry Vacuum Pumps		N.A.		0		0
6.4.2.3(f): Water Treatment Syst.		N.A.		0		0
6.4.3 Special Water Features						
6.4.3(a): Ornamental Fountains		24	0.00	0	3.00	26,280
6.4.3(b): Pools and Spas		N.A.		0		0
		TOTAL	**Std 189:**	**962,521**	**Prop.:**	**802,698**
					Reduction from Std 189 =	**15.87%**

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INFORMATIVE APPENDIX I

EXAMPLE FOR CONVERTING ENERGY USE TO ENERGY COST AND CO_2e

Energy Cost Assumptions for this example; For Electricity = $0.10/kWh, For Natural Gas = $0.0245/kWh ($7.20/MMBtu)
CO_2e Emissions Factors from Table 7.5.3; For Electricity = 0.799 kg/kWh (1.76 lb/kWh), For Natural Gas = 0.184 kg/kWh (0.406 lb/kWh)

BASELINE (MANDATORY PROVISIONS AND PRESCRIPTIVE OPTION)						
End Use	Fuel Type	Electric kWh	Natural Gas kWh (MMBtu)	Energy Use kWh	Cost $	CO_2e kg (CO_2e lb)
Lighting, Interior	Electric	350,000		350,000	35,000	279,650 (616,000)
Lighting, Façade	Electric					
Lighting, Parking	Electric					
Space Heating	Natural Gas		264,000 (900)	264,000	6,480	48,576 (107,185)
Space Cooling	Electric	250,000		250,000	25,000	199,750 (440,000)
Fans, Interior	Electric	160,000		160,000	16,000	127,840 (281,600)
Fans, Parking Garage	Electric					
Pumps	Electric					
Service Water Heating	Natural Gas		51,290 (175)	51,290	1,260	9,437 (20,824)
Office Equipment	Electric	125,000		125,000	12,500	99,875 (220,000)
Elevators and Escalators	Electric					
Refrigeration (food, etc.)	Electric					

Cooking (commercial)	Natural Gas					
Total Building		885,000	315,290 (1,075)	1,200,290	96,240	765,128 (1,685,609)
PROPOSED BUILDING						
End Use	Fuel Type	Electric kWh	Natural Gas kWh (MMBtu)	Energy Use kWh	Cost $	CO_2e kg (CO_2e lb)
Lighting, Interior	Electric	180,200		180,200	18,020	143,980 (317,152)
Lighting, Façade	Electric					
Lighting, Parking	Electric					
Space Heating	Natural Gas		133,353 (455)	133,353	3,276	24,537 (54,141)
Space Cooling	Electric	220,300		220,300	22,030	176,020 (387,728)
Fans, Interior	Electric	110,150		110,150	11,015	88,010 (193,864)
Fans, Parking Garage	Electric					
Pumps	Electric					
Service Water Heating	Natural Gas		51,290 (175)	51,290	1,260	9,437 (20,824)
Office Equipment	Electric	125,000		125,000	12,500	99,875 (220,000)
Elevators and Escalators	Electric					
Refrigeration (food, etc.)	Electric					
Cooking (commercial)	Natural Gas					
Total Building		635,650	184,643 (630)	820,293	68,101	541,859 (1,193,709)

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INFORMATIVE APPENDIX J

EXAMPLE CONSTRUCTION WASTE AND MATERIALS CALCULATIONS

Example for Section 8.3.1 Construction Waste Management

Description of Waste Generated	Receiving Agent and Location	Quantity of Waste Diverted or Recycled	Quantity of Waste Sent to Landfill	Unit (Metric tons, tons, cubic meters, or cubic yards)
Masonry	ABC Recycling, Fort Worth, TX	32		tons
Crushed asphalt	ABC Paving, Dallas, TX	148		tons
Gypsum wallboard	ABC Recycling, Fort Worth, TX	10		tons
General mixed waste	XYZ Landfill, Dallas, TX		50	tons
Total		190		

Construction Waste Diverted from Landfill = (Total Quantity of Construction Waste Diverted or Recycled)/(Total Quantity of All Construction Waste) = _190/240 = 79%_____

Construction waste diverted from landfill shall greater than or equal to 50%.

I _____(Name of Responsible Individual) of _____(Name of Company or Organization) verify that the information provided above is accurate to the best of my knowledge.

Address of Responsible Company or Organization:
_____
_____
_____

Example for Section 8.4.1.1 Recycled Content

Material Name	Manufacturer	Material Cost, $	Post-Consumer Recycled Content, %	Pre-Consumer Recycled Content, %	Recycled Content Value, $	Recycled Content Information Source
Steel	ABC Company	100,000	57.5	32.5	73,750	ABC Company
Concrete	Joe Ready Mix	200,000		20	20,000	Joe Ready Mix (20% fly ash)
Carpet	XYZ Carpets	80,000	50		40,000	XYZ Carpets
Ceiling Tile	Square Ceiling	50,000	65		32,500	Square Ceiling
Total					166,250	

Recycled content value = (% *post-consumer recycled content* x material cost) + 0.5 x (% *pre-consumer recycled content* x material cost)

Sum of *Recycled Content* Value = $_166,250_____

Total Materials Cost for Project = $ __1,500,000_____

(Sum of *Recycled Content* Value)/(Total Material Cost for Project) = _166,250/1,500,000 = 11%_

The requirement is met if sum of the *recycled content* value divided by the total cost of materials is greater than or equal to 10%, provided not more than 50% of the *recycled content* is from one type of material.

Documentation on *recycled content* shall include an invoice, letter, or description from the product manufacturer indicating the *recycled content*. This requirement is met by using annual average industry values for steel products manufactured in basic oxygen furnaces and electric arc furnaces. This requirement is met for concrete products with documentation of the mix design(s) indicating the proportion or quantity of *recycled content* of the cementitious materials (e.g. fly ash or slag cement) and other constituent materials, and the quantity of delivered concrete with that mix design.

I _____(Name of Responsible Individual) of _____(Name of Company or Organization) verify that the information provided above is accurate to the best of my knowledge.

Address of Responsible Company or Organization:
_____
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Example for Section 8.4.1.2 Regionally Extracted, Processed, and Manufactured

Product Name	Manufacturer	Total Product Cost, $	Extraction Distance km or miles	Transportation Method from Extraction, km or miles	Manufactured Distance, km or miles	Transportation Method from Manufacture, km or miles
Steel	ABC Company	100,000	800 miles 50 miles	Water Other	100 miles	Other
Concrete	Joe Ready Mix	150,000	200 miles	Other	30 miles	Other
Lumber	ABC Lumber	50,000	500 miles 100 miles	Rail Other	500 miles 100 miles	Rail Other
Total		300,000				

Documentation shall include an invoice, letter, or description from the product manufacturer indicating that a minimum of 70% of the mass was extracted, harvested or recovered, and manufactured within the and the specified distances.

Sum of Regional Product Costs= $__300,000_____

Total Materials Cost for Project = $ ___1,500,000_____

(Sum of Regional Product Costs)/(Total Material Cost for Project) = 300,000/1,500,000 = 20%_

The requirement is met if the sum of the regional product costs divided by the total cost of materials is greater than or equal to 15%.

The extraction and manufactured distances each shall be less than the required distances (they are not additive). The required distances are within a radius of 800 km (500 mi) of the project site or, if shipped primarily by rail or water, within a radius of 2400 km (1500 mi).

If either the extraction or manufactured distance is a combination of rail and/or water and other, then the combined distance ratios below shall each be less than or equal to 1.0.

Combined extraction distance ratio = (Extraction distance by rail or water)/2400 km [1500 mi.] + (Extraction distance by other means)/800 km [500 mi.]

Combined manufactured distance ratio = (Manufactured distance by rail or water)/2400 km [1500 mi.]+ (Manufactured distance by other means)/800 km [500 mi.]

I _____(Name of Responsible Individual) of _____(Name of Company or Organization) verify that the information provided above is accurate to the best of my knowledge.

Address of Responsible Company or Organization:
_____
_____
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Example for Section 8.4.1.3 Biobased Products

Product Name	Manufacturer or Vendor	Product Cost, $	Chain of Custody Certificate Number for Wood Products
Wool carpet	ABC Carpet	30,000	
Lumber	ABC Forest Products	50,000	10-808449
Total		80,000	

Sum of Bio-based Product Costs = $____80,000_____

Total Materials Cost for Project = $ _____1,500,000_____

(Sum of Bio-based Product Costs)/(Total Material Cost for Project) = _80,000/1,500,000 = 5.3%_

The requirement is met if the sum of the bio-based product costs divided by the total cost of materials is greater than or equal to 5 %.

I _____(Name of Responsible Individual) of _____(Name of Company or Organization) verify that the information provided above is accurate to the best of my knowledge.

Address of Responsible Company or Organization:
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INFORMATIVE APPENDIX K
SAMPLE DURABILITY PLAN

K1 Intent

Minimize materials use and construction waste over a building's life resulting from premature failure of the building and its structural and *building envelope* components and assemblies.

K2 Design Approach

The durable building credit recognizes that proper design and materials can provide components and assemblies that, over the life of a building, will use less material and create less waste. This life cycle approach is based on a long-term assessment of components such as the wall and roof systems to determine how much maintenance, repair and replacement will be required to resist the elements and to minimize premature deterioration. The environmental loads, and the means employed to achieve adequate resistance, will vary by climate

Design strategies for durability shall address appropriate durable materials. The most important design principals in buildings include deflection (overhangs/flashings), drainage (cavities), drying (venting of cavities/air leakage control), durable materials, details and documentation.

K3 Calculations

The predicted service life of components or assemblies is allowed to be assessed by: demonstrated effectiveness, modeling or testing. Demonstrated effectiveness may be applied where identical assemblies have been used successfully in the same environments. CSA S478 listed in Informative Appendix F provides a number of examples to illustrate the process described in the document, as well as tables that can be used to capture the required information.

The following is an example table with the required information.

Table K-1 Durability Example

Project Name: Building ABC
Location of Building: St. Louis
Design Service Life: 60

Building Assembly		Materials	Design Service Life, Yrs	Predicted Service Life, Yrs	Predicted Service Life (Method of Selection)	Failure Category	Effects of Failure	Maintenance Frequency	Maintenance Access
1	**Walls Below Grade (structural and building envelope)**								
1.1	Exterior								
1.1.1	Foundation Footings	Concrete (incl. rebar)	60	60	Experience	8	Sudden collapse	None	Expensive
1.1.2	Foundation Walls	Concrete (incl. rebar)	60	60	Experience	8	Danger to life	Low	Expensive
1.2	Interior								
1.2.1	Columns	Concrete (incl. rebar)	60	60	Experience	8	Danger to life	None	Minimal
		Paint (specify type)	10	15	Experience	1	No except. problems	Medium	Minimal
1.2.2	Elevator core	Concrete (incl. rebar)	60	60	Experience	8	Danger to life	None	Moderate
		Paint (specify type)	10	10	Experience	1	No except. problems	Medium	Minimal
1.2.3	Air shaft	Concrete block	60	60	Experience	6	Eco system	Low	Moderate
2	**Walls Above Grade (structural and building envelope)**								
2.1	Exterior Walls								
2.1.1	Exposed Concrete	Coating (specify type)	10	10	Experience	3	Interrupt. of building use	Medium	Moderate
		Caulking	10	10	Experience	4	Costly because repeated	Medium	Moderate
		Concrete (incl. rebar)	60	60	Experience	8	Danger to life	Low	Moderate
		25 mm rigid insulation (type)	30	40	Experience	5	Costly repair	None	Expensive
		92 mm steel studs (20 ga.)	40	40	Experience	5	Costly repair	None	Expensive
		R20 batt insulation	30	30	Experience	5	Costly repair	None	Expensive
		Vapour barrier (specify type)	30	60	Experience	3	Interrupt. of building use	None	Expensive

		Gypsum wallboard (specify type)	30	30	Experience	3	Interrupt. of building use	Low	Moderate
		Paint (specify type)	10	10	Experience	1	No except. problems	Medium	Minimal
2.1.2	Exterior Insulated Metal Panel	Metal panel	40	40	Experience	5	Costly repair	Low	Moderate
		Semi-rigid insulation	40	40	Experience	5	Costly repair	None	Expensive
		Self-adhesive membrane	40	40	Experience	5	Costly repair	None	Expensive
		Exterior gypsum	40	40	Experience	5	Costly repair	None	Expensive
		92 mm steel studs (20 ga.)	40	40	Experience	5	Costly repair	None	Expensive
		Gypsum wallboard (specify type)	30	30	Experience	3	Interrupt. of building use	Low	Minimal
		Paint (specify type)	10	10	Experience	1	No except. problems	Medium	Moderate
2.2	**Windows & Doors**								
2.2.1	Window Wall	Aluminum frame	35	40	Experience	6	Eco system	Low	Moderate
		IGU	25	30	Experience	4	Costly because repeated	Low	Moderate
		Insulated metal panel	35	35	Experience	4	Costly because repeated	None	Expensive
		Caulking	10	10	Experience	4	Costly because repeated	Medium	Moderate
		Flashings	25	30	Experience	4	Costly because repeated	Low	Moderate
2.2.2	Curtain wall	Aluminum frame	40	40	Experience	5	Costly repair	Low	Moderate
		IGU	20	20	Experience	4	Costly because repeated	Low	Moderate
		Caulking	15	15	Experience	4	Costly because repeated	Low	Moderate
		Flashings	25	30	Experience	4	Costly because repeated	Low	Moderate

2.2.3	Doors	Aluminum storefront frame	30	30	Experience	3	Interrupt. of building use	Low	Minimal
		IGU	20	20	Experience	2	Security Comp.	Low	Minimal
3	**Roof & Floor Schedule (including Balconies, Podium and Suspended Slabs)**								
3.1	**Exterior Roof Assemblies**								
3.1.1	Inverted Green Roof	Vegetation & soil	60	60	Experience	5	Costly repair	Medium	Moderate
		Filter cloth & drainage mat	30	30	Experience	5	Costly repair	Low	Expensive
		Rigid insulation	30	30	Experience	5	Costly repair	Low	Expensive
		Drainage mat	30	30	Experience	5	Costly repair	Low	Expensive
		Roofing membrane	30	40	Experience	5	Costly repair	Low	Expensive
		Concrete (incl. rebar)	60	60	Experience	8	Danger to life	Low	Expensive
		Ceiling paint	10	10	Experience	1	No except. problems	Low	Minimal
3.1.2	Exposed Membrane	Roofing membrane	25	25	Experience	4	Costly because repeated	Medium	Moderate
		Concrete (incl. rebar)	60	60	Experience	8	Danger to life	Low	Minimal
		Ceiling paint	60	60	Experience	1	No except. problems	Low	Minimal
3.1.3	Typical Balcony	Balcony membrane	15	15	Experience	3	Interrupt. of building use	Medium	Minimal
		Concrete (incl. rebar)	60	60	Experience	8	Danger to life	Low	Minimal
		Exterior ceiling paint	15	15	Experience	1	No except. problems	Low	Minimal
3.2	**Interior Floor Assemblies**								
3.2.1	Foundation Slab on Ground	Concrete (incl. rebar)	60	60	Experience	8	Danger to life	Low	Minimal
3.2.2	Finished Concrete suspended slab	Concrete (incl. rebar)	60	60	Experience	8	Danger to life	Low	Minimal
		Sealer	10	10	Experience	1	No except. problems	Medium	Minimal
3.2.3	Typical floor	Tile	10	10	Experience	3	Interrupt. of building use	Low	Minimal

		Laminate flooring	60	60	Experience	3	Interrupt. of building use	Medium	Minimal
		Underlayment	15	15	Experience	3	Interrupt. of building use	None	Moderate
		Concrete (incl. rebar)	15	15	Experience	8	Danger to life	None	Moderate
		Ceiling paint	15	15	Experience	1	No except. problems	Medium	Minimal

Table courtesy of the Canadian Standards Association.

Table K-2 Failure Categories for Durability Example

Category	Effects of Failure	Example
1	No exceptional problems	Replacement of light fittings
2	Security compromised	Broken door latch
3	Interruption of building use	Repair requires discontinuation of services or dislocation of occupants
4	Costly because repeated	Window hardware replacement
5	Costly repair	Requires extensive materials or component (direct and indirect) replacement
6	Danger to health or eco system	Excessive dampness, mold, soil gases, asbestos, PCB's
7	Risk of injury	Loose handrail
8	Danger to life	Sudden collapse of structure

Table courtesy of the Canadian Standards Association.