ANSI/ASHRAE/IESNA Standard 90.1-2001
(Includes ANSI/ASHRAE/IESNA Addenda listed in Appendix F)

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and ANSI.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard

Jointly sponsored by

IES
The LIGHTING AUTHORITY
Illuminating Engineering Society of North America
120 Wall Street, 17th Floor, New York, NY 10005-4001

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE · Atlanta, GA 30329

ASHRAE/IESNA Standard Project Committee 90.1-2001
Cognizant TC: TC 9.6, Systems Energy Utilization
Standards Project Committee Liaison: James K. Vallort
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

NOTE

This standard is under continuous maintenance. Future changes to the standard will be posted on the ASHRAE Home Page at www.ashrae.org/STANDARDS/standa.htm.

SPECIAL NOTE

This standard was developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member, as ìsubstantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.î Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAEís Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

When addenda or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE Home Page at *www.ashrae.org/STANDARDS/addenda.htm* or *www.ashrae.org/STANDARDS/intpstd.htm*.

1791 Tullie Circle NE
Atlanta, GA 30329
www.ashrae.org

CONTENTS

ANSI/ASHRAE/IESNA 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

SECTION **PAGE**

(This foreword is not part of this standard but is included for information purposes only.)

FOREWORD

The original Standard 90 was published in 1975 and again in 1980, 1989, and 1999 using the ANSI and ASHRAE periodic maintenance procedures. Thus, the entire standard was publicly reviewed and published in its entirety each time. As technology and energy prices are changing more rapidly, the ASHRAE Board of Directors voted in 1999 to place the standard on continuous maintenance.

This 2001 edition of the standard has several new features. The standard will now be issued on a regular three-year cycle. It will be published in its entirety every third year in the fall, starting in 2001. This schedule allows the standard to be submitted and proposed by the deadline for inclusion or reference in model building and energy codes. All approved addenda and errata will be included in the new edition every three years. It also allows users to have some certainty about when new editions will be published.

This is also the first time that the standard includes changes resulting from continuous maintenance proposals from the public. The committee welcomes suggestions for improving the standard. Users of the standard are encouraged and invited to use the continuous maintenance procedure to suggest changes. The form for Submittal of Proposed Change to ASHRAE Standard Under Continuous Maintenance is included in the back of this standard. The committee will take formal action on every proposal received.

The 2001 edition is the first version to be published using the ANSI and ASHRAE continuous maintenance procedures. Thus, the project committee is continually considering changes and proposing addenda for public review. When addenda are approved, notices will be published on the ASHRAE website. Users are encouraged to sign up for the free ASHRAE internet list server for this standard to receive notice of all public reviews and approved and published addenda and errata.

Changes from the previous 1999 edition of the standard are marked in the margins. A vertical line in the margin shows where something has been changed or added. An arrow in the margin shows where something has been deleted from the prior edition of the standard.

This edition corrects all known typographical errors in the 1999 standard. It includes the content of 34 addenda that were processed by the committee and approved by the ASHRAE and IESNA Boards of Directors.

1. PURPOSE

The purpose of this standard is to provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings.

2. SCOPE

2.1 This standard provides

a. minimum energy-efficient requirements for the design and construction of
   (1) new buildings and their systems,
   (2) new portions of buildings and their systems, and
   (3) new systems and equipment in existing buildings and

b. criteria for determining compliance with these requirements.

2.2 The provisions of this standard apply to

a. the envelope of buildings, provided that the enclosed spaces are
   (1) heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h·ft^2 or
   (2) cooled by a cooling system whose sensible output capacity is greater than or equal to 5 Btu/h·ft^2, and

b. the following systems and equipment used in conjunction with buildings:
   (1) heating, ventilating, and air conditioning,
   (2) service water heating,
   (3) electric power distribution and metering provisions,
   (4) electric motors and belt drives, and
   (5) lighting.

2.3 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),

b. buildings that do not use either electricity or fossil fuel, or

c. equipment and portions of building systems that use energy primarily to provide for industrial, manufacturing, or commercial processes.

2.4 Where specifically noted in this standard, certain other buildings or elements of buildings shall be exempt.

2.5 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 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 adopting authority.

3.2 Definitions

above-grade wall: see ***wall.***

access hatch: see ***door***.

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

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

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

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

application part-load value (APLV): a single number part-load efficiency figure of merit calculated in accordance with the method described in ARI Standard 550 or 590 referenced to modified rating conditions described in those standards.

attic and all other roofs: see ***roof***.

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

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

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

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

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

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

(a) ***electronic ballast:*** a ballast constructed using electronic circuitry.

(b) ***hybrid ballast:*** a ballast constructed using a combination of magnetic core and insulated wire winding and electronic circuitry.

(c) ***magnetic ballast:*** a ballast constructed with magnetic core and a winding of insulated wire.

below-grade wall: see ***wall***.

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

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

branch circuit: the circuit conductors between the final overcurrent device protecting the circuit and the outlet(s); the final wiring run to the load.

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

building: a structure wholly or partially enclosed within exterior walls, or within exterior and party walls, and a roof, affording shelter to persons, animals, or property.

building entrance: any doorway, set of doors, turnstiles, or other form of portal that is ordinarily used to gain access to the building by its users and occupants.

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

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

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

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

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

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

building official: the officer or other designated representative authorized to act on behalf of the authority having jurisdiction.

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

check metering: measurement instrumentation for the supplementary monitoring of equipment and tenant energy use (electric, gas, oil, etc.) in addition to the revenue metering furnished by the utility.

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

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

clerestory: that part of a building that rises clear of the roofs or other parts and whose walls contain windows for lighting the interior.

code official: see ***building official***.

coefficient of performance (COP)ó cooling: the ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.

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

color temperature: the absolute temperature (in degrees kelvin) of an incandescent blackbody radiator that radiates light of the same color. Lower color temperatures are near the red-orange end of the spectrum. Higher color temperatures are near the blue-violet end of the spectrum.

conditioned floor area: see ***floor area***.

conditioned space: see ***space***.

conductance: see ***thermal conductance***.

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

control: to regulate the operation of equipment.

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

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

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

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

cooled space: see ***space***.

cooling degree-day: see ***degree-day***.

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

cooling design wet-bulb temperature: the outdoor wet-bulb temperature for sizing cooling systems and evaporative heat rejection systems such as cooling towers.

current transformers: an electrical device used to convert large currents to proportionally smaller currents based on a given ratio; typically used for metering.

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

decorative lighting: see ***lighting, decorative***.

degree-day: the difference in temperature between the outdoor mean temperature over a 24-hour period and a given base temperature. For the purposes of determining building envelope requirements, the classifications are defined as follows:

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

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

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

Design A: National Electrical Manufacturers Association (NEMA) design class designations for standard general purpose polyphase squirrel-cage induction motors.

Design B: National Electrical Manufacturers Association (NEMA) design class designations for standard general purpose polyphase squirrel-cage induction motors.

Design E: National Electrical Manufacturers Association (NEMA) design class designations for standard general purpose polyphase squirrel-cage induction motors.

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

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

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

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

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

disconnect: a device or group of devices or other means by which the conductors of a circuit can be disconnected from their source of supply.

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

door: all operable opening areas (which are not fenestration) in the building envelope, including swinging and roll-up doors, fire doors, and access hatches. Doors that are more than one-half glass are considered fenestration. (See ***fenestration***.) For the purposes of determining building envelope requirements, the classifications are defined as follows:

(a) ***non-swinging:*** roll-up, sliding, and all other doors that are not swinging doors.

(b) ***swinging:*** all operable opaque panels with hinges on one side and opaque revolving doors.

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

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

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

economizer, water: a system by which the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling.

efficiency: performance at specified rating conditions.

electric meter: a mechanical/electrical device that can measure electric power.

electric supplier: an agency that sells and/or distributes electric power.

emergency power system: a system that is required by codes or other laws to automatically supply illumination or power or both in the event of failure of the normal supply or in the event of accidents to such systems. Such systems may also include standby loads incidental to system operations but shall not include systems for optional standby loads only.

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

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

enclosure: the case or housing of an apparatus, or the fence or walls surrounding an installation, to prevent personnel from accidentally contacting energized parts or protect equipment from physical damage.

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

energy cost budget: the annual energy cost for the budget building.

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

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

envelope performance factor: the trade-off value for the building envelope performance compliance option calculated using the procedures specified in Section 5. For the purposes of determining building envelope requirements, the classifications are defined as follows:

(a) ***base envelope performance factor:*** the building envelope performance factor for the base design.

(b) ***proposed envelope performance factor:*** the building envelope performance factor for the proposed design.

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

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

existing equipment: equipment previously installed in an existing building.

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

exfiltration: uncontrolled outward air leakage from inside a building including leakage through cracks and interstices around windows and doors and through any other exterior partition or penetration.

exterior building envelope: see ***building envelope***.

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

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

F-factor: the perimeter heat loss factor for slab-on-grade floors, expressed in Btu/h·ft·°F.

fan system energy demand (or fan system power): the sum of the nominal power demand (nameplate horsepower) of motors of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the conditioned space(s) and return it to the source or exhaust it to the outdoors.

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

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

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

(b) ***vertical fenestration:*** all fenestration other than skylights.

Trombe wall assemblies, where glazing is installed within 12 in. of a mass wall, are considered walls, not fenestration.

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

fenestration, vertical: (See ***fenestration*** and ***skylight***.)

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

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

(a) ***mass floor:*** a floor with a heat capacity that exceeds (1) 7 Btu/ft^2·°F or (2) 5 Btu/ft^2·°F provided that the floor has a material unit mass not greater than 120 lb/ft^3.

(b) ***steel joist floor:*** a floor that (1) is not a mass floor and (2) that has steel joist members supported by structural members.

(c) ***wood framed and other floors:*** all other floor types, including wood joist floors.

(See ***building envelope***, ***fenestration***, ***opaque area***, and ***slab-on-grade floo***r).

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

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

(b) ***gross conditioned floor area:*** the gross floor area of conditioned spaces.

(c) ***gross lighted floor area:*** the gross floor area of lighted spaces.

(d) ***gross semiheated floor area:*** the gross floor area of semiheated spaces.

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

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

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

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

general lighting: see ***lighting, general***.

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

glazed wall system: a category of site-assembled fenestration products, which includes, but is not limited to, curtainwalls and solariums.

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

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

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

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

gutter: the space available for wiring inside panel boards and other electric panels. A separate wireway used to supplement wiring spaces in electric panels.

harmonics: voltages and currents at frequencies other than 60 Hz (or 50 Hz where applicable) that cause heating and other detrimental effects in the power system.

harmonic losses: the wasting of electric energy (to heat) that occurs when harmonic currents are present in the power system.

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

heated space: see ***space***.

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

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

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

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

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

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

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

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

indirectly conditioned space: see ***space.***

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

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

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

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

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

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

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

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

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

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

(a) ***compact fluorescent lamp:*** a fluorescent lamp of a small compact shape, with a single base that provides the entire mechanical support function.
(b) ***fluorescent lamp:*** a low-pressure electric discharge lamp in which a phosphor coating transforms some of the ultraviolet energy generated by the discharge into light.
(c) ***general service lamp:*** a class of incandescent lamps that provide light in virtually all directions. General service lamps are typically characterized by bulb shapes such as A, standard; S, straight side; F, flame; G, globe; and PS, pear straight.
(d) ***high-intensity discharge (HID) lamp:*** an electric discharge lamp in that light is produced when an electric arc is discharged through a vaporized metal such as mercury or sodium. Some HID lamps may also have a phosphor coating that contributes to the light produced or enhances the light color.
(e) ***incandescent lamp:*** a lamp in which light is produced by a filament heated to incandescence by an electric current.
(f) ***reflector lamp:*** a class of incandescent lamps that have an internal reflector to direct the light. Reflector lamps are typically characterized by reflective characteristics such as R, reflector; ER, ellipsoidal reflector; PAR, parabolic aluminized reflector; MR, mirrorized reflector; and others.

lamp wattage, rated: the power consumption of a lamp as published in manufacturers' literature.

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

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

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

lighting power allowance:

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

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

lighting power density (LPD): the maximum lighting power per unit area of a building classification of space function.

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

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

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

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

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

mass floor: see ***floor***.

mass wall: see ***wall***.

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

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

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

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

metal building roof: see ***roof.***

metal building wall: see ***wall***.

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

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

nameplate rating: see marked (nameplate) rating.

nonautomatic: see ***manual***.

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

nonrenewable energy: energy derived from a fossil fuel source.

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

non-standard part load value (NPLV): a single number part-load efficiency figure of merit calculated and referenced to conditions other than IPLV conditions, for units that are not designed to operate at ARI Standard Rating Conditions.

non-swinging door: see ***door.***

north-oriented: facing within 45 degrees of true north (northern hemisphere).

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

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

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

orientation: the direction an envelope element faces, i.e., the direction of a vector perpendicular to and pointing away from the surface outside of the element. For vertical fenestration, the two categories are north-oriented and all other. (See ***north-oriented***.)

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

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

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

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

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

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

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

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

power factor: The ratio of total real power in watts to the apparent power (root-mean-square volt amperes).

primary air system: the central air-moving heating and cooling equipment that serves multiple zones through mixing boxes, VAV boxes, or reheat coils.

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

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

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

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

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

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

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

rated lamp wattage: see ***lamp wattage, rated***.

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

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

readily accessible: capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. In public facilities, accessibility may be limited to certified personnel through locking covers or by placing equipment in locked rooms.

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

recooling: lowering the temperature of air that has been previously heated by a mechanical heating system.

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

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

reheating: raising the temperature of air that has been previously cooled either by mechanical refrigeration or an economizer system.

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

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

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

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

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

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

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

(c) ***roof with insulation entirely above deck:*** a roof with all insulation (1) installed above (outside of) the roof structure and (2) continuous (i.e., uninterrupted by framing members).

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

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

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

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

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

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

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

semi-exterior building envelope: see ***building envelope.***

semiheated floor area: see ***floor area***.

semiheated space: see ***space***.

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

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

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

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

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

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

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

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

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

single-rafter roof: see ***roof***.

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

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

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

skylight: see ***fenestration***.

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

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

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

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

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

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

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

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

(1) ***cooled space:*** an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^2 of floor area.

(2) ***heated space:*** an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to the criteria in Table 3-2.

(3) ***indirectly conditioned space:*** an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided (a) the product of the U-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds the combined sum of the product of the U-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semiheated spaces (e.g., corridors) or (b) that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding 3 air changes per hour (ACH) (e.g., atria).

TABLE 3.2
Heated Space Criteria

Heating Output	Climate
Btu/h·ft^2	HDD65
5	0-1800
10	1801-3600
15	3601-7200
20	7201-10,800
25	10,801-16,200
30	16,201+

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

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

space-conditioning category: (1) nonresidential conditioned space, (2) residential conditioned space, and (3) nonresidential and residential semiheated space. (See ***nonresidential***, ***residential***, and ***space***.)

steel-framed wall: see ***wall***.

steel joist floor: see ***floor***.

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

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

swinging door: see ***door***.

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

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

tandem wiring: pairs of luminaires operating with lamps in each luminaire powered from a single ballast contained in one of the luminaires.

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

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

thermal conductance: see ***C-factor.***

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

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

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

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

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

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

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

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

unconditioned space: see ***space***.

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

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

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

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

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

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

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

vertical fenestration: see ***fenestration***.

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

wall: that portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of 60° from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors, and foundation walls. For the purposes of determining building envelope requirements, the classifications are defined as follows:

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

(b) ***below-grade wall:*** that portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground.

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

(d) ***metal building wall:*** a wall whose structure consists of metal spanning members supported by steel structural members (i.e., does not include spandrel glass or metal panels in curtain wall systems).

(e) ***steel-framed wall:*** a wall with a cavity (insulated or otherwise) whose exterior surfaces are separated by steel framing members (i.e., typical steel stud walls and curtain wall systems).

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

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

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

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

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

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

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

3.3 Abbreviations and Acronyms

ac	alternating current
ACH	air changes per hour
AFUE	annual fuel utilization efficiency
AHAM	Association of Home Appliance Manufacturers
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BSR	Board of Standards Review
Btu	British thermal unit
Btu/h	British thermal unit per hour
$Btu/ft^2\cdot°F$	British thermal unit per square foot per degree Fahrenheit
$Btu/h\cdot ft^2$	British thermal unit per hour per square foot
Btu/h·ft·°F	British thermal unit per hour per lineal foot per degree Fahrenheit
$Btu/h\cdot ft^2\cdot°F$	British thermal unit per hour per square foot per degree Fahrenheit
CDD	cooling degree-day
CDD50	cooling degree-days base 50°F
CE	combustion efficiency
cfm	cubic feet per minute
ci	continuous insulation
cont. ins.	continuous insulation
COP	coefficient of performance
CSA	Canadian Standards Association
CTI	Cooling Tower Institute
DDC	direct digital control
DOE	U.S. Department of Energy
DSM	demand-side management
EER	energy efficiency ratio
EF	energy factor
ENVSTD	Envelope System Performance Compliance Program
F	Fahrenheit
ft	foot
h	hour
HC	heat capacity
HDD	heating degree-day
HDD65	heating degree-days base 65°F
$h\cdot ft^2\cdot°F/Btu$	hour per square foot per degree Fahrenheit per British thermal unit
HID	high-intensity discharge
hp	horsepower
HSPF	heating seasonal performance factor
HVAC	heating, ventilating, and air conditioning
Hz	hertz
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IESNA	Illuminating Engineering Society of North America
in.	inch
IP	inch-pound
IPLV	integrated part-load value
K	kelvin
kg	kilogram
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
lb	pound
lin	linear
lin ft	linear foot
LPD	lighting power density
MICA	Midwest Insulation Contractors Association
NAECA	U.S. National Appliance Energy Conservation Act of 1987
NAGDM	National Association of Garage Door Manufacturers
NFPA	National Fire Protection Association
NFRC	National Fenestration Rating Council
NPLV	non-standard part load value
PF	projection factor
psig	pounds per square inch gauge
PTAC	packaged terminal air conditioner
PTHP	packaged terminal heat pump
R	R-value (thermal resistance)
R_c	thermal resistance of a material or construction from surface to surface
R_u	total thermal resistance of a material or construction including air film resistances
rpm	revolutions per minute

SC	shading coefficient
SEER	seasonal energy efficiency ratio
SHGC	solar heat gain coefficient
SL	standby loss
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
TE	thermal efficiency
T_{db}	dry-bulb temperature
T_{wb}	wet-bulb temperature
UL	Underwriters Laboratories Inc.
UV	ultraviolet
VAV	variable air volume
VLT	visible light transmittance
W	watt
W/ft^2	watts per square foot
Wh	watthour

4. ADMINISTRATION AND ENFORCEMENT

4.1 Compliance Requirements

4.1.1 New *Buildings*. New ***buildings*** shall comply with either the provisions of Sections 5, 6, 7, 8, 9, and 10, or Section 11.

4.1.2 Existing *Buildings*. Additions to existing buildings shall comply with either the provisions of Sections 5, 6, 7, 8, 9, and 10 or Section 11, as described in 4.1.2.1. Alterations of existing buildings shall comply with either the provisions of Sections 5, 6, 7, 8, 9, and 10, or Section 11, as described in 4.1.2.2, provided, however, that nothing in this standard shall require compliance with any provision of this standard if such compliance will result in an increase in the annual energy consumption of the building.

4.1.2.1 Additions to Existing *Buildings*. An extension or increase in floor area or height of a building outside of the existing building envelope shall comply with the provisions of Sections 5, 6, 7, 8, 9, and 10, applicable to ***building envelope***, heating, ventilating, air-conditioning***, service water heating***, power, lighting, and other ***systems*** and ***equipment.*** Alternatively, ***additions*** shall comply with the provisions of Section 11.

Exceptions to 4.1.2.1:

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

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

4.1.2.2 Alterations to Existing Buildings. Portions of a building envelope, heating, ventilating, air-conditioning, service water heating, power, lighting, and other systems and equipment that are being replaced shall comply with the applicable requirements of Sections 5, 6, 7, 8, 9, and 10 as provided in 4.1.2.2.1 through 4.1.2.2.6.

Exceptions to 4.1.2.2:

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

(b) Where one or more components of an existing building or portions thereof is being replaced, the annual energy consumption of the comprehensive proposed design shall not be greater than the annual energy consumption of a substantially indentical design, using the same energy types, in which the individual components comply with the applicable requirements of Sections 5, 6, 7, 8, 9, and 10 as provided in 4.1.2.2.1 through 4.1.2.2.6, and such compliance is verfied by a ***design professional***, by the use of any calculation methods acceptable to the ***authority having jurisdiciton***.

4.1.2.2.1 Envelope Alterations. *Alterations* to the ***building envelope*** shall comply with the requirements of Section 5 for insulation, moisture control, air leakage, and ***fenestration*** applicable to those specific portions of the building that are being altered.

Exceptions to 4.1.2.2.1: The following ***alterations*** need not comply with these requirements, provided such ***alterations*** will not increase the energy usage of the building:

(a) installation of storm windows over existing glazing,

(b) replacement of glazing in existing sash and frame provided the ***U-factor*** and ***SHGC*** will be equal to or lower than before the glass replacement,

(c) alterations to roof/ceiling, wall, or floor cavities, which are insulated to full depth with insulation having a minimum nominal value of R-3.0/in.,

(d) alterations to walls and floors, where the existing structure is without framing cavaties and no new framing cavities are created, or

(e) replacement of a roof membrane where either the roof sheathing or roof insulation is not exposed or, if there is existing roof insulation, below the roof deck,

(f) replacement of existing doors that separate conditioned space from the exterior shall not require the installation of a vestibule or revolving door, provided, however, that an existing vestibule that separates a conditioned space from the exterior shall not be removed, and

(g) replacement of existing fenestration, provided, however, that the area of the replacement fenestration does not exceed 25% of the total fenestration area of an existing building and that the ***U-factor*** and ***SHGC*** will be equal to or lower than before the fenestration replacement.

4.1.2.2.2 Heating, Ventilating, and Air-Conditioning Alterations. New HVAC equipment as a direct replacement of existing HVAC equipment shall comply with the specific minimum efficiency requirements applicable to that equipment, including, but not limited to, air conditioners and condensing units, heat pumps, water chilling packages, packaged terminal and room air conditioners and heat pumps, furnaces, duct furnaces, unit heaters, boilers, and cooling towers. New cooling systems installed to serve previously uncooled spaces shall comply with Section 6. Alterations to existing cooling systems shall not decrease economizer capability unless the system complies with 6.3.1. New and replacement ductwork shall comply with 6.2.4.1, 6.2.4.2, and 6.2.4.3. New and replacement piping shall comply with 6.2.4.1 and 6.2.4.5.

Exceptions to 4.1.2.2.2: Compliance shall not be required

(a) for ***equipment*** that is being modified or repaired but not replaced, provided that such modifications and/or repairs will not result in an increase in the annual energy consumption of the equipment using the same energy type, or

(b) where a replacement or ***alteration*** of ***equipment*** requires extensive revisions to other ***systems***, ***equipment***, or elements of a ***building,*** and such replaced or altered equipment is a like-for-like replacement, or

(c) for a refrigerant change of existing ***equipment***, or

(d) for the relocation of existing ***equipment***, or

(e) for ducts and pipes where there is insufficient space or access to meet these requirements.

4.1.2.2.3 Service Water Heating Alterations. Building service water heating equipment installed as a direct replacement for existing building service water heating equipment shall comply with the requirements of Section 7 applicable to being replaced. New and replacement piping shall comply with 7.2.3.

Exception to 4.1.2.2.3: Compliance shall not be required where there is insufficient space or access to meet these requirements.

4.1.2.2.4 Power Alterations. Building electrical ***systems*** that are replaced shall comply with the requirements of Section 8, applicable to those specific portions of the ***building*** and its electrical ***systems*** that are being replaced.

4.1.2.2.5 Lighting Alterations. The replacement of lighting ***systems*** in any building space shall comply with the lighting power density requirements of Section 9 applicable to that space. New lighting ***systems*** shall comply with the applicable lighting power density requirements of Section 9. Any new ***control devices*** as a direct replacement of existing ***control devices*** shall comply with the specific requirements of 9.2.1.2(a) and 9.2.1.2(c).

Exception to 4.1.2.2.5: ***Alterations*** that replace less than 50% of the ***luminaires*** in a ***space*** need not comply with these requirements provided that such ***alterations*** do not increase the installed interior lighting power.

4.1.2.2.6 Other Equipment Alterations. ***Alterations*** to other ***building equipment*** or ***systems*** shall comply with the requirements of Section 10 applicable to those specific portions of the ***building*** and its ***systems*** that are being altered. Any new ***equipment*** subject to the requirements of Section 10 that is installed in conjunction with the ***alteration*** as a direct replacement of existing ***equipment*** or ***control devices*** shall comply with the specific requirements applicable to that ***equipment*** or ***control devices*** provided, however, that compliance shall not be required for the relocation or reuse of existing equipment.

4.1.2.3 Changes in Space Conditioning. Whenever unconditioned or semi-heated ***spaces*** in a building are converted to conditioned spaces, such conditioned ***spaces*** shall be brought into compliance with all applicable requirements of this standard that would apply to the ***building envelope***, heating, ventilating, air-conditioning, ***service water heating***, power, lighting, and other ***systems*** and ***equipment*** of the ***space*** as if the building were new.

4.2 Administrative Requirements.

Administrative requirements relating to permit requirements, enforcement by the ***authority having jurisdiction***, locally adopted energy standards, interpretations, claims of exemption, and rights of appeal are specified by the ***authority having jurisdiction.***

4.3 Compliance Documents

4.3.1 General. Compliance documents are those plans, specifications, engineering calculations, diagrams, reports, and other data that are approved as part of the permit by the ***authority having jurisdiction.***

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

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

4.4 Labeling of Materials and Equipment

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

4.4.2 Fenestration. The ***U-factor, SHGC,*** and air leakage rate for all manufactured ***fenestration*** products shall be identified on a permanent nameplate installed on the product by the manufacturer. Alternatively, when fenestration products do not have such nameplate, the installer or supplier of such fenestration shall provide a signed and dated certification for the installed fenestration listing the ***U-factor***, SHGC, and air leakage rate.

4.4.3 Doors. The ***U-factor*** and the air leakage rate for all manufactured ***doors*** installed between ***conditioned space***, ***semi-heated space***, ***unconditioned space***, and exterior ***space*** as outlined in 5.1.1 shall be identified on a permanent nameplate installed on the product by the manufacturer. Alternatively, when doors do not have such nameplate, the installer or supplier of any such doors shall provide a signed and dated certification for the installed doors listing the ***U-factor*** and the air leakage rate.

4.4.4 Building Envelope Insulation. The ***rated R-value*** shall be clearly identified by an identification mark applied by the manufacturer to each piece of ***building envelope*** insulation. Alternatively, when insulation does not have such an identification mark, the installer of such insulation shall provide a signed and dated certification for the installed insulation listing the type of insulation, the manufacturer, the ***rated R-value***, and, where appropriate, the initial installed thickness, the settled thickness, and the coverage area.

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

4.4.6 Packaged Terminal Air Conditioners. Packaged terminal air conditioners and heat pumps with sleeve sizes less than 16 in. high and 42 in. wide shall be factory labeled as follows: ***Manufactured for replacement applications only: not to be installed in new construction projects.***

4.4.7 Transformers. The energy-efficiency level shall be identified on a permanent nameplate installed on the ***transformer*** by the manufacturer.

4.5 Alternative Materials, Methods of Construction, or Design. The provisions of this standard are not intended to prevent the use of any material, method of construction, design, equipment, or ***building*** system not specifically prescribed herein.

4.6 Inspections. All building construction, ***additions,*** or ***alterations*** subject to the provisions of this standard shall be subject to inspection by the ***building official***, and all such work shall remain accessible and exposed for inspection purposes until approved in accordance with procedures specified by the building official. Items for inspection include at least the following:

a. wall insulation after wall insulation and vapor retarder are in place but before concealment,
b. roof/ceiling insulation after roof/ceiling insulation is in place but before concealment,
c. slab/foundation wall after slab/foundation wall insulation is in place but before concealment,
d. ***fenestration*** after all glazing materials are in place,
e. mechanical ***systems, equipment,*** and insulation after installation but before concealment, and
f. electrical ***equipment*** and ***systems*** after installation but before concealment.

4.7 Referenced Standards. The standards referenced in this standard and listed in Section 12 shall be considered part of the requirements of this standard to the prescribed extent of such reference. Where differences occur between the provisions of this standard and referenced standards, the provisions of this standard shall apply. Informative references are cited to acknowledge sources and are not part of this standard. They are identified in Informative Appendix E.

4.8 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.

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

4.10 Validity. If any term, part, provision, section, paragraph, subdivision, table, chart, or referenced standard of this standard shall be held unconstitutional, invalid, or ineffective in whole or in part, such determination shall not be deemed to invalidate any remaining terms, parts, provisions, sections, paragraphs, subdivisions, tables, or charts of this standard.

4.11 Manuals. Operating and maintenance information shall be provided to the building owner. This information shall include, but not be limited to, the information specified in 6.2.5.2 and 8.2.2.2.

4.12 Other Laws. The provisions of this standard shall not be deemed to nullify any provisions of local, state, or federal law. Where there is a conflict between a requirement of this standard and such other law affecting construction of buildings, precedence shall be determined by the ***authority having jurisdiction.***

5. BUILDING ENVELOPE

5.1 General

5.1.1 Building Envelope Scope. Section 5 specifies requirements for the ***exterior building envelope***, which separates ***conditioned space*** from the exterior.

Exceptions to 5.1.1: For buildings that contain ***spaces*** that will be only ***semi-heated*** or ***unconditioned***, and if alternative compliance is sought for such spaces, then Section 5 also specifies requirements for the ***semi-exterior building envelope***, which separates

(a) ***conditioned space*** from either ***semiheated space*** or ***unconditioned space***,

(b) ***semiheated space*** from either ***unconditioned space*** or from the exterior.

Section 5 does not address moisture control or provide design guidelines to prevent moisture migration that leads to condensation, mold and mildew, or deterioration to insulation or equipment performance.

5.1.2 Compliance. For the appropriate climate, ***space-conditioning category***, and ***class of construction***, the ***building envelope*** shall comply with

a. 5.1, General,

b. 5.2, Mandatory Provisions, and

c. either

1. 5.3, Prescriptive Building Envelope Option, provided that
   (a) the ***vertical fenestration area*** does not exceed 50% of the ***gross wall area*** for each ***space-conditioning category*** and
   (b) the ***skylight fenestration area*** does not exceed 5% of the ***gross roof area*** for each ***space-conditioning category***,

or

2. 5.4, Building Envelope Trade-Off Option.

5.1.3 Climate. The climate shall be determined based on the ***cooling degree-days base 50 F, CDD50,*** and ***heating degree-days base 65 F, HDD65***.

5.1.3.1 Locations Listed. For those locations listed in Normative Appendix D, use the published climatic data to determine compliance. In the case of cities or urban regions with several climatic data entries, the designer shall select the location within the region or city that best represents the climate of the construction site.

5.1.3.2 Locations Not Listed. For locations not listed in Normative Appendix D, designers shall select the location that best represents the climatic conditions of the construction site being analyzed to determine compliance. If there are recorded historical climatic data available for a construction site, they may be used to determine compliance if approved by the building official.

5.1.4 Envelope Requirements Are Specified by Space-Conditioning Categories. Separate ***exterior building envelope*** requirements are specified for each of two categories of conditioned space:

a. nonresidential conditioned space,

b. residential conditioned space.

Spaces shall be assumed to be ***conditioned space*** and shall comply with the requirements for ***conditioned space*** at the time of construction, regardless of whether mechanical or electrical equipment is included in the building permit application or installed at that time.

Exceptions to 5.1.4: For buildings that contain ***spaces*** that will be only ***semi-heated*** or ***unconditioned***, and if alternative compliance is sought for such spaces, then all ***semi-heated*** or ***unconditioned*** spaces shall be clearly indicated on the floor plan as such, and the following ***semi-exterior building envelope*** requirements apply:

(a) If a ***space*** will be only ***semiheated,*** the ***space*** shall be considered ***semiheated***.

(b) If a ***space*** will remain ***unconditioned,*** the ***space*** shall be considered ***unconditioned***.

In climates that exceed 1800 ***HDD 65***, a space may be designated as either ***semiheated*** or ***unconditioned*** only if approved by the ***building official***.

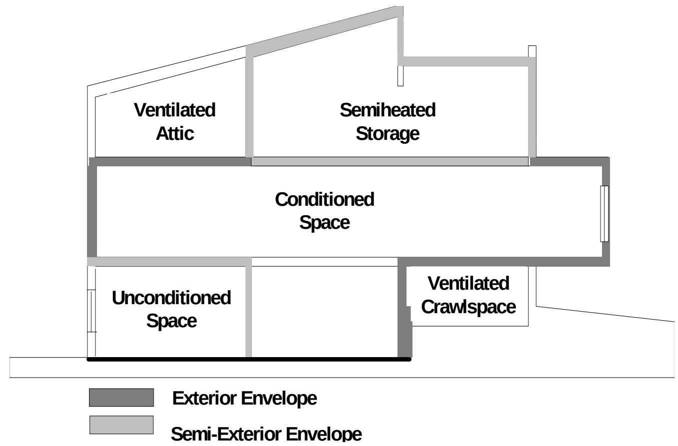

Figure 5.3 Building Envelope

5.2 Mandatory Provisions

5.2.1 Insulation General. Where insulation is required in 5.3 or 5.4, it shall also comply with 5.5.1.1 through 5.5.1.5.

5.2.2 Fenestration and doors shall comply with 5.5.2.

5.2.3 Air Leakage.

5.2.3.1 Building Envelope Sealing. Building envelope sealing shall comply with 5.5.3.1, air leakage for fenestration and doors shall comply with 5.5.3.2, loading dock weather seals shall comply with 5.5.3.3, and vestibules shall comply with 5.5.3.4.

5.3 Prescriptive Building Envelope Option

For ***conditioned space***, the ***exterior building envelope*** shall comply with either the "nonresidential" or "residential" requirements in Table 5.3 (located in Normative Appendix B) for the appropriate climate.

(Table 5.3: When adopted the appropriate tables are to be inserted here by the adopting jurisdiction (state, province, county, city, etc.). Only a limited number of tables in Normative Appendix B are applicable to any one particular jurisdiction. The remainder of Normative Appendix B need not be adopted. See Appendix B for the process to select the applicable tables. Then, select the actual tables from the Normative Appendix B and insert them here: An example table is shown on the next page.)

If a building contains any semiheated space or unconditioned space, as noted in the exceptions to 5.1.1, then the ***semi-exterior building envelope*** shall comply with the requirements for ***semiheated space*** in Table 5.3 for the appropriate climate. (See Figure 5.3, Exterior and Semi-Exterior Building Envelope.)

5.3.1 Opaque Areas. Opaque surfaces shall comply with the following sections:

a. **Roof Insulation** shall comply with 5.3.1.1,

b. **Above-Grade Wall Insulation** shall comply with 5.3.1.2,

c. **Below-Grade Wall Insulation** shall comply with 5.3.1.3,

d. **Floor Insulation** shall comply with 5.3.1.4,

e. **Slab-On-Grade Floor Insulation** shall comply with 5.3.1.5,

f. **Opaque doors** shall comply with 5.3.1.6.

TABLE 5.3
Example Building Envelope Requirements
(Values can be found in the appropriate tables in Normative Appendix B)

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely Above Deck	U-	R-	U-	R-	U-	R-
Metal Building	U-	R-	U-	R-	U-	R-
Attic and Other	U-	R-	U-	R-	U-	R-
Walls, Above Grade						
Mass	U-	R-	U-	R-	U-	R-
Metal Building	U-	R-	U-	R-	U-	R-
Steel Framed	U-	R-	U-	R-	U-	R-
Wood Framed and Other	U-	R-	U-	R-	U-	R-
Walls, Below Grade						
Below-Grade Wall	C-	R-	C-	R-	C-	R-
Floors						
Mass	U-	R-	U-	R-	U-	R-
Steel Joist	U-	R-	U-	R-	U-	R-
Wood Framed and Other	U-	R-	U-	R-	U-	R-
Slab-On-Grade Floors						
Unheated	F-	R-	F-	R-	F-	R-
Heated	F-	R-	F-	R-	F-	R-
Opaque Doors						
Swinging	U-		U-		U-	
Non-Swinging	U-		U-		U-	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-
	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-
10.1-20.0%	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-
	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-
20.1-30.0%	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-
	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-
30.1-40.0%	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-
	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-
40.1-50.0%	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-	U_{fixed}-	$SHGC_{all}$-
	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-	U_{oper}-	$SHGC_{north}$-
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-
2.1-5.0%	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-
2.1-5.0%	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-
2.1-5.0%	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-	U_{all}-	$SHGC_{all}$-

Note to adopting authority: Insert appropriate tables here from Appendix B.

For all opaque sufaces except doors, compliance shall be demonstrated by one of the following three methods:

(1) Compliance with the minimum ***rated R-values of insulation*** shall be demonstrated for the thermal resistance of the added insulation in framing cavities and ***continuous insulation*** only. ***Rated R-values of insulation*** shall not include the thermal transmittance of other ***building materials*** or air films. Insulation shall extend over the full component area to the intended ***rated R-value of insulation*** unless otherwise allowed in 5.2.1. If NR appears in a table, there are no insulation requirements for that ***class of construction*** and ***space-conditioning category***. This option does not apply to ***opaque doors***.

(2) Compliance shall be shown with the maximum ***U-factor, C-factor,*** or ***F-factor*** for the entire assembly in Table 5.3 for the component in lieu of complying with the minimum ***rated R-value of insulation*** for the insulation alone. ***U-factors, C-factors,*** and ***F-factors*** for typical construction assemblies are included in Normative Appendix A, and these values shall be used to determine compliance. For assemblies significantly different from those in Normative Appendix A, calculations shall be performed in accordance with the procedures required in Normative Appendix A. If NR appears in a table in the minimum insulation column, there are also no maximum U-factor, C-factor, or F-factor requirements for the entire assembly for that class of construction and space-conditioning category for the prescriptive option in 5.3. However, the U-factor, C-factor, or F-factor specified is the basis for the trade-off option in 5.4.

(3) If there are multiple assemblies within a single ***class of construction*** for a single ***space-conditioning category***, compliance shall be shown for an area-weighted average ***U-factor, C-factor,*** or ***F-factor***. It is not acceptable to do an area-weighted average for the ***rated R-value of insulation*** or to do an area-weighted average across multiple ***classes of construction*** or multiple ***space-conditioning categories***.

5.3.1.1 Roof Insulation. All ***roofs***, including ***roofs with insulation entirely above deck, metal building roofs,*** and ***attics and other roofs,*** shall have a ***rated R-value of insulation*** not less than that specified in Table 5.3. ***Skylight*** curbs shall be insulated to the level of ***roofs with insulation entirely above the deck*** or R-5, whichever is less.

a. For ***roofs with insulation entirely above deck***, the ***rated R-value of insulation*** is for ***continuous insulation***. Interruptions presented by framing and pads for mechanical equipment with the combined total area no greater than one percent of the opaque assembly area shall be permitted.

b. For ***metal building roofs***, the first ***rated R-value of insulation*** is for insulation draped over purlins and then compressed when the metal spanning members are attached, or for insulation hung between the purlins, provided there is a minimum 1 in. thermal break between the purlins and the metal spanning members. For double-layer installations, the second ***rated R-value of insulation*** is for insulation installed parallel to the purlins. For continuous insulation (e.g., insulation boards), it is assumed that the insulation boards are installed below the purlins and are uninterrupted by framing members. Insulation exposed to the ***conditioned space*** or ***semiheated space*** shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

c. For ***attics and other roofs,*** the ***rated R-value of insulation*** is for insulation installed both inside and outside the roof, or entirely inside the roof cavity, and it allows occasional interruption by framing members but requires that the framing members be covered with insulation when the depth of the insulation exceeds the depth of the framing cavity. Insulation in attics and other roofs shall be permitted to be tapered at the eaves where the building structure does not allow full depth. For ***single-rafter roofs***, the requirement is the lesser of the values for ***attics and other roofs*** and those listed in Table 5.3.1.1A.

Exception to 5.3.1.1: For roofs where the exterior surface has a minimum total solar reflectance of 0.70 when tested in accordance with one of the solar reflectance test methods listed below, and has a minimum thermal emittance of 0.75 when tested in accordance with one of the thermal emittance test methods listed below, other than roofs with ventilated attics or roofs with semiheated spaces, the U-factor of the proposed roof shall be permitted to be adjusted using Equation 5-1 for demonstrating compliance:

$$U_{roofadj} = U_{roofproposed} \times Factor_{roofmultiplier} \quad (5\text{-}1)$$

where:

$U_{roofadj}$	=	the adjusted roof U-factor for use in demonstrating compliance.
$U_{roofproposed}$	=	the U-factor of the proposed roof, as designed.
$Factor_{roofmultiplier}$	=	the roof U-factor multiplier from Table 5.3.1.1B.

Solar Reflectance Test Methods: ASTM E903, ASTM E1175, or ASTM E1918.

Thermal Emittance Test Methods: ASTM C835, ASTM C1371, or ASTM E408.

5.3.1.2 Above-Grade Wall Insulation. All ***above-grade walls,*** including ***mass walls, metal building walls, steel-framed walls,*** and ***wood-framed and other walls,*** shall have a ***rated R-value of insulation*** not less than that specified in Table 5.3. Mass wall heat capacity shall be determined from Table A-6 or A-7, as appropriate.

a. For ***mass walls***, the ***rated R-value of insulation*** is for ***continuous insulation*** uninterrupted by framing other than 20 gauge 1 in. metal clips spaced no closer than 24 in. on center horizontally and 16 in. on center vertically. Where other framing, including metal and wood studs, is used, compliance shall be based on the maximum assembly ***U-factor***. Where ***rated R-value of insulation*** is used for concrete sandwich panels, the insulation shall be continuous throughout the entire panel.

TABLE 5.3.1.1A
Single Rafter Roofs

	Minimum Insulation R-Value or Maximum Assembly U-Factor		
	Wood Rafter Depth, *d* (actual)		
HDD65	***d*** ≤ 8 in.	8 < ***d*** ≤ 10 in.	10 < ***d*** ≤ 12 in.
0-12,600	R-19 U-0.055	R-30 U-0.036	R-38 U-0.028
>12,600	R-21 U-0.052	R-30 U-0.036	R-38 U-0.028

TABLE 5.3.1.1B
Roof U-Factor Multipliers for Exception to 5.3.1.1

HDD65	Roof U-Factor Multiplier
0-900	0.77
901-1800	0.83
1801-2700	0.85
2701-3600	0.86
>3600	1.00

Exception to 5.3.1.2a: Alternatively, for ***mass walls***, where the requirement in the table is for a maximum assembly U-0.151 followed by an asterisk only, ASTM C90 concrete block walls, ungrouted or partially grouted at 32 in. or less on center vertically and 48 in. or less on center horizontally, shall have ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu·in./h·ft^2·°F. Other ***mass walls*** with integral insulation shall meet the criteria when their ***U-factors*** are equal to or less than those for the appropriate thickness and density in the "Partly Grouted Cells Insulated" column of Table A-7.

b. For ***metal building walls***, the first ***rated R-Value of insulation*** is for insulation compressed between metal wall panels and the steel structure. For double-layer installations, the second ***rated R-value of insulation*** is for insulation installed from the inside, covering the girts. For continuous insulation (e.g., insulation boards) it is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the ***conditioned space*** or ***semiheated space*** shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

c. For ***steel-framed walls***, the first ***rated R-value of insulation*** is for uncompressed insulation installed in the cavity between steel studs. It is acceptable for this insulation to also be ***continuous insulation*** uninterrupted by framing. If there are two values, the second ***rated R-value of insulation*** is for ***continuous insulation*** uninterrupted by framing, etc., to be installed in addition to the first insulation. Opaque mullions in spandrel glass shall be covered with insulation complying with the steel-framed wall requirements.

d. For ***wood-framed and other walls***, the first ***rated R-value of insulation*** is for uncompressed insulation installed in the cavity between wood studs. It is acceptable for this insulation to also be ***continuous insulation*** uninterrupted by framing. If there are two values, the second ***rated R-value of insulation*** is for ***continuous insulation*** uninterrupted by framing, etc., to be installed in addition to the first insulation.

When a ***wall*** consists of both ***above-grade*** and ***below-grade*** portions, the entire ***wall*** for that story shall be insulated on either the exterior or the interior or be integral. If insulated on the interior, the ***wall*** shall be insulated to the ***above-grade wall*** requirements. If insulated on the exterior or integral, the ***below-grade wall*** portion shall be insulated to the ***below-grade wall*** requirements, and the ***above-grade wall*** portion shall be insulated to the ***above-grade wall*** requirements.

5.3.1.3 Below-Grade Wall Insulation. ***Below-grade walls*** shall have a ***rated R-value of insulation*** not less than that specified in Table 5.3. For ***below-grade walls***, the ***rated R-value of insulation*** is for ***continuous insulation*** uninterrupted by framing. Where framing, including metal and wood studs, is used, compliance shall be based on the maximum assembly ***C-factor***.

5.3.1.4 Floor Insulation. All ***floors***, including ***mass floors, steel joist floors,*** and ***wood-framed and other floors***, shall have a ***rated R-value of insulation*** not less than that specified in Table 5.3.

a. For ***mass floors***, the ***rated R-value of insulation*** is for ***continuous insulation*** uninterrupted by framing. Where framing, including metal and wood joists, is used, compliance shall be based on the maximum assembly ***U-factor*** rather than the minimum ***rated R-value of insulation***. For waffle-slab ***floors***, the ***floor*** shall be insulated either on the interior above the slab or on all exposed surfaces of the waffle. For ***floors*** with beams that extend below the floor slab, the ***floor*** shall be insulated either on the interior above the slab or on the exposed floor and all exposed surfaces of the beams that extend 24 in. and less below the exposed floor.

b. For ***steel joist floors***, the first ***rated R-value of insulation*** is for uncompressed insulation installed in the cavity between steel joists or for spray-on insulation. It is acceptable for this insulation to also be ***continuous insulation*** uninterrupted by framing. All ***continuous insulation*** shall be installed either on the interior above the floor structure or below a framing cavity completely filled with insulation.

c. For ***wood-framed and other floors***, the first ***rated R-value of insulation*** is for uncompressed insulation installed in the cavity between wood joists. It is acceptable for this insulation to also be ***continuous insulation*** uninterrupted by framing. All ***continuous insulation*** shall be installed either on the interior above the floor structure or below a framing cavity completely filled with insulation.

5.3.1.5 Slab-on-Grade Floor Insulation. All ***slab-on-grade floors***, including ***heated slab-on-grade floors*** and

unheated slab-on-grade floors, shall have a ***rated R-value of insulation*** not less than that specified in Table 5.3 and shall be installed around the perimeter of the ***slab-on-grade floor*** to the distance specified. Perimeter insulation installed inside the foundation wall shall extend downward from the top of the slab a minimum of the distance specified or to the top of the footing, whichever is less. Perimeter insulation installed outside the foundation wall shall extend from the top of the slab, or downward to at least the bottom of the slab and then horizontally to a minimum of the distance specified. In all climates, the horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 10 in. thick.

Exception to 5.3.1.5: For a monolithic ***slab-on-grade floor***, the insulation shall extend from the top of the slab-on-grade to the bottom of the footing.

5.3.1.6 Opaque Doors. All ***opaque doors***, including ***swinging doors*** and ***non-swinging doors***, shall have a ***U-factor*** not greater than that specified in Table 5.3.

5.3.2 Fenestration. Compliance with ***U-factors*** and ***solar heat gain coefficient (SHGC)*** shall be demonstrated for the overall fenestration product, including glass, sash, and frame, as provided in 5.2.2. Gross wall areas and gross roof areas shall be calculated separately for each ***space-conditioning category*** for the purposes of determining compliance.

Exception to 5.3.2: Alternatively, if there are multiple assemblies within a single ***class of construction*** for a single ***space-conditioning category***, compliance shall be based on an area-weighted average ***U-factor*** or ***SHGC***. It is not acceptable to do an area-weighted average across multiple ***classes of construction*** or multiple ***space-conditioning categories***.

5.3.2.1 Fenestration Area. The total ***vertical fenestration area***, including both fixed ***vertical fenestration*** and operable ***vertical fenestration***, shall be less than 50% of the ***gross wall area***. The total ***skylight area***, including glass ***skylights***, plastic ***skylights*** with a curb, and all ***skylights*** without a curb, shall be less than 5% of the ***gross roof area***.

Exception to 5.3.2.1: ***Vertical fenestration*** complying with Exception (c) to 5.3.2.3.

5.3.2.2 Fenestration U-Factor. ***Fenestration***, including fixed ***vertical fenestration***, operable ***vertical fenestration***, glass ***skylights*** with a curb, plastic ***skylights*** with a curb, and all ***skylights*** without a curb shall have a ***U-factor*** not greater than that specified in Table 5.3 for the appropriate ***fenestration area***. ***U-factor*** for ***fenestration*** shall be determined in accordance with 5.2.2.

Exception to 5.3.2.2: ***Vertical fenestration*** complying with Exception (c) to 5.3.2.3 shall have a ***U-factor*** not greater than that specified for 40% of the ***gross wall area***.

5.3.2.3 Fenestration Solar Heat Gain Coefficient (SHGC). ***Vertical fenestration*** shall have an ***SHGC*** not greater than that specified for "all" orientations in Table 5.3 for the appropriate total ***vertical fenestration area***. ***Skylights***, including glass ***skylights*** with a curb, plastic ***skylights*** with a curb, and all ***skylights*** without a curb, shall have an ***SHGC*** not greater than that specified for "all" orientations in Table 5.3 for the appropriate total ***skylight area***. ***SHGC*** for ***fenestration*** shall be determined in accordance with 5.2.2. There are no ***SHGC*** requirements for ***semiheated spaces*** or for buildings in climates with greater than 10800 HDD65.

Exceptions to 5.3.2.3:

(a) Alternatively, in latitudes greater than 10 degrees, the ***SHGC*** for ***north-oriented vertical fenestration*** shall be calculated separately and shall not be greater than that specified in Table 5.3 for ***north-oriented fenestration***. When this exception is used, the ***fenestration area*** used in selecting the criteria shall be calculated separately for ***north-oriented*** and all other-oriented ***fenestration***.

Note to adopting authority: If the project is in the southern hemisphere, change north to south.

TABLE 5.3.2.3
SHGC Multipliers for Permanent Projections

Projection Factor	SHGC Multiplier (All Other Orientations)	SHGC Multiplier (North-Oriented)
0 - 0.10	1.00	1.00
<0.10 - 0.20	0.91	0.95
<0.20 - 0.30	0.82	0.91
<0.30 - 0.40	0.74	0.87
<0.40 - 0.50	0.67	0.84
<0.50 - 0.60	0.61	0.81
<0.60 - 0.70	0.56	0.78
<0.70 - 0.80	0.51	0.76
<0.80 - 0.90	0.47	0.75
<0.90 - 1.00	0.44	0.73

(b) For demonstrating compliance for ***vertical fenestration*** only, the ***SHGC*** in the proposed building shall be reduced by using the multipliers in Table 5.3.2.3 for each ***fenestration*** product shaded by permanent projections that will last as long as the building itself.

(c) ***Vertical fenestration*** that is located on the street side of the street-level story only, provided that

1. the street side of the street-level story does not exceed 20 ft in height,
2. the ***fenestration*** has a continuous overhang with a weighted average ***projection factor*** greater than 0.5, and
3. the ***fenestration area*** for the street side of the street-level story is less than 75% of the ***gross wall area*** for the street side of the street-level story.

When this exception is utilized, separate calculations shall be performed for these sections of the ***building envelope,*** and these values shall not be averaged with any others for compliance purposes. No credit shall be given here or elsewhere in the building for not fully utilizing the ***fenestration area*** allowed. This exception does not apply to the ***building envelope*** trade-off option in 5.4 or the energy cost budget option in 11.

5.3.2.4 Visible Light Transmittance (VLT). There are no minimum visible light transmittance criteria in the Prescriptive Building Envelope Option; however, there are minimum criteria in the Building Envelope Trade-Off Option.

5.4 Building Envelope Trade-Off Option

The ***building envelope*** complies with the standard if the proposed building satisfies the provisions of 5.1 and 5.2 and the ***envelope performance factor*** of the proposed building is less than or equal to the ***envelope performance factor*** of the budget building. The ***envelope performance factor*** considers only the ***building envelope*** components. Schedules of operation, lighting power, equipment power, occupant density, and mechanical systems shall be the same for both the proposed building and the budget building. ***Envelope performance factor*** shall be calculated using the procedures of Normative Appendix C.

5.5 Mandatory Provisions

5.5.1 Insulation General

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

Open-blown or poured loose-fill insulation shall not be used in ***attic roof*** spaces when the slope of the ceiling is more than three in twelve. When eave vents are installed, baffling of the vent openings shall be provided to deflect the incoming air above the surface of the insulation.

Exception to 5.5.1.1: Where ***metal building roof*** and ***metal building wall*** insulation is compressed between the ***roof*** or ***wall*** skin and the structure.

5.5.1.2 Substantial Contact. Insulation shall be installed in a permanent manner in ***substantial contact*** with the inside surface in accordance with manufacturer's recommendations for the framing system used. Flexible batt insulation installed in floor cavities shall be supported in a permanent manner by supports no greater than 24 in. on center.

Exception to 5.5.1.2: Insulation materials that rely on air-spaces adjacent to reflective surfaces for their rated performance.

5.5.1.3 Recessed Equipment. Lighting fixtures; heating, ventilating, and air-conditioning equipment, including wall heaters, ducts, and plenums; and other equipment shall not be recessed in such a manner as to affect the insulation thickness unless:

a. the total combined area affected (including necessary clearances) is less than one percent of the opaque area of the assembly, or

b. the entire ***roof***, ***wall***, or ***floor*** is covered with insulation to the full depth required, or

c. the effects of reduced insulation are included in calculations using an area-weighted average method and compressed insulation values obtained from Table A-24.

In all cases, air leakage through or around the recessed equipment to the ***conditioned space*** shall be limited in accordance with 5.2.3.1.

5.5.1.4 Location of Roof Insulation. The ***roof*** insulation shall not be installed on a suspended ceiling with removable ceiling panels.

5.5.1.5 Insulation Protection. Exterior insulation shall be covered with a protective material to prevent damage from sunlight, moisture, landscaping operations, equipment maintenance, and wind. In ***attics*** and mechanical rooms, a way to access equipment that prevents damaging or compressing the insulation shall be provided. Foundation vents shall not interfere with the insulation.

Insulation materials in ground contact shall have a water absorption rate no greater than 0.3% when tested in accordance with ASTM C272.

5.5.2 Fenestration and Doors.

Product samples used for determining ***fenestration*** performance shall be production line units or representative of units as purchased by the consumer or contractor.

5.5.2.1 U-Factor. ***U-factors*** shall be determined in accordance with NFRC 100. ***U-factors*** for ***skylights*** shall be determined for a slope of 20° above the horizontal. ***U-factor*** shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be ***labeled*** and certified by the manufacturer.

Exceptions to 5.5.2.1:

(a) ***U-factors*** from A8.1 shall be an acceptable alternate for determining compliance with the ***U-factor*** criteria for ***skylights***. Where credit is being taken for a low-emissivity coating, the emissivity of the coating shall be determined in accordance with NFRC 301. Emissivity shall be verified and certified by the manufacturer.

(b) ***U-factors*** from A8.2 shall be an acceptable alternate for determining compliance with the ***U-factor*** criteria for ***vertical fenestration***.

(c) ***U-factors*** from A7 shall be an acceptable alternate for determining compliance with the ***U-factor*** criteria for ***opaque doors***.

(d) For garage ***doors***, ANSI/DASMA 105 shall be an acceptable alternate for determining ***U-factors***.

5.5.2.2 Solar Heat Gain Coefficient. ***SHGC*** for the overall ***fenestration area*** shall be determined in accordance with NFRC 200. ***SHGC*** shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be ***labeled*** and certified by the manufacturer.

Exceptions to 5.5.2.2:

(a) ***Shading coefficient*** of the center of glass multiplied by 0.86 shall be an acceptable alternate for determining compliance with the ***SHGC*** requirements for the overall ***fenestration area***. ***Shading coefficient*** shall be determined using a spectral data file determined in accordance with NFRC 300. ***Shading coefficient*** shall be verified and certified by the manufacturer.

(b) ***SHGC*** of the center of glass shall be an acceptable alternate for determining compliance with the ***SHGC*** requirements for the overall ***fenestration area***. ***SHGC*** shall be determined using a spectral data file determined in accordance with NFRC 300. ***SHGC*** shall be verified and certified by the manufacturer.

(c) ***SHGC*** from A8.1 shall be an acceptable alternate for determining compliance with the ***SHGC*** criteria for ***skylights***. Where credit is being taken for a low-emissivity coating, the emissivity of the coating shall be determined in accordance with NFRC 301. Emissivity shall be verified and certified by the manufacturer.

(d) ***SHGC*** from A8.2 shall be an acceptable alternate for determining compliance with the ***SHGC*** criteria for ***vertical fenestration***.

5.5.2.3 Visible Light Transmittance. When 5.4 is used, visible light transmittance shall be determined in accordance with NFRC 200. Visible light transmittance shall be verified and certified by the manufacturer.

5.5.3 Air Leakage

5.5.3.1 Building Envelope Sealing. The following areas of the ***building envelope*** shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage

a. joints around ***fenestration*** and ***door*** frames
b. junctions between ***walls*** and foundations, between ***walls*** at building corners, between ***walls*** and structural ***floors*** or ***roofs***, and between ***walls*** and ***roof*** or ***wall*** panels
c. openings at penetrations of utility services through ***roofs***, ***walls***, and ***floors***
d. site-built ***fenestration*** and ***doors***
e. building assemblies used as ducts or plenums
f. joints, seams, and penetrations of vapor retarders
g. all other openings in the ***building envelope***.
Outside air intakes, exhaust outlets, relief outlets, stair shaft, elevator shaft smoke relief openings, and other similar elements shall also comply with 6.2.3.2.4 and 6.2.3.3.

5.5.3.2 Fenestration and Doors. Air leakage for ***fenestration*** and ***doors*** shall be determined in accordance with NFRC 400. Air leakage shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be ***labeled*** and certified by the manufacturer. Air leakage shall not exceed 1.0 cfm/ft^2 for glazed swinging entrance doors and for revolving doors and 0.4 cfm/ft^2 for all other products.

Exceptions to 5.5.3.2:

(a) Field-fabricated fenestration and doors.

(b) For garage ***doors***, air leakage determined by test at standard test conditions in accordance with ANSI/DASMA 105 shall be an acceptable alternate for compliance with air leakage requirements.

5.5.3.3 Loading Dock Weatherseals. In climates that exceed 3600 ***HDD65***, cargo ***doors*** and loading dock ***doors*** shall be equipped with weatherseals to restrict ***infiltration*** when vehicles are parked in the doorway.

5.5.3.4 Vestibules. A ***door*** that separates ***conditioned space*** from the exterior shall be protected with an enclosed vestibule, with all ***doors*** opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior ***doors*** to open at the same time. Interior and exterior ***doors*** shall have a minimum distance between them of not less than 7 ft when in the closed position.

Exceptions to 5.5.3.4:

(a) ***Doors*** in buildings in climates that have less than 1800 ***HDD65***

(b) ***Doors*** in buildings less than four stories above grade

(c) ***Doors*** not intended to be used as a ***building entrance door***, such as mechanical or electrical equipment rooms

(d) ***Doors*** opening directly from a ***dwelling unit***

(e) ***Doors*** that open directly from a space less than 3000 ft^2 in area

(f) ***Doors*** in building entrances with revolving ***doors***

(g) ***Doors*** used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

6. HEATING, VENTILATING, AND AIR CONDITIONING

6.1 General

6.1.1 HVAC Scope. All mechanical equipment and systems serving the building heating, cooling, or ventilating needs shall meet the requirements of Section 6.

6.1.2 Compliance. Compliance with Section 6 shall be achieved by meeting all requirements for either

a. 6.1.3 (Simplified Approach Option for HVAC Systems), or

b. 6.2 (Mandatory Provisions) and 6.3 (Prescriptive Path), or

c. 6.2 (Mandatory Provisions) in conjunction with Section 11 (Energy Cost Budget Method).

6.1.3 Simplified Approach Option for HVAC Systems. Each HVAC ***system*** in buildings two ***stories*** or less in height and with less than 25,000 ft^2 ***gross floor area*** that meet criteria a. through o. given below shall be considered in compliance with the requirements of Section 6 (Heating, Ventilating, and Air Conditioning).

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

b. Cooling (if any) shall be provided by a unitary packaged or split-system air conditioner that is either air-cooled or evaporatively cooled with efficiency meeting the requirements shown in Table 6.2.1A (air conditioners), Table 6.2.1B (heat pumps), or Table 6.2.1D (packaged terminal and room air conditioners and heat pumps) for the applicable equipment category.

c. The ***system*** shall have an air economizer where indicated in Table 6.3.1, with controls as indicated in Tables 6.3.1.1.3A and 6.3.1.1.3B and with either barometric or powered relief sized to prevent overpressurization of the building. Where the cooling efficiency meets or exceeds the efficiency requirement in Table 6.1.3, no economizer is required. Outside air dampers for economizer use shall be provided with blade and jamb seals.

d. Heating (if any) shall be provided by a unitary packaged or split-system heat pump that meets the applicable efficiency requirements shown in Table 6.2.1B (heat pumps) or Table 6.2.1D (packaged terminal and room air conditioners and heat pumps), a fuel-fired furnace that meets the applicable efficiency requirements shown in Table 6.2.1E (furnaces, duct furnaces, and unit heaters), an electric resistance heater, or a baseboard system connected to a boiler that meets the applicable efficiency requirements shown in Table 6.2.1F (boilers).

e. The outside air quantity supplied by the system shall be less than or equal to 3000 cfm and less than 70% of the supply air quantity at minimum outside air design conditions unless an energy recovery ventilation system is provided in accordance with the requirements in 6.3.6.

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

g. If a heat pump equipped with auxiliary internal electric resistance heaters is installed, controls shall be provided that prevent supplemental heater operation when the heating load can be met by the heat pump

TABLE 6.1.3
Eliminate Required Economizer by Increasing Cooling Efficiency

Unitary Systems with Heat Pump Heating							
System Size (kBtu/h)	**Mandatory Minimum EER**	**Cooling Degree-Days (CDD50)**					
		0 - 3600	**3601 - 5400**	**5401 - 7200**	**7201 - 9000**	**9001 - 10800**	
		Minimum Cooling Efficiency Required (EER)[a]					**Test Procedure[c]**
≥ 65 and < 135	10.1	N/A[b]	12.1	11.6	11.1	10.7	ARI 210/240
≥ 135 and ≤ 240	9.3	N/A[b]	11.3	10.8	10.4	9.9	ARI 340/360
> 240 and < 760	9.0	N/A[b]	10.9	10.5	10.0	9.6	
Other Unitary Systems							
System Size (kBtu/h)	**Mandatory Minimum EER**	**Cooling Degree-Days (CDD50)**					
		0 ñ 3600	**3601 - 5400**	**5401 - 7200**	**7201 - 9000**	**9001 - 10800**	
		Minimum Cooling Efficiency Required (EER)[a]					**Test Procedure[c]**
≥ 65 and < 135	10.3	N/A[b]	12.5	12.0	11.5	11.0	ARI 210/240
≥ 135 and ≤ 240	9.7	N/A[b]	11.5	11.1	10.6	10.1	ARI 340/360
> 240 and < 760	9.5	N/A[b]	11.2	10.7	10.3	9.9	

[a] Each EER shown below should be reduced by 0.2 for units with a heating section other than electric resistance heat.
[b] Elimination of required economizer is not allowed.
[c] Section 12 contains complete specification of the referenced test procedure, including the referenced year version of the test procedure

alone during both steady-state operation and setback recovery. Supplemental heater operation is permitted during outdoor coil defrost cycles.

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

i. ***Systems*** serving spaces other than hotel/motel guest rooms, and other than those requiring continuous operation, that have a cooling or heating capacity greater than 65,000 Btu/h and a supply fan motor power greater than 3/4 hp shall be provided with a timeclock that (1) can start and stop the system under different schedules for seven different day-types per week, (2) is capable of retaining programming and time setting during a loss of power for a period of at least 10 hours, (3) includes an accessible manual override that allows temporary operation of the system for up to two hours, (4) is capable of temperature setback down to 55°F during off hours, and (5) is capable of temperature setup to 90°F during off hours.

j. Except for piping within manufacturer's units, HVAC piping shall be insulated in accordance with Table 6.2.4.1.3. Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation.

k. Ductwork and plenums shall be insulated in accordance with Tables 6.2.4.1.2A and 6.2.4.1.2B and shall be sealed in accordance with Table 6.2.4.2.1A.

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

m. Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

n. Exhausts with a design capacity of over 300 cfm on ***systems*** that do not operate continuously shall be equipped with gravity or motorized dampers that will automatically shut when the ***systems*** are not in use.

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

6.2 Mandatory Provisions

6.2.1 Mechanical Equipment Efficiency. Equipment shown in Tables 6.2.1A through 6.2.1G shall have a minimum performance at the specified rating conditions when tested in accordance with the specified test procedure. Omission of minimum performance requirements for equipment not listed in Tables 6.2.1A through 6.2.1G does not preclude use of such equipment. Equipment not listed in Tables 6.2.1A through 6.2.1G has no minimum performance requirements. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements, unless otherwise exempted by footnotes in the table. However, equipment covered under the Federal Energy Policy Act of 1992 (EPACT) shall have no minimum efficiency requirements for operation at minimum capacity or other than standard rating conditions. Equipment used to provide water heating functions as part of a combination system shall satisfy all stated requirements for the appropriate space heating or cooling category.

If a certification program exists for a product covered in Tables 6.2.1A through 6.2.1G, and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be either listed in the certification program or, alternatively, the ratings shall be verified by an independent laboratory test report. If no certification program exists for a product covered in Tables 6.2.1A through 6.2.1G, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where components such as indoor or outdoor coils from different manufacturers are used, the system designer shall specify component efficiencies whose combined efficiency meets the minimum equipment efficiency requirements in 6.2.1.

Tables 6.2.1A through 6.2.1G contain the minimum efficiency requirements for equipment covered by this section of the standard. The tables are organized to cover the following types of equipment:

Table 6.2.1A	Air Conditioners and Condensing Units
Table 6.2.1B	Heat Pumps
Table 6.2.1C	Water Chilling Packages
Table 6.2.1D	Packaged Terminal and Room Air Conditioners and Heat Pumps
Table 6.2.1E	Furnaces, Duct Furnaces, and Unit Heaters
Table 6.2.1F	Boilers
Table 6.2.1G	Heat Rejection Equipment

Gas-fired and oil-fired forced air furnaces with input ratings ≥225,000 Btu/h shall also have an intermittent ignition or interrupted device (IID) and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings ≥225,000 Btu/h, including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75% of the input rating.

Exception to 6.2.1: Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550/590 test conditions (and thus cannot be tested to meet the requirements of Table 6.2.1C) of 44°F leaving chilled water temperature and 85°F entering condenser water temperature shall have a minimum full-load COP as shown in Tables 6.2.1H, I, and J and a minimum NPLV rating as shown in Tables 6.2.1 K, L, and M. The table values are only applicable over the following full-load design ranges:

Leaving Chiller Water Temperature:	40°F to 48°F
Entering Condenser Water Temperature:	75°F to 85°F
Condensing Water Temperature Rise:	5°F to 15°F

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

Non-standard part-load value (NPLV) is defined as a single-number part-load efficiency figure of merit for chillers referenced to conditions other than IPLV conditions.

6.2.2 Load Calculations. Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with generally accepted engineering standards and handbooks acceptable to the adopting authority (for example, ***ASHRAE Handbookó Fundamentals***).

TABLE 6.2.1A
Electrically Operated Unitary Air Conditioners and Condensing Unitsó Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Conditioners, Air Cooled	<65,000 Btu/h[c]	All	Split System	10.0 SEER	ARI 210/240
			Single Package	9.7 SEER	
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.3 EER	
		All other	Split System and Single Package	10.1 EER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER	ARI 340/360
		All other	Split System and Single Package	9.5 EER	
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.7 IPLV	
		All other	Split System and Single Package	9.3 EER 9.5 IPLV	
	≥760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.2 EER 9.4 IPLV	
		All other	Split System and Single Package	9.0 EER 9.2 IPLV	
Air Conditioners, Water and Evaporatively Cooled	<65,000 Btu/h	All	Split System and Single Package	12.1 EER	ARI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER	
		All other	Split System and Single Package	11.3 EER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER	ARI 340/360
		All other	Split System and Single Package	10.8 EER	
	≥240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 10.3 IPLV	
		All other	Split System and Single Package	10.8 EER 10.1 IPLV	
Condensing Units, Air Cooled	≥135,000 Btu/h	–		10.1 EER 11.2 IPLV	ARI 365
Condensing Units, Water or Evaporatively Cooled	≥135,000 Btu/h	–		13.1 EER 13.1 IPLV	

[a] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] IPLVs are only applicable to equipment with capacity modulation.
[c] Single-phase, air-cooled air-conditioners < 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

TABLE 6.2.1B
Electrically Operated Unitary and Applied Heat Pumpsó Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled (Cooling Mode)	<65,000 Btu/h[c]	All	Split System	10.0 SEER	ARI 210/240
			Single Package	9.7 SEER	
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.1 EER	
		All other	Split System and Single Package	9.9 EER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.3 EER	ARI 340/360
		All other	Split System and Single Package	9.1 EER	
	≥240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.0 EER 9.2 IPLV	
		All other	Split System and Single Package	8.8 EER 9.0 IPLV	
Water-Source (Cooling Mode)	<17,000 Btu/h	All	86ºF Entering Water	11.2 EER	ISO-13256-1
	≥17,000 Btu/h and <135,000 Btu/h	All	86ºF Entering Water	12.0 EER	ISO-13256-1
Groundwater-Source (Cooling Mode)	<135,000 Btu/h	All	59ºF Entering Water	16.2 EER	ISO-13256-1
Ground Source (Cooling Mode)	<135,000 Btu/h	All	77ºF Entering Water	13.4 EER	ISO-13256-1
Air Cooled (Heating Mode)	<65,000 Btu/h[c] (Cooling Capacity)	–	Split System	6.8 HSPF	ARI 210/240
			Single Package	6.6 HSPF	
	≥65,000 Btu/h and <135,000 Btu/h (Cooling Capacity)	–	47ºF db/43ºF wb Outdoor Air	3.2 COP	
			17ºF db/15ºF wb Outdoor Air	2.2 COP	
	≥135,000 Btu/h (Cooling Capacity)	–	47ºF db/43ºF wb Outdoor Air	3.1 COP	ARI 340/360
			17ºF db/15ºF wb Outdoor Air	2.0 COP	
Water-Source (Heating Mode)	<135,000 Btu/h (Cooling Capacity)	–	68ºF Entering Water	4.2 COP	ISO-13256-1
Groundwater-Source (Heating Mode)	<135,000 Btu/h (Cooling Capacity)	–	50ºF Entering Water	3.6 COP	ISO-13256-1
Ground Source (Heating Mode)	<135,000 Btu/h (Cooling Capacity)	–	32ºF Entering Water	3.1 COP	ISO-13256-1

[a] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
[c] Single-phase, air-cooled heat pumps < 65,000 Btu/h are regulated by NAECA. SEER and HSPF values are those set by NAECA

TABLE 6.2.1C
Water Chilling PackagesñMinimum Efficiency Requirements

Equipment Type	Size Category	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air Cooled, with Condenser, Electrically Operated	All Capacities		2.80 COP 3.05 IPLV	ARI 550/590
Air Cooled, without Condenser, Electrically Operated	All Capacities		3.10 COP 3.45 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities		4.20 COP 5.05 IPLV	ARI 550/590
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	<150 tons		4.45 COP 5.20 IPLV	ARI 550/590
	≥150 tons and <300 tons		4.90 COP 5.60 IPLV	
	≥300 tons		5.50 COP 6.15 IPLV	
Water Cooled, Electrically Operated, Centrifugal	<150 tons		5.00 COP 5.25 IPLV	ARI 550/590
	≥150 tons and <300 tons		5.55 COP 5.90 IPLV	
	≥300 tons		6.10 COP 6.40 IPLV	
Air-Cooled Absorption Single Effect	All Capacities		0.60 COP	ARI 560
Water-Cooled Absorption Single Effect	All Capacities		0.70 COP	
Absorption Double Effect, Indirect-Fired	All Capacities		1.00 COP 1.05 IPLV	
Absorption Double Effect, Direct-Fired	All Capacities		1.00 COP 1.00 IPLV	

a The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is ≤40ºF.
b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

TABLE 6.2.1D
Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat PumpsñMinimum Efficiency Requirements

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
PTAC (Cooling Mode) New Construction	All Capacities	95°F db Outdoor Air	12.5 – (0.213 × Cap/1000)[c] EER	ARI 310/380
PTAC (Cooling Mode) Replacements[b]	All Capacities	95°F db Outdoor Air	10.9 – (0.213 × Cap/1000)[c] EER	
PTHP (Cooling Mode) New Construction	All Capacities	95°F db Outdoor Air	12.3 – (0.213 × Cap/1000)[c] EER	
PTHP (Cooling Mode) Replacements[b]	All Capacities	95°F db Outdoor Air	10.8 – (0.213 × Cap/1000)[c] EER	
PTHP (Heating Mode) New Construction	All Capacities		3.2 – (0.026 × Cap/1000)[c] COP	
PTHP (Heating Mode) Replacements[b]	All Capacities		2.9 – (0.026 × Cap/1000)[c] COP	
Room Air Conditioners, with Louvered Sides	<8000 Btu/h		9.7 EER	ANSI/AHAM RAC-1
	≥8000 Btu/h and <14,000 Btu/h		9.8 EER	
	≥14,000 Btu/h and <20,000 Btu/h		9.7 EER	
	≥20,000 Btu/h		8.5 EER	
Room Air Conditioners, without Louvered Sides	<8000 Btu/h		9.0 EER	
	≥8000 Btu/h		8.5 EER	
Room Air Conditioner Heat Pumps with Louvered Sides	<20,000 Btu/h		9.0 EER	
	≥20,000 Btu/h		8.5 EER	
Room Air Conditioner Heat Pumps without Louvered Sides	<14,000 Btu/h		8.5 EER	
	≥14,000 Btu/h		8.0 EER	
Room Air Conditioner, Casement Only	All Capacities		8.7 EER	
Room Air Conditioner, Casement–Slider	All Capacities		9.5 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 must 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 6.2.1E
Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Warm Air Furnace, Gas-Fired	<225,000 Btu/h		78% AFUE or 80% E_t[d]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥225,000 Btu/h	Maximum Capacity[d]	80% E_c[c]	ANSI Z21.47
Warm Air Furnace, Oil-Fired	<225,000 Btu/h		78% AFUE or 80% E_t[d]	DOE 10 CFR Part 430 or UL 727
	≥225,000 Btu/h	Maximum Capacity[e]	81% E_t[f]	UL 727
Warm Air Duct Furnaces, Gas-Fired	All Capacities	Maximum Capacity[e]	80% E_c[g]	ANSI Z83.9
Warm Air Unit Heaters, Gas-Fired	All Capacities	Maximum Capacity[e]	80% E_c[g]	ANSI Z83.8
Warm Air Unit Heaters, Oil-Fired	All Capacities	Maximum Capacity[e]	80% E_c[g]	UL 731

a E_t = thermal efficiency. See test procedure for detailed discussion.
b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c E_c = combustion efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
d Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating.
e Minimum and maximum ratings as provided for and allowed by the unit's controls.
f E_t = thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
g E_c = combustion efficiency (100% less flue losses). See test procedure for detailed discussion.

TABLE 6.2.1F
Gas- and Oil-Fired BoilersñMinimum Efficiency Requirements

Equipment Type[d]	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Boilers, Gas-Fired	<300,000 Btu/h	Hot Water	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[c]	75% E_t[a]	H.I. Htg Boiler Std.
	>2,500,000 Btu/h[d]	Hot Water	80% E_c	
	>2,500,000 Btu/h[d]	Steam	80% E_c	
Boilers, Oil-Fired	<300,000 Btu/h		80% AFUE	DOE 10 CFR Part 430
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[c]	78% E_t[a]	H.I. Htg Boiler Std.
	>2,500,000 Btu/h[d]	Hot Water	83% E_c	
	>2,500,000 Btu/h[d]	Steam	83% E_c	
Oil-Fired (Residual)	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[c]	78% E_t[a]	H.I. Htg Boiler Std.
	>2,500,000 Btu/h[d]	Hot Water	83% E_c	
	>2,500,000 Btu/h[d]	Steam	83% E_c	

a E_t = thermal efficiency. See reference document for detailed information.
b Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c Minimum and maximum ratings as provided for and allowed by the unit's controls.
d 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.

TABLE 6.2.1G
Performance Requirements for Heat Rejection Equipment

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition	Performance Required[a b]	Test Procedure[c]
Propeller or Axial Fan Cooling Towers	All	95°F Entering Water 85°F Leaving Water 75°F wb Outdoor Air	≥38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal Fan Cooling Towers	All	95°F Entering Water 85°F Leaving Water 75°F wb Outdoor Air	≥20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Air-Cooled Condensers	All	125°F Condensing Temperature R-22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering db	≥176,000 Btu/h·hp	ARI 460

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

TABLE 6.2.1H
COPs for Centrifugal Chillers < 150 Tons
COP_{std} = 5.0

Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT[a] (F)	Condenser Flow Rate: 2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP					
46	75	29	5.58	5.83	6.03	6.32	6.54	6.70
45	75	30	5.50	5.74	5.92	6.19	6.38	6.53
44	75	31	5.42	5.65	5.82	6.07	6.24	6.37
43	75	32	5.35	5.57	5.72	5.95	6.11	6.23
42	75	33	5.27	5.49	5.64	5.85	6.00	6.11
41	75	34	5.19	5.41	5.56	5.75	5.89	5.99
46	80	34	5.19	5.41	5.56	5.75	5.89	5.99
40	75	35	5.11	5.33	5.48	5.67	5.79	5.88
45	80	35	5.11	5.33	5.48	5.67	5.79	5.88
44	80	36	5.03	5.26	5.40	5.58	5.70	5.79
43	80	37	4.94	5.18	5.32	5.50	5.62	5.70
42	80	38	4.84	5.10	5.25	5.43	5.53	5.61
41	80	39	4.73	5.01	5.17	5.35	5.46	5.53
46	85	39	4.73	5.01	5.17	5.35	5.46	5.53
40	80	40	4.62	4.92	5.09	5.27	5.38	5.45
45	85	40	4.62	4.92	5.09	5.27	5.38	5.45
44	85	41	4.49	4.82	5.00	5.20	5.30	5.38
43	85	42	4.35	4.71	4.91	5.12	5.23	5.30
42	85	43	4.19	4.59	4.81	5.03	5.15	5.22
41	85	44	4.02	4.46	4.70	4.94	5.06	5.14
40	85	45	3.84	4.32	4.58	4.84	4.98	5.06
	Cond 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] Cond DT = Leaving Condenser Water Temperature (F)—Entering Condenser Water Temperature (F)

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$

where X = Cond. DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

The table values are only applicable over the following full load design ranges:

- Leaving chilled water temperature: 40°F to 48°F
- Entering condenser water temperature: 75°F to 85°F
- Condensing water temperature rise: 5°F to 15°F

Chillers designed to operate outside these ranges are not covered by th is standard.

TABLE 6.2.1I
COPs for Centrifugal Chillers ≥150 tons, ≤300 tons
COP_{std} = 5.55

			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 Condenser Water Temperature (F)	LIFT[a] (F)	Required COP					
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.90	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.8	6.14	6.36	6.51	6.62
46	80	34	5.74	5.8	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59

Cond 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)
$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$
where X = Condenser DT + LIFT
$COP_{adj} = K_{adj} \times COP_{std}$

The table values are only applicable over the following full load design ranges:

- Leaving chilled water temperature: 40°F to 48°F
- Entering condenser water temperature: 75°F to 85°F
- Condensing water temperature rise: 5°F to 15°F

Chillers designed to operate outside these ranges are not covered by th is standard.

TABLE 6.2.1J
COPs for Centrifugal Chillers >300 tons
COP_{std} = 6.1

Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT[a] (F)	Condenser Flow Rate: 2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required COP					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17
	Cond 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)

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} \times COP_{std}$

The table values are only applicable over the following full load design ranges:

- Leaving chilled water temperature: 40°F to 48°F
- Entering condenser water temperature: 75°F to 85°F
- Condensing water temperature rise: 5°F to 15°F

Chillers designed to operate outside these ranges are not covered by th is standard.

TABLE 6.2.1K
IPLV/NPLV for Centrifugal Chillers < 150 Tons
$IPLV_{std}$ = 5.25

Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT[a] (F)	Condenser Flow Rate 2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required IPLV/NPLV					
46	75	29	5.84	6.10	6.30	6.61	6.84	7.00
45	75	30	5.75	6.00	6.19	6.47	6.68	6.83
44	75	31	5.67	5.91	6.08	6.34	6.53	6.67
43	75	32	5.59	5.82	5.99	6.23	6.39	6.52
42	75	33	5.51	5.74	5.90	6.12	6.27	6.39
41	75	34	5.43	5.66	5.81	6.02	6.16	6.26
46	80	34	5.43	5.66	5.81	6.02	6.16	6.26
40	75	35	5.35	5.58	5.73	5.93	6.06	6.15
45	80	35	5.35	5.58	5.73	5.93	6.06	6.15
44	80	36	5.26	5.50	5.65	5.84	5.96	6.05
43	80	37	5.16	5.42	5.57	5.76	5.87	5.96
42	80	38	5.06	5.33	5.49	5.67	5.79	5.87
41	80	39	4.95	5.24	5.41	5.60	5.71	5.78
46	85	39	4.95	5.24	5.41	5.60	5.71	5.78
40	80	40	4.83	5.14	5.32	5.52	5.63	5.70
45	85	40	4.83	5.14	5.32	5.52	5.63	5.70
44	85	41	4.69	5.04	5.25[b]	5.43	5.55	5.62
43	85	42	4.55	4.93	5.13	5.35	5.47	5.54
42	85	43	4.38	4.80	5.03	5.26	5.38	5.46
41	85	44	4.21	4.67	4.91	5.17	5.30	5.38
40	85	45	4.01	4.52	4.79	5.06	5.20	5.29

	2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Cond DT[c]	14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature—Leaving Chilled Water Temperature
[b] All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.
$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.00004559\,(X)^3$
where X = Cond. DT + LIFT
$COP_{adj} = K_{adj} * COP_{std}$
[c] Cond DT = Leaving Condenser Water Temperature (F)—Entering Condenser Water Temperature (F)

TABLE 6.2.1L
IPLV/NPLV for Centrifugal Chillers ≥ 150 Tons ≤ 300 Tons
$IPLV_{std}$= 5.9

Leaving Chilled Water Temperature (F)	Entering Condenser Water Temperature (F)	LIFT[a] (F)	Condenser Flow Rate: 2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
			Required IPLV/NPLV					
46	75	29	6.58	6.87	7.11	7.46	7.71	7.90
45	75	30	6.49	6.76	6.98	7.30	7.53	7.70
44	75	31	6.40	6.66	6.86	7.15	7.36	7.52
43	75	32	6.31	6.56	6.75	7.02	7.21	7.35
42	75	33	6.22	6.47	6.65	6.90	7.07	7.20
41	75	34	6.13	6.38	6.55	6.79	6.95	7.06
46	80	34	6.13	6.38	6.55	6.79	6.95	7.06
40	75	35	6.03	6.29	6.46	6.68	6.83	6.94
45	80	35	6.03	6.29	6.46	6.68	6.83	6.94
44	80	36	5.93	6.20	6.37	6.58	6.72	6.82
43	80	37	5.82	6.11	6.28	6.49	6.62	6.72
42	80	38	5.71	6.01	6.19	6.40	6.53	6.62
41	80	39	5.58	5.91	6.10	6.31	6.44	6.52
46	85	39	5.58	5.91	6.10	6.31	6.44	6.52
40	80	40	5.44	5.80	6.00	6.22	6.35	6.43
45	85	40	5.44	5.80	6.00	6.22	6.35	6.43
44	85	41	5.29	5.68	5.90[b]	6.13	6.26	6.34
43	85	42	5.13	5.55	5.79	6.03	6.16	6.25
42	85	43	4.94	5.41	5.67	5.93	6.07	6.16
41	85	44	4.74	5.26	5.54	5.82	5.97	6.07
40	85	45	4.52	5.09	5.40	5.71	5.87	5.97

	2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Cond DT[c]	14.04	11.23	9.36	7.02	5.62	4.68

a LIFT = Entering Condenser Water Temperature—Leaving Chilled Water Temperature

b All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.

$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$

where X = Cond. DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

c Cond DT = Leaving Condenser Water Temperature (F)—Entering Condenser Water Temperature (F)

TABLE 6.2.1M
IPLV/NPLV for Centrifugal Chillers > 300 Tons
$IPLV_{std}$ = 6.4

			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 Condenser Water Temperature (F)**	**LIFT[a] (F)**	**Required IPLV/NPLV**					
46	75	29	7.15	7.47	7.72	8.10	8.37	8.58
45	75	30	7.05	7.35	7.58	7.93	8.18	8.36
44	75	31	6.95	7.23	7.45	7.77	8.00	8.16
43	75	32	6.85	7.13	7.33	7.63	7.83	7.98
42	75	33	6.75	7.03	7.22	7.49	7.68	7.82
41	75	34	6.65	6.93	7.12	7.37	7.55	7.67
46	80	34	6.65	6.93	7.12	7.37	7.55	7.67
40	75	35	6.55	6.83	7.01	7.26	7.42	7.54
45	80	35	6.55	6.83	7.01	7.26	7.42	7.54
44	80	36	6.44	6.73	6.92	7.15	7.30	7.41
43	80	37	6.32	6.63	6.82	7.05	7.19	7.30
42	80	38	6.20	6.53	6.72	6.95	7.09	7.19
41	80	39	6.06	6.42	6.62	6.85	6.99	7.08
46	85	39	6.06	6.42	6.62	6.85	6.99	7.08
40	80	40	5.91	6.30	6.52	6.76	6.89	6.98
45	85	40	5.91	6.30	6.52	6.76	6.89	6.98
44	85	41	5.75	6.17	6.40[b]	6.66	6.79	6.89
43	85	42	5.57	6.03	6.28	6.55	6.70	6.79
42	85	43	5.37	5.88	6.16	6.44	6.59	6.69
41	85	44	5.15	5.71	6.01	6.33	6.49	6.59
40	85	45	4.91	5.53	5.86	6.20	6.37	6.48
	Cond DT[c]		14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature—Leaving Chilled Water Temperature
[b] All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.
$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$
where X = Cond. DT + LIFT
$COP_{adj} = K_{adj} * COP_{std}$
[c] Cond DT = Leaving Condenser Water Temperature (F)—Entering Condenser Water Temperature (F)

6.2.3 Controls

6.2.3.1 Zone Thermostatic Controls

6.2.3.1.1 General. The supply of heating and cooling energy to each ***zone*** shall be individually controlled by thermostatic controls responding to temperature within the ***zone***. All ***zone*** and loop controllers shall use control methodology that incorporates the application of control error reduction. For the purposes of 6.2.3.1, a dwelling unit shall be permitted to be considered a single ***zone.***

Exceptions to 6.2.3.1.1: Independent perimeter systems that are designed to offset only ***building envelope*** loads shall be permitted to serve one or more ***zones*** also served by an interior system provided:

(a) the perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one ***orientation*** for 50 contiguous ft or more**,** and

(b) the perimeter system heating and cooling supply is controlled by a thermostatic control(s) located within the zones(s) served by the system.

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

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

Exceptions to 6.2.3.1.2:

(a) Thermostats that require manual changeover between heating and cooling modes.

(b) Special occupancy or special applications where wide temperature ranges are not acceptable (such as retirement homes, process applications, data processing, museums, some areas of hospitals) and are approved by the authority having jurisdiction

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

6.2.3.2 Off-Hour Controls. HVAC systems having a design heating or cooling capacity greater than 65,000 Btu/h and ***fan system power*** greater than 3/4 hp shall have all of the following off-hour controls: Automatic Shutdown (6.2.3.2.1), Setback Controls (6.2.3.2.2), Optimum Start Controls (6.2.3.2.3), Shutoff Damper Controls (6.2.3.2.4), and Zone Isolation (6.2.3.2.5).

Exceptions to 6.2.3.2:

(a) ***HVAC systems*** serving hotel/motel guest rooms.

(b) ***HVAC systems*** intended to operate continuously.

6.2.3.2.1 Automatic Shutdown. ***HVAC systems*** shall be equipped with at least one of the following:

a. Controls that can start and stop the system under different time schedules for seven different day-types per week, are capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and include an accessible manual override, or equivalent function, that allows temporary operation of the system for up to two hours.

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

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

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

Exception to 6.2.3.2.1: Residential occupancies may use controls that can start and stop the system under two different time schedules per week.

6.2.3.2.2 Setback Controls. Heating systems located where the ***heating design temperature*** is 40°F or less shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain ***zone*** temperatures above a heating set point adjustable down to 55°F or lower. (See Appendix D for ***heating design temperatures***.)

Cooling systems located where the ***cooling design temperature*** is greater than 100°F shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain ***zone*** temperatures below a cooling set point adjustable up to 90°F or higher or to prevent high space humidity levels. (See Appendix D for ***cooling design temperatures***.)

Exception to 6.2.3.2.2: Radiant floor and ceiling heating ***systems.***

6.2.3.2.3 Optimum Start Controls. Individual heating and cooling air distribution systems with a total design supply air capacity exceeding 10,000 cfm, served by one or more supply fans, shall have ***optimum start controls***. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint and the amount of time prior to scheduled occupancy.

6.2.3.2.4 Zone Isolation. ***HVAC systems*** serving ***zones*** that are intended to operate or be occupied nonsimultaneously shall be divided into isolation areas. Zones may be grouped into a single isolation area provided it does not exceed 25,000 ft^2 of conditioned floor area nor include more than one floor.

Each isolation area shall be equipped with ***isolation devices*** capable of automatically shutting off the supply of conditioned air and outside air to and exhaust air from the area. Each isolation area shall be controlled independently by a device meeting the requirements of 6.2.3.2.1 (Automatic Shutdown). For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions to 6.2.3.2.4: Isolation devices and controls are not required for the following:

(a) Exhaust air and outside air connections to isolation ***zones*** when the fan system to which they connect is 5000 cfm and smaller.

(b) Exhaust airflow from a single isolation ***zone*** of less than 10% of the design airflow of the exhaust system to which it connects.

(c) ***Zones*** intended to operate continuously or intended to be inoperative only when all other ***zones*** are inoperative.

6.2.3.3 Ventilation System Controls.

6.2.3.3.1 Stair and Shaft Vents. Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of being automatically closed during normal building operation and are interlocked to open as required by fire and smoke detection systems.

6.2.3.3.2 Gravity Hoods, Vents, and Ventilators. All outdoor air supply and exhaust hoods, vents, and ventilators shall be equipped with motorized dampers that will automatically shut when the spaces served are not in use.

Exceptions to 6.2.3.3.1 and 6.2.3.3.2:

(a) Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height above grade and for buildings of any height located in climates with less than 2700 HDD65.

(b) Ventilation systems serving unconditioned spaces.

6.2.3.3.3 Shutoff Damper Controls. Both outdoor air supply and exhaust systems shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use. Ventilation outside air dampers shall be capable of automatically shutting off during preoccupancy building warmup, cooldown, and ***setback,*** except when ***ventilation*** reduces energy costs (e.g., night purge) or when ventilation must be supplied to meet code requirements.

Exceptions to 6.2.3.3.3:

(a) Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height and for buildings of any height located in climates with less than 2700 HDD65.

(b) Gravity (nonmotorized) dampers are acceptable in systems with a design outside air intake or exhaust capacity of 300 cfm or less.

6.2.3.3.4 Dampers. Where outdoor air supply and exhaust air dampers are required by Section 6.2.3.3, they shall have a maximum leakage rate when tested in accordance with AMCA Standard 500 as indicated in Table 6.2.3.3.4.

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

Exception to 6.2.3.4: Heat pumps whose minimum efficiency is regulated by NAECA and whose HSPF rating both meets the requirements shown in Table 6.2.1B and includes all usage of internal electric resistance heating.

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

TABLE 6.2.3.3.4
Maximum Damper Leakage

Climate	Maximum Damper Leakage at 1.0 in w.g.cfm per ft^2 of damper area	
	Motorized	Non-motorized
HDD65>7200 or CDD50>7200	4	Not allowed
HDD65<2701 and CDD50<3601	20	20[a]
All others	10	20[a]

Notes:
[a] Dampers smaller than 24 in. in either dimension may have leakage of 40 cfm/ft^2.

6.2.3.6 Humidification and Dehumidification. Where a ***zone*** is served by a system or systems with both humidification and dehumidification capability, means (such as limit switches, mechanical stops, or, for DDC systems, software programming) shall be provided capable of preventing simultaneous operation of humidification and dehumidification equipment.

Exception to 6.2.3.6:

(a) Zones served by desiccant systems, used with direct evaporative cooling in series.

(b) Systems serving zones where specific humidity levels are required, such as computer rooms, museums, and hospitals, and approved by the ***authority having jurisdiction***.

6.2.3.7 Freeze Protection and Snow/Ice Melting Systems. Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls capable of shutting off the systems when outside air temperatures are above 40°F or when the conditions of the protected fluid will prevent freezing. Snow- and ice-melting systems shall include automatic controls capable of shutting off the systems when the pavement temperature is above 50°F and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F so that the potential for snow or ice accumulation is negligible.

6.2.3.8 Ventilation Controls for High-Occupancy Areas. Systems with design outside air capacities greater than 3000 cfm serving areas having an average design occupancy density exceeding 100 people per 1000 ft^2 shall include means to automatically reduce outside air intake below design rates when spaces are partially occupied. Ventilation controls shall be in compliance with ASHRAE Standard 62 and local standards.

Exception to 6.2.3.8: Systems with heat recovery complying with 6.3.6.1.

TABLE 6.2.4.1.3
Minimum Pipe Insulation Thickness[a]

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	2.5	3.0	3.0	4.0	4.0
251-350	0.29-0.32	200	1.5	2.5	3.0	3.0	3.0
201-250	0.27-0.30	150	1.5	1.5	2.0	2.0	2.0
141-200	0.25-0.29	125	1.0	1.0	1.0	1.5	1.5
105-140	0.22-0.28	100	0.5	0.5	1.0	1.0	1.0
Domestic and Service Hot Water Systems							
105+	0.22-0.28	100	0.5	0.5	1.0	1.0	1.0
Cooling Systems (Chilled Water, Brine, and Refrigerant)[d]							
40-60	0.22-0.28	100	0.5	0.5	1.0	1.0	1.0
<40	0.22-0.28	100	0.5	1.0	1.0	1.0	1.5

[a] For insulation outside the stated conductivity range, the minimum thickness (***T***) shall be determined as follows:

$$T = r\{(1 + t/r)^{K/k} - 1\}$$

where ***T*** = minimum insulation thickness (in.), ***r*** = actual outside radius of pipe (in.), ***t*** = insulation thickness listed in this table for applicable fluid temperature and pipe size, ***K*** = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in.[h·ft²·°F]); and ***k*** = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

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

[c] 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.

6.2.4 HVAC System Construction and Insulation

6.2.4.1 Insulation

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

a. Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

b. Insulation covering chilled water piping, refrigerant suction piping, or cooling ducts located outside the conditioned space shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant), all penetrations and joints of which shall be sealed.

6.2.4.1.2 Duct and Plenum Insulation. All supply and return ducts and plenums installed as part of an HVAC air distribution system shall be thermally insulated in accordance with Tables 6.2.4.1.2A and 6.2.4.1.2B.

Exceptions to 6.2.4.1.2:

(a) Factory-installed plenums, casings, or ductwork furnished as a part of HVAC equipment tested and rated in accordance with 6.2.1.

(b) Ducts or plenums located in heated spaces, ***semi-heated spaces***, or cooled spaces.

(c) For runouts less than 10 ft in length to air terminals or air outlets, the rated R-value of insulation need not exceed R-3.5.

(d) Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas exceeding 5 ft² need not exceed R-2; those 5 ft² or smaller need not be insulated.

6.2.4.1.3 Piping Insulation. Piping shall be thermally insulated in accordance with Table 6.2.4.1.3.

Exceptions to 6.2.4.1.3:

(a) Factory-installed piping within HVAC equipment tested and rated in accordance with 6.2.1.

(b) Piping that conveys fluids having a design operating temperature range between 60°F and 105°F, inclusive.

(c) Piping that conveys fluids that have not been heated or cooled through the use of nonrenewable energy (such as roof and condensate drains, domestic cold water supply, natural gas piping, or refrigerant liquid piping) or where heat gain or heat loss will not increase energy usage.

(d) Hot water piping between the shutoff valve and the coil, not exceeding 4 ft in length, when located in conditioned spaces.

(e) Pipe unions in heating systems (steam, steam condensate, and hot water).

6.2.4.2 Ducts and Plenum Leakage

6.2.4.2.1 Duct Sealing. Ductwork and plenums shall be sealed in accordance with Table 6.2.4.2.1A (Table 6.2.4.2.1B provides definitions of seal levels), as required to meet the requirements of 6.2.4.2.2, and with standard industry practice (see Appendix E).

6.2.4.2.2 Duct Leakage Tests. Ductwork that is designed to operate at static pressures in excess of 3 in. w.c. shall be leak tested according to industry-accepted test procedures (see Appendix E). Representative sections totaling no less than 25% of the total installed duct area for the designated pressure class shall be tested. Duct systems with pressure ratings in excess of 3 in. w.c. shall be identified on the drawings. The maximum permitted duct leakage shall be:

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

where

L_{max} = maximum permitted leakage in cfm/100 ft^2 duct surface area

C_L = duct leakage class, cfm/100 ft^2 at 1 in. w.c.
6 for rectangular sheetmetal, rectangular fibrous ducts, and round flexible ducts
3 for round/flat oval sheetmetal or fibrous glass ducts

P = test pressure, which shall be equal to the design duct pressure class rating in inches w.c.

6.2.5 Completion Requirements

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

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

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

6.2.5.3 System Balancing

6.2.5.3.1 General. Construction documents shall require that all HVAC systems be balanced in accordance with generally accepted engineering standards (see Appendix E).

Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving ***zones*** with a total conditioned area exceeding 5000 ft^2.

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

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

Exceptions to 6.2.5.3.3: Impellers need not be trimmed nor pump speed adjusted:

(a) For pumps with pump motors of 10 hp or less.
(b) When throttling results in no greater than 5% of the nameplate horsepower draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed.

6.2.5.4 System Commissioning. HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft^2 conditioned area, except warehouses and semiheated spaces, detailed instructions for commissioning HVAC systems (see Appendix E) shall be provided by the designer in plans and specifications.

6.3 Prescriptive Path

6.3.1 Economizers. Each cooling system having a fan shall include either an air or water economizer meeting the requirements of 6.3.1.1 through 6.3.1.4.

Exceptions to 6.3.1: Economizers are not required for the systems listed below.

(a) Individual fan-cooling units with a supply capacity less than the minimum listed in Table 6.3.1
(b) Systems that include gas phase air cleaning in order to meet 6.1.2 of ASHRAE Standard 62**.**
(c) Where more than 25% of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F dewpoint temperature to satisfy process needs.
(d) Systems that include a condenser heat recovery system complying with 6.3.6.2.
(e) Systems that serve ***residential*** spaces where the system capacity is less than five times the requirement listed in Table 6.3.1.

TABLE 6.2.4.1.2A
Minimum Duct Insulation R-Value,[a] Cooling and Heating Only Supply Ducts and Return Ducts

Climate Zone			Duct Location						
Envelope Criteria Table	HDD65	CDD50	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with Roof Insulation	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Heating Ducts Only									
B-1 to B-7	0-1800	all	none	none	none	none	none	none	none
B-8 to B-12	1801-3600	all	R-3.5	none	none	none	none	none	none
B-13 to B-15	3601-5400	all	R-3.5	none	none	none	none	none	none
B-16 to B-18	5401-7200	all	R-6	R-3.5	none	none	none	none	R-3.5
B-19 to B-20	7201-9000	all	R-6	R-6	R-3.5	none	none	none	R-3.5
B-21 to B-22	9001-10800	all	R-8	R-6	R-6	none	R-3.5	none	R-3.5
B-23	10801-12600	all	R-8	R-6	R-6	none	R-6	none	R-6
B-24	12601-16200	all	R-8	R-8	R-6	none	R-6	none	R-6
B-25	16201-19800	all	R-10	R-8	R-8	none	R-6	none	R-6
B-26	19801+	all	R-10	R-10	R-8	none	R-8	none	R-6
Cooling Only Ducts									
B-15, 18, 20, 22 to 26	all	0-1800	R-1.9	R-1.9	R-1.9	R-1.9	R-1.9	none	none
B-12, 14, 17, 19, 21	all	1801-3600	R-3.5	R-1.9	R-3.5	R-1.9	R-1.9	none	none
B-7, 9, 11, 13, 16	all	3601-5400	R-3.5	R-3.5	R-6	R-1.9	R-1.9	none	none
B-4, 6, 8, 10	all	5401-7200	R-6	R-6	R-6	R-3.5	R-1.9	none	none
B-3, B-5	all	7201-9000	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-2	all	9001-10800	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
B-1	all	10801+	R-8	R-8	R-8	R-3.5	R-3.5	none	R-3.5
Return Ducts									
B-1 to B-26	all climates		R-3.5	R-3.5	R-3.5	none	none	none	none

[a] Insulation R-values, measured in (h·ft^2·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 6.2.4.2 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 6.2.4.1.2B
Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Ducts

Climate Zone			Duct Location						
Envelope Criteria Table	HDD65	CDD50	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic w/ Roof Insulation[a]	Uncon-ditioned Space[b]	Indirectly Condi-tioned Space[c]	Buried
B-1	0-900	10801+	R-8	R-6	R-8	R-3.5	R-3.5	none	R-3.5
B-2	0-900	9001-10800	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
B-3	0-900	7201-9000	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-4	0-900	0-7200	R-6	R-3.5	R-6	R-3.5	R-1.9	none	R-3.5
B-5	901-1800	7201+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-6	901-1800	5401-7200	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-7	901-1800	0-5400	R-3.5	R-3.5	R-6	R-1.9	R-1.9	none	R-1.9
B-8	1801-2700	5401+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-9	1801-2700	0-5400	R-6	R-3.5	R-6	R-1.9	R-1.9	none	R-1.9
B-10	2701-3600	5401+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-11	2701-3600	3601-5400	R-6	R-6	R-6	R-3.5	R-3.5	none	R-1.9
B-12	2701-3600	0-3600	R-3.5	R-3.5	R-3.5	R-1.9	R-1.9	none	R-1.9
B-13	3601-5400	3601+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-14	3601-5400	1801-3600	R-6	R-3.5	R-6	R-1.9	R-3.5	none	R-1.9
B-15	3601-5400	0-1800	R-3.5	R-3.5	R-3.5	R-1.9	R-1.9	none	R-1.9
B-16	5401-7200	3601+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-17	5401-7200	1801-3600	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-18	5401-7200	0-1800	R-6	R-3.5	R-3.5	R-1.9	R-3.5	none	R-3.5
B-19	7201-9000	1801+	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-20	7201-9000	0-1800	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-21	9001-10800	1801+	R-8	R-6	R-6	R-1.9	R-6	none	R-3.5
B-22	9001-10800	0-1800	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-23	10801-12600	all	R-8	R-6	R-6	R-1.9	R-6	none	R-6
B-24	12601-16200	all	R-8	R-8	R-8	R-1.9	R-6	none	R-6
B-25	16201-19800	all	R-10	R-8	R-8	R-3.5	R-6	none	R-6
B-26	19801+	all	R-10	R-10	R-8	R-3.5	R-8	R-3.5	R-6

[a] Insulation R-values, measured in (h·ft^2·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 6.2.4.2 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 6.2.4.2.1A
Minimum Duct Seal Level[a]

Duct Location	Duct Type			
	Supply		Exhaust	Return
	≤2 in. w.c.[b]	>2 in. w.c.[b]		
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces[c]	C	B	B	C

[a] See Table 6.2.4.2.1B definition of Seal Level.
[b] Duct design static pressure classification.
[c] Includes indirectly conditioned spaces such as return air plenums.

TABLE 6.2.4.2.1B
Duct Seal Levels

Seal Level	Sealing Requirements[a]
A	All transverse joints, longitudinal seams, and duct wall penetrations. Pressure-sensitive tape shall not be used as the primary sealant.
B	All transverse joints and longitudinal seams. Pressure-sensitive tape shall not be used as the primary sealant.
C	Transverse joints only.

[a] Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod, or wire. Spiral lock seams in round and flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps and other branch connections, access door frames and jambs, duct connections to equipment, etc.

(f) Systems that serve spaces whose sensible cooling load at design conditions, excluding transmission and infiltration loads, is less than or equal to transmission and infiltration losses at an outdoor temperature of 60°F.

(g) Systems expected to operate less than 20 hours per week.

(h) Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.

(i) Where the cooling efficiency meets or exceeds the efficiency requirements in Table 6.1.3.

6.3.1.1 Air Economizers

6.3.1.1.1 Design Capacity. Air economizer systems shall be capable of modulating outside air and return air dampers to provide up to 100% of the design supply air quantity as outside air for cooling.

6.3.1.1.2 Control Signal. Economizer dampers shall be capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature.

Exception to 6.3.1.1.2: The use of mixed air temperature limit control shall be permitted for systems controlled from space temperature (such as single-***zone*** systems).

6.3.1.1.3 High Limit Shutoff. All air economizers shall be capable of automatically reducing outside air intake to the design minimum outdoor air quantity when outside air intake will no longer reduce cooling energy usage. High limit shutoff control types for specific climates shall be chosen from Table 6.3.1.1.3A. High limit shutoff control settings for these control types shall be those listed in Table 6.3.1.1.3B.

6.3.1.1.4 Dampers. Both return air and outside air dampers shall meet the requirements of 6.2.3.3.4.

6.3.1.1.5 Relief of Excess Outside Air. Systems shall provide a means to relieve excess outdoor air during air economizer operation to prevent overpressurizing the building. The relief air outlet shall be located to avoid recirculation into the building.

6.3.1.2 Water Economizers

6.3.1.2.1 Design Capacity. Water economizer systems shall be capable of cooling supply air by indirect evaporation and providing up to 100% of the expected system cooling load at outside air temperatures of 50°F dry bulb/45°F wet bulb and below.

Exception to 6.3.1.2.1: Systems in which a water economizer is used and where dehumidification requirements cannot be met using outside air temperatures of 50°F dry bulb/45°F wet bulb must satisfy 100% of the expected system cooling load at 45°F dry bulb/40°F wet bulb.

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

6.3.1.3 Integrated Economizer Control. Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

Exceptions to 6.3.1.3:

(a) Direct expansion systems that include controls that reduce the quantity of outdoor air required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is no greater than 25% of the total system capacity.

(b) Individual direct expansion units that have a rated cooling capacity less than 65,000 Btu/h and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.

(c) Systems in locations having less than 800 average hours per year between 8 a.m. and 4 p.m. when the ambient dry-bulb temperatures are between 55°F and 69°F inclusive. (See Appendix D for climatic data.)

6.3.1.4 Economizer Heating System Impact. HVAC system design and economizer controls shall be such that economizer operation does not increase the building heating energy use during normal operation.

Exception to 6.3.1.4: Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature.

TABLE 6.3.1
Minimum System Size for Which an Economizer is Required

No. of Hours Between 8 a.m. and 4 p.m. with 55 F < T_{db} < 69 F	1% Cooling Design Wet-Bulb Temperature		
	T_{wb} < 69°F	69°F ≤ T_{wb} ≤ 73°F	T_{wb} > 73°F
	Minimum System Size (Btu/h)	Minimum System Size (Btu/h)	Minimum System Size (Btu/h)
0-199	N.R.[a]	N.R.	N.R.
200-399	135,000	N.R.	N.R.
400-599	135,000	N.R.	N.R.
600-799	65,000	135,000	N.R.
800-999	65,000	135,000	135,000
1000-1199	65,000	65,000	135,000
>1199	65,000	65,000	65,000

[a] N.R. means that there is no system size for which an economizer is a requirement in this climate.

6.3.2 Simultaneous Heating and Cooling Limitation

6.3.2.1 Zone Controls. ***Zone*** thermostatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the ***zone***. Such controls shall prevent (1) ***reheating***, (2) ***recooling***, (3) mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems, and (4) other simultaneous operation of heating and cooling systems to the same ***zone***.

Exceptions to 6.3.2.1:

(a) ***Zones*** for which the volume of air that is reheated, recooled, or mixed is no greater than the larger of the following:

(1) The volume of outside air required to meet the ventilation requirements of 6.1.3 of ASHRAE Standard 62 for the ***zone***.

(2) 0.4 cfm/ft^2 of the ***zone*** conditioned floor area.

(3) 30% of the zone design peak supply rate.

(4) 300 cfm. This exception is for zones whose peak flow rate totals no more than 10% of the total fan system flow rate.

(5) Any higher rate that can be demonstrated, to the satisfaction of the ***authority having jurisdiction***, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in outdoor air intake in accordance with the multiple space requirements defined in ASHRAE Standard 62.

(b) ***Zones*** where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that variable air volume systems are impractical.

(c) ***Zones*** where at least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a ***site-recovered*** (including condenser heat) or ***site-solar energy*** source.

6.3.2.2 Hydronic System Controls. The heating of fluids in hydronic systems that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with 6.3.2.2.1 through 6.3.2.2.3.

6.3.2.2.1 Three-Pipe System. Hydronic systems that use a common return system for both hot water and chilled water shall not be used.

6.3.2.2.2 Two-Pipe Changeover System. Systems that use a common distribution system to supply both heated and chilled water are acceptable provided all of the following are met:

a. The system is designed to allow a deadband between changeover from one mode to the other of at least 15°F outside air temperature.

b. The system is designed to operate and is provided with controls that will allow operation in one mode for at least four hours before changing over to the other mode.

c. Reset controls are provided that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F apart.

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

a. Controls that are capable of providing a heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by the central devices (e.g., tower and boiler).

b. For climates with greater than 1800 HDD65, if a closed-circuit tower (fluid cooler) is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection) or low-leakage positive closure dampers shall be provided. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. If an open-circuit tower is used in conjunction with a separate heat exchanger to isolate the tower

TABLE 6.3.1.1.3A
High-Limit Shutoff Control Options for Air Economizers

Climate	Allowed Control Types	Prohibited Control Types
Dry T_{wb} < 69°F or (T_{wb} < 75°F and T_{db} ≥ 100°F[a]	Fixed Dry Bulb Differential Dry Bulb Electronic Enthalpy[b] Differential Enthalpy	Fixed Enthalpy
Intermediate 69°F ≤ T_{wb} ≤ 73°F T_{db} < 100°F	Fixed Dry Bulb Differential Dry Bulb Fixed Enthalpy Electronic Enthalpy[b] Differential Enthalpy	
Humid T_{wb} > 73°F	Fixed Dry Bulb Fixed Enthalpy Electronic Enthalpy[b] Differential Enthalpy	Differential Dry Bulb

[a] T_{wb} is the 1% ***cooling design*** wet-bulb temperature. T_{db} is the 1% ***cooling design*** dry-bulb temperature.
[b] Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

TABLE 6.3.1.1.3B
High-Limit Shutoff Control Settings for Air Economizers

Device Type	Climate	Required High Limit (Economizer Off When):	
		Equation	Description
Fixed Dry Bulb	Dry Intermediate Humid	T_{OA} > 75°F T_{OA} > 70°F T_{OA} > 65°F	Outside air temperature exceeds 75°F Outside air temperature exceeds 70°F Outside air temperature exceeds 65°F
Differential Dry Bulb	All	$T_{OA} > T_{RA}$	Outside air temperature exceeds return air temperature
Fixed Enthalpy	All	h_{OA} > 28 Btu/lb[a]	Outside air enthalpy exceeds 28 Btu/lb of dry air[a]
Electronic Enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outside air temperature/RH exceeds the “A” set point curve[b]
Differential Enthalpy	All	$h_{OA} > h_{RA}$	Outside air enthalpy exceeds return air enthalpy

[a] At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. As an example, at approximately 6000 ft elevation the fixed enthalpy limit is approximately 30.7 Btu/lb.
[b] Set point “A” corresponds to a curve on the psychometric chart that goes through a point at approximately 75°F and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

Exception to 6.3.2.2.3: Where a system loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of demand and capacity, dead bands of less than 20°F shall be allowed.

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

Exceptions to 6.3.2.3:

(a) The system is capable of reducing supply air volume to 50% or less of the design airflow rate or the minimum rate specified in 6.1.3 of ASHRAE Standard 62, whichever is larger, before simultaneous heating and cooling takes place.

(b) The individual fan cooling unit has a design cooling capacity of 80,000 Btu/h or less and is capable of unloading to 50% capacity before simultaneous heating and cooling takes place.

(c) The individual mechanical cooling unit has a design cooling capacity of 40,000 Btu/h or less. An individual mechanical cooling unit is a single system composed of a fan or fans and a cooling coil capable of providing mechanical cooling.

(d) Systems serving spaces where specific humidity levels are required to satisfy process needs, such as computer rooms, museums, surgical suites, and buildings with refrigerating systems, such as supermarkets, refrigerated warehouses, and ice arenas. This exception also applies to other applications for which fan volume controls in accordance with Exception (a) are proven to be impractical to the enforcement agency.

(e) At least 75% of the energy for reheating or for providing warm air in mixing systems is provided from a ***site-recovered*** (including condenser heat) or ***site solar energy*** source.

(f) Systems where the heat added to the airstream is the result of the use of a desiccant system and 75% of the heat added by the desiccant system is removed by a heat exchanger, either before or after the desiccant system with energy recovery.

6.3.2.4 Humidification. Systems with hydronic cooling and humidification systems designed to maintain inside humidity at greater than 35°F dewpoint temperature shall use a water economizer if an economizer is required by 6.3.1.

6.3.3 Air System Design and Control. HVAC systems having a total ***fan system power*** exceeding 5 hp shall meet the provisions of 6.3.3.1 through 6.3.3.2 unless otherwise noted.

6.3.3.1 Fan Power Limitation.

a. The ratio of the fan system power to the supply fan airflow rate (main fan) of each HVAC system at design conditions shall not exceed the allowable fan system power shown in Table 6.3.3.1.

b. Where air systems require air treatment or filtering systems with pressure drops over 1 in. w.c. when filters are clean, or heat recovery coils or devices, or direct evaporative humidifiers/coolers, or other devices to serve process loads in the airstream, the allowable fan system power may be adjusted using the pressure credit in the allowable fan system equation at the end of 6.3.3.1.

c. If the temperature difference between design room temperature and supply air temperature at cooling design conditions that is used to calculate design zone supply airflow is larger than 20°F, the allowable fan system power may be adjusted using the temperature ratio in the allowable fan system power equation at the end of 6.3.3.1.

TABLE 6.3.3.1
Fan Power Limitation

Supply Air Volume	Allowable Nameplate Motor Power	
	Constant Volume	Variable Volume
<20,000 cfm	1.2 hp/1000 cfm	1.7 hp/1000 cfm
≥20,000 cfm	1.1 hp/1000 cfm	1.5 hp/1000 cfm

$$\text{Allowable Fan System Power} = [\text{Table 6.3.3.1 Fan Power Limitation} \times (\text{Temperature Ratio}) + \text{Pressure Credit} + \text{Relief Fan Credit}]$$

where

Table 6.3.3.1 Fan Power Limitation = Table Value $\times \boldsymbol{CFM_n}/1000$

Temperature Ratio = $(\boldsymbol{T_{t\text{-}stat}} - \boldsymbol{T_S}) / 20$

Pressure Credit (hp) = Sum of $[\boldsymbol{CFM_n} \times (\boldsymbol{SP_n} - 1.0) / 3718]$ + Sum of $[\boldsymbol{CFM_{HR}} \times \boldsymbol{SP_{HR}}/3718]$

Relief Fan Credit HP (kW) = $\boldsymbol{F_R\ HP}$ (kW) $\times [1 - (\boldsymbol{CFM_{RF}} / \boldsymbol{CFM_n})]$

$\boldsymbol{CFM_n}$ = supply air volume of the unit with the filtering system (cfm)

$\boldsymbol{CFM_{HR}}$ = supply air volume of heat recovery coils or direct evaporative humidified/cooler (cfm)

$\boldsymbol{CFM_{RF}}$ = relief fan air volume at normal cooling design operation

$\boldsymbol{SP_n}$ = air pressure drop of the filtering system when filters are clean (in. w.g.)

$\boldsymbol{SP_{HR}}$ = air pressure drop of heat recovery coils or direct evaporative humidifier/cooler (in. w.g.).

$\boldsymbol{T_{t\text{-}stat}}$ = room thermostat set point

$\boldsymbol{T_S}$ = design supply air temperature for the zone in which the thermostat is located

$\boldsymbol{F_R}$ = name plate rating of the relief fan in hp

6.3.3.2 Variable Air Volume (VAV) Fan Control (Including Systems Using Series Fan Power Boxes).

6.3.3.2.1 Part-Load Fan Power Limitation. Individual VAV fans with motors 30 hp and larger shall meet one of the following:

a. The fan shall be driven by a mechanical or electrical variable-speed drive.

b. The fan shall be a vane-axial fan with variable-pitch blades.

c. The fan shall have other controls and devices that will result in fan motor demand of no more than 30% of design wattage at 50% of design air volume when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

6.3.3.2.2 Static Pressure Sensor Location. Static pressure sensors used to control variable air volume fans shall be placed in a position such that the controller set point is no greater than one-third the total design fan static pressure, except for systems with zone reset control complying with 6.3.3.2.3. If this results in the sensor being located downstream of major duct splits, multiple sensors shall be installed in each major branch to ensure that static pressure can be maintained in each.

6.3.3.2.3 Set Point Reset. For systems with direct digital control of individual zone boxes reporting to the central control panel, static pressure set point shall be reset based on the ***zone*** requiring the most pressure; i.e., the set point is reset lower until one ***zone*** damper is nearly wide open.

6.3.4 Hydronic System Design and Control. HVAC hydronic systems having a total ***pump system power*** exceeding 10 hp shall meet provisions of 6.3.4.1 through 6.3.4.4.

6.3.4.1 Hydronic Variable Flow Systems. HVAC pumping systems that include control valves designed to modulate or step open and close as a function of load shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to 50% or less of the design flow rate.

Individual pumps serving variable flow systems having a pump head exceeding 100 ft and motor exceeding 50 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. The controls or devices shall be controlled as a function of desired flow or to maintain a minimum required differential pressure. Differential pressure shall be measured at or near the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure.

Exceptions to 6.3.4.1:

(a) Systems where the minimum flow is less than the minimum flow required by the equipment manufacturer for the proper operation of equipment served by the system, such as chillers, and where total pump system power is 75 hp or less.

(b) Systems that include no more than three control valves.

6.3.4.2 Pump Isolation. When a chilled water plant includes more than one chiller, provisions shall be made so that the flow in the chiller plant can be automatically reduced, correspondingly, when a chiller is shut down. Chillers referred to in this section, piped in series for the purpose of increased temperature differential, shall be considered as one chiller.

When a boiler plant includes more than one boiler, provisions shall be made so that the flow in the boiler plant can be automatically reduced, correspondingly, when a boiler is shut down.

6.3.4.3 Chilled and Hot Water Temperature Reset Controls. Chilled and hot water systems with a design capacity exceeding 300,000 Btu/h supplying chilled or heated water (or both) to comfort conditioning systems shall include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature.

Exceptions to 6.3.4.3:

(a) Where the supply temperature reset controls cannot be implemented without causing improper operation of heating, cooling, humidifying, or dehumidifying systems.

(b) Hydronic systems, such as those required by 6.3.4.1, that use variable flow to reduce pumping energy.

6.3.4.4 Hydronic (Water Loop) Heat Pump Systems. Each hydronic heat pump shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off.

6.3.5 Heat Rejection Equipment.

6.3.5.1 General. Subsection 6.3.5 applies to heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers, and evaporative condensers.

Exception to 6.3.5.1: Heat rejection devices whose energy usage is included in the equipment efficiency ratings listed in Tables 6.2.1A through 6.2.1D.

6.3.5.2 Fan Speed Control. Each fan powered by a motor of 7.5 hp or larger shall have the capability to operate that fan at two-thirds of full speed or less and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exceptions to 6.3.5.2:

(a) Condenser fans serving multiple refrigerant circuits.

(b) Condenser fans serving flooded condensers.

(c) Installations located in climates with greater than 7200 CDD50.

(d) Up to one-third of the fans on a condenser or tower with multiple fans, where the lead fans comply with the speed control requirement

6.3.6 Energy Recovery

6.3.6.1 Exhaust Air Energy Recovery. Individual fan systems that have both a design supply air capacity of 5000 cfm or greater and have a minimum outside air supply of 70% or greater of the design supply air quantity shall have an energy recovery system with at least 50% recovery effectiveness. Fifty percent energy recovery effectiveness shall mean a change in the enthalpy of the outdoor air supply equal to 50% of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by 6.3.1.1.

Exceptions to 6.3.6.1:

(a) Laboratory systems meeting 6.3.7.2.

(b) Systems serving spaces that are not cooled and that are heated to less than 60°F.

(c) Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

(d) Commercial kitchen hoods (grease) classified as Type 1 by ***NFPA 96***.

(e) Where more than 60% of the outdoor air heating energy is provided from site-recovered or site solar energy.

(f) Heating systems in climates with less than 3600 HDD65.

(g) Cooling systems in climates with a 2.5% cooling design wet-bulb temperature less than 65°F.

(h) Where the largest exhaust source is less than 75% of the design outdoor airflow.

(i) Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil.

6.3.6.2 Heat Recovery for Service Water Heating. Condenser heat recovery systems shall be installed for heating or preheating of service hot water provided all of the following are true:

a. The facility operates 24 hours a day.

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

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

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

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

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

Exceptions to 6.3.6.2:

(a) Facilities that employ condenser heat recovery for space heating with a heat recovery design exceeding 30% of the peak water-cooled condenser load at design conditions.

(b) Facilities that provide 60% of their service water heating from ***site solar*** or ***site recovered energy*** or from other sources.

6.3.7 Exhaust Hoods

6.3.7.1 Kitchen Hoods. Individual kitchen exhaust hoods larger than 5000 cfm shall be provided with makeup air sized for at least 50% of exhaust air volume that is (a) unheated or heated to no more than 60°F and (b) uncooled or cooled without the use of mechanical cooling.

Exceptions to 6.3.7.1:

(a) Where hoods are used to exhaust ventilation air that would otherwise exfiltrate or be exhausted by other fan systems.

(b) Certified grease extractor hoods that require a face velocity no greater than 60 fpm.

6.3.7.2 Fume Hoods. Buildings with fume hood systems having a total exhaust rate greater than 15,000 cfm shall include at least one of the following features:

a. Variable air volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50% or less of design values.

b. Direct makeup (auxiliary) air supply equal to at least 75% of the exhaust rate, heated no warmer than 2°F below room set point, cooled to no cooler than 3°F above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control.

c. Heat recovery systems to precondition makeup air from fume hood exhaust in accordance with 6.3.6.1 (Exhaust Air Energy Recovery) without using any exception.

6.3.8 Radiant Heating Systems

6.3.8.1 Heating Unenclosed Spaces. Radiant heating shall be used when heating is required for unenclosed spaces.

Exception to 6.3.8.1: Loading docks equipped with air curtains.

6.3.8.2 Heating Enclosed Spaces. Radiant heating systems that are used as primary or supplemental enclosed space heating must be in conformance with the governing provisions of the standard, including, but not limited, to the following:

a Radiant hydronic ceiling or floor panels (used for heating or cooling).

b. Combination or hybrid systems incorporating radiant heating (or cooling) panels.

c. Radiant heating (or cooling) panels used in conjunction with other systems such as variable air volume or thermal storage systems.

TABLE 6.3.9
Hot Gas Bypass Limitation

Rated Capacity	Maximum Hot Gas Bypass Capacity (% of Total Capacity)
≤240,000 Btu/h	50%
>240,000 Btu/h	25%

6.3.9 Hot Gas Bypass Limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table 6.3.9.

Exception to 6.3.9: Unitary packaged systems with cooling capacities not greater than 90,000 Btu/h.

7. SERVICE WATER HEATING

7.1 General

7.1.1 Service Water Heating Scope. Service water heating ***systems*** and ***equipment*** shall meet the requirements of Section 7.

7.1.2 Compliance. Compliance shall be achieved by meeting the requirements of either

a. 7.2 (Mandatory Provisions) and 7.3 (Prescriptive Path), if applicable, or

b. 7.2 (Mandatory Provisions) in conjunction with Section 11 (Energy Cost Budget Method).

7.2 Mandatory Provisions

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

7.2.2 Equipment Efficiency. All water heating ***equipment***, hot water supply boilers used solely for heating potable water, pool heaters, and hot water storage tanks shall meet the criteria listed in Table 7.2.2. Where multiple criteria are listed, all criteria shall be met. Omission of minimum performance requirements for certain classes of ***equipment*** does not preclude use of such ***equipment*** where appropriate. Equipment not listed in Table 7.2.2 has no minimum performance requirements.

Exception to 7.2.2: All water heaters and hot water supply boilers having more than 140 gal of storage capacity are not required to meet the ***standby loss*** (SL) requirements of Table 7.2.2 when

(a) the tank surface is thermally insulated to R-12.5, and

(b) a standing pilot light is not installed, and

(c) gas- or oil-fired storage water heaters have a flue damper or fan-assisted combustion.

7.2.3 Service Hot Water Piping Insulation. The following piping shall be insulated to levels shown in Section 6, Table 6.2.4.1.3:

a. Recirculating system piping, including the supply and return piping of a circulating tank type water heater.

b. The first 8 ft of outlet piping for a constant temperature nonrecirculating storage ***system.***

c. The inlet pipe between the storage tank and a heat trap in a nonrecirculating storage ***system***.

d. Pipes that are externally heated (such as heat trace or impedance heating).

7.2.4 Service Water Heating System Controls

7.2.4.1 Temperature Controls. Temperature controls shall be provided that allow for storage temperature adjust-

TABLE 7.2.2
Performance Requirements for Water Heating Equipment

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required [a]	Test Procedure[b]
Electric Water Heaters	≤12 kW	≥20 gal Resistance	0.93-0.00132V EF	DOE 10 CFR Part 430
	>12 kW	≥20 gal Resistance	$20 + 35\sqrt{V}$ 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 and	<4000 (Btu/h)/gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	ANSI Z21.10.3
Gas Instantaneous Water Heaters	>50,000 Btu/h and <200,000 Btu/h[c]	≥4000 (Btu/h)/gal and <2 gal	0.62-0.0019V EF	DOE 10 CFR Part 430
	≥200,000 Btu/h	≥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 $(Q/800 + 110\sqrt{V})$ 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% E_t $(Q/800 + 110\sqrt{V})$ 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% E_t $(Q/800 + 110\sqrt{V})$ 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 $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Hot Water Supply Boilers, Oil		≥4000 (Btu/h)/gal and ≥10 gal	78% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Pool Heaters Oil and Gas	All		78% E_t	ASHRAE 146
Unfired Storage Tanks	All		R-12.5	(none)

[a] Energy factor (EF) and thermal efficiency (E_t) 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 must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

ment from 120°F or lower to a maximum temperature compatible with the intended use.

Exception to 7.2.4.1: When the manufacturer's installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion.

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

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

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

7.2.5 Pools

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

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

Exception to 7.2.5.2: Pools deriving over 60% of the energy for heating from ***site-recovered energy or solar energy source.***

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

Exceptions to 7.2.5.3:

(a) Where public health standards require 24-hour pump operation.

(b) Where pumps are required to operate solar and waste heat recovery pool heating ***systems***.

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

7.3 Prescriptive Path

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

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

$$(13.3 \times \boldsymbol{pmd} + 400) / \boldsymbol{n}$$

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

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

b. It is demonstrated to the satisfaction of the ***authority having jurisdiction*** that the use of a single heat source will consume less energy than separate units.

c. The energy input of the combined boiler and water heater system is less than 150,000 Btu/h.

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

8. POWER

8.1 General

Subsection 8.2 applies to all building power distribution ***systems.***

8.2 Mandatory Provisions

8.2.1 Voltage Drop

8.2.1.1 Feeders. ***Feeder conductors*** shall be sized for a maximum ***voltage drop*** of 2% at design load.

8.2.1.2 Branch Circuits. ***Branch circuit*** conductors shall be sized for a maximum ***voltage drop*** of 3% at design load.

8.2.2 Completion Requirements

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

a. a single-line diagram of the building electrical distribution system and

b. floor plans indicating location and area served for all distribution.

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

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

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

9. LIGHTING

9.1 General

Lighting systems and equipment shall comply with the requirements of 9.2 and 9.3. This section shall apply to the following:

a. interior spaces of ***buildings***;
b. exterior building features, including facades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies; and
c. exterior building grounds lighting provided through the ***building's*** electrical ***service***.

Exceptions to 9.1:

(a) emergency lighting that is automatically off during normal ***building*** operation,
(b) lighting within living units,
(c) lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation,
(d) decorative gas lighting systems.

9.2 Mandatory Provisions

9.2.1 Lighting Control

9.2.1.1 Automatic Lighting Shutoff. Interior lighting in ***buildings*** larger than 5000 ft^2 shall be controlled with an ***automatic control device*** to shut off ***building*** lighting in all spaces. This ***automatic control device*** shall function on either

a. a scheduled basis using a time-of-day operated control device that turns lighting off at specific programmed times—an independent program schedule shall be provided for areas of no more than 25,000 ft^2 but not more than one floor—or
b. an ***occupant sensor*** that shall turn lighting off within 30 minutes of an occupant leaving a space—or
c. a signal from another control or alarm system that indicates the area is unoccupied.

Exception to 9.2.1.1: Lighting intended for 24-hour operation shall not require an ***automatic control device.***

9.2.1.2 Space Control. Each space enclosed by ceiling-height partitions shall have at least one ***control device*** to independently ***control*** the ***general lighting*** within the space. Each ***control device*** shall be activated either manually by an occupant or automatically by sensing an occupant. Each ***control device*** shall

a. ***control*** a maximum of 2500 ft^2 area for a space 10,000 ft^2 or less and a maximum of 10,000 ft^2 area for a space greater than 10,000 ft^2,
b. be capable of overriding the shutoff ***control*** required in 9.2.1.1 for no more than four hours, and
c. be readily accessible and located so the occupant can see the controlled lighting.

Exception to 9.2.1.2: Remote location shall be permitted for reasons of safety or security when the remote control device has an indicator pilot light as part of or next to the control device and it shall be clearly labeled to identify the controlled lighting.

9.2.1.3 Exterior Lighting Control. Lighting for all exterior applications not exempted in 9.1 and 9.3.2 shall be controlled by a photosensor or astronomical time switch that is capable of automatically turning off the exterior lighting when sufficient daylight is available or the lighting is not required.

Exception to 9.2.1.3: Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.

9.2.1.4 Additional Control.

a. ***Display/Accent Lighting***—display or accent lighting shall have a separate ***control device***.
b. ***Case Lighting***—lighting in cases used for display purposes shall have a separate ***control device***.
c. ***Hotel and Motel Guest Room Lighting***—hotel and motel guest rooms and guest suites shall have a master ***control device*** at the main room entry that ***controls*** all ***permanently installed luminaires*** and switched receptacles.
d. ***Task Lighting***—supplemental task lighting, including ***permanently installed*** undershelf or undercabinet lighting, shall have a ***control device*** integral to the ***luminaires*** or be controlled by a wall-mounted ***control device*** provided the ***control device*** is readily accessible and located so that the occupant can see the controlled lighting.
e. ***Nonvisual Lighting***—lighting for nonvisual applications, such as plant growth and food warming, shall have a separate ***control device***.
f. ***Demonstration Lighting—lighting equipment*** that is for sale or for demonstrations in lighting education shall have a separate ***control device***.

9.2.2 Tandem Wiring. Luminaires designed for use with one or three linear fluorescent lamps greater than 30 W each shall use two-lamp tandem-wired ballasts in place of single-lamp ballasts when two or more luminaires are in the same space and on the same control device.

TABLE 9.3.1.1
Lighting Power Densities Using the Building Area Method

Building Area Type[a]	Lighting Power Density (W/ft^2)
Automotive Facility	1.5
Convention Center	1.4
Court House	1.4
Dining: Bar Lounge/Leisure	1.5
Dining: Cafeteria/Fast Food	1.8
Dining: Family	1.9
Dormitory	1.5
Exercise Center	1.4
Gymnasium	1.7
Hospital/Health Care	1.6
Hotel	1.7
Library	1.5
Manufacturing Facility	2.2
Motel	2.0
Motion Picture Theater	1.6
Multi-Family	1.0
Museum	1.6
Office	1.3
Parking Garage	0.3
Penitentiary	1.2
Performing Arts Theater	1.5
Police/Fire Station	1.3
Post Office	1.6
Religious Building	2.2
Retail	1.9
School/University	1.5
Sports Arena	1.5
Town Hall	1.4
Transportation	1.2
Warehouse	1.2
Workshop	1.7

[a] In cases where both general building area type and a specific building area type are listed, the specific building area type shall apply.

Exceptions to 9.2.2:

(a) Recessed luminaires more than 10 ft apart measured center to center.

(b) Surface-mounted or pendant luminaires that are not continuous.

(c) Luminaires using single-lamp high-frequency electronic ballasts.

(d) Luminaires using three-lamp high-frequency electronic or three-lamp electromagnetic ballasts.

(e) Luminaires on emergency circuits.

(f) Luminaires with no available pair.

9.2.3 Exit Signs. Exit sign ***luminaires*** operating at greater than 20 watts shall have a minimum source efficacy of 35 lm/W.

9.2.4 Installed Interior Lighting Power. The ***installed interior lighting power*** shall include all power used by the ***luminaires***, including ***lamps***, ***ballasts***, current regulators, and ***control devices*** except as specifically exempted in 9.3.1.

Exception to 9.2.4: If two or more independently operating lighting systems in a space are capable of being controlled to prevent simultaneous user operation, the installed interior lighting power shall be based solely on the lighting system with the highest wattage.

9.2.5 Luminaire Wattage. Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following criteria:

a. The wattage of incandescent or tungsten-halogen luminaires with medium screw base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaire.

b. The wattage of luminaires with permanently installed or remote ballasts or ***transformers*** shall be the operating input wattage of the maximum lamp/auxiliary combination based on values from the auxiliary manufacturer's literature or recognized testing laboratories.

c. The wattage of line-voltage lighting track and plug-in busway that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the specified wattage of the luminaires included in the system with a minimum of 30 W/lin ft.

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

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

9.2.6 Exterior Building Grounds Lighting. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under 9.1 or 9.3.2.

9.3 Prescriptive Path

9.3.1 Interior Lighting Power. The ***interior lighting power allowance*** for a ***building*** or a separately metered or permitted portion of a ***building*** shall be determined by either the ***building*** area method described in 9.3.1.1 or the space-by-space method described in 9.3.1.2. Trade-offs of ***interior lighting power allowance*** among portions of the ***building*** for which a different method of calculation has been used are not permitted. The ***installed interior lighting power*** identified in accordance with 9.2.4 shall not exceed the ***interior lighting power allowance*** developed in accordance with 9.3.1.1 or 9.3.1.2.

Exceptions to 9.3.1: The following ***lighting equipment*** and applications shall not be considered when determining the ***interior lighting power allowance*** developed in accordance with 9.3.1.1 or 9.3.1.2, nor shall the wattage for such lighting be included in the ***installed interior lighting power*** identified in accordance with 9.2.4. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent ***control device***.

(a) Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments.
(b) Lighting that is integral to ***equipment*** or instrumentation and is installed by its ***manufacturer.***
(c) Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical ***equipment***.
(d) Lighting integral to both open and glass enclosed refrigerator and freezer cases.
(e) Lighting integral to food warming and food preparation ***equipment***.
(f) Lighting for plant growth or maintenance.
(g) Lighting in spaces specifically designed for use by the visually impaired.
(h) Lighting in ***retail*** display windows, provided the display area is enclosed by ceiling-height partitions.
(i) Lighting in interior spaces that have been specifically designated as a registered interior ***historic*** landmark.
(j) Lighting that is an integral part of advertising or directional signage.
(k) Exit signs.
(l) Lighting that is for sale or lighting educational demonstration ***systems***.
(m) Lighting for theatrical purposes, including performance, stage, and film and video production.
(n) Athletic playing areas with permanent facilities for television broadcasting.
(o) Casino gaming areas.

9.3.1.1 Building Area Method of Calculating Interior Lighting Power Allowance. Use the following steps to determine the interior lighting power allowance by the building area method:

a. Determine the appropriate building area type from Table 9.3.1.1 and the allowed lighting power density (watts per unit area) from the building area method column. For building area types not listed, selection of a reasonably equivalent type shall be permitted.
b. Determine the gross lighted floor area (square feet) of the building area type.
c. Multiply the gross lighted floor areas of the building area type(s) times the ***lighting power density***.
d. The ***interior lighting power allowance*** for the building is the sum of the ***lighting power allowances*** of all building area types. Trade-offs among building area types are permitted provided that the total ***installed interior lighting power*** does not exceed the ***interior lighting power allowance***.

9.3.1.2 Space-by-Space Method of Calculating Interior Lighting Power Allowance. Use the following steps to determine the interior lighting power allowance by the space-by-space method:

a. Determine the appropriate building type from Table 9.3.1.2. For building types not listed, selection of a reasonably equivalent type shall be permitted.
b. For each space enclosed by partitions 80% or greater than ceiling height, determine the gross interior floor area by measuring to the center of the partition wall. Include the floor area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.
c. Determine the ***interior lighting power allowance*** by using the columns designated space-by-space method in Table 9.3.1.2. Multiply the floor area(s) of the space(s) times the allowed ***lighting power density*** for the space type that most closely represents the proposed use of the space(s). The product is the ***lighting power allowance*** for the space(s). For space types not listed, selection of a reasonable equivalent category shall be permitted.
d. The ***interior lighting power allowance*** is the sum of ***lighting power allowances*** of all spaces. Trade-offs among spaces are permitted provided that the total ***installed interior lighting power*** does not exceed the ***interior lighting power allowance***.

9.3.1.2.1 Additional Interior Lighting Power. When using the space-by-space method, an increase in the ***interior lighting power allowance*** is allowed for specific lighting functions. Additional power shall be allowed only if the specified lighting is installed, shall be used only for the specified ***luminaires,*** and shall not be used for any other purpose or in any other space.

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

a. For spaces in which lighting is specified to be installed in addition to the general lighting for the purpose of decorative appearance, such as chandelier-type luminaries or sconces or for highlighting art or exhibits, provided that the additional lighting power shall not exceed 1.0 W/ft^2 of such spaces.
b. For spaces in which lighting is specified to be installed to meet the requirements of visual display terminals as the primary viewing task, provided that the additional lighting power shall not exceed 0.35 W/ft^2 of such spaces and that the specified luminaire meets requirements for use in such spaces. Maximum average luminance measured from the vertical in candelas per square foot of not more than 80 cd/ft^2 at 65 degrees, 33 cd/ft^2 at 75 degrees, and 17 cd/ft^2 at 85 to 90 degrees.
c. For lighting equipment installed in retail spaces that is specifically designed and directed to highlight merchandise, provided that the additional lighting power shall not exceed

(1) 1.6 W/ft^2 times the area of specific display or

(2) 3.9 W/ft^2 times the area of specific display for valuable merchandise, such as jewelry, fine apparel and accessories, china and silver, art, and similar items, where detailed display and examination of merchandise are important.

TABLE 9.3.1.2
Lighting Power Densities Using the Space-by-Space Method

Building Type	Space-by-Space Method LPDs: Common Space Types and LPDs (W/ft^2): Officeó Enclosed	Officeó Open Plan	Conference Meeting/Mulitpurpose	Classroom/Lecture/Training	Audience/Seating Area	Lobby	Atriumó first three floors	Atriumó each additional floor	Lounge/Recreation	Dining Area	Food Preparation	Restrooms	Corridor/Transition	Stairsó Active	Active Storage	Inactive Storage	Electrical/Mechanical	Building Specific Space Types and LPDs (W/ft^2)	
Athletic Facility Buildings																			
Gymnasium	1.5	1.3	1.5		0.5	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Playing Area	1.9
																		Dressing/Locker/Fitting Room	0.8
																		Exercise Area	1.1
Exercise Center	1.5	1.3	1.5		0.5	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Exercise Area	1.1
																		Dressing/Locker/Fitting Room	0.8
Civil Service Buildings																			
Courthouse	1.5	1.3	1.5	1.6	1.6	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Courtroom	2.1
																		Confinement Cells	1.1
																		Judges Chambers	1.1
Police Stations	1.5	1.3	1.5	1.6	1.6	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Police Station Laboratory	1.8
Fire Stations	1.5	1.3	1.5	1.6		1.8			1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Fire Station Engine Room	0.9
																		Sleeping Quarters	1.1
Post Office	1.5	1.3	1.5	1.6		1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Sorting Area	1.7
Town Hall	1.5	1.3	1.5	1.6	1.6	1.8				1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3		
Convention Center Buildings																			
Convention Center	1.5	1.3	1.5	1.6	0.5	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Exhibit space	3.3
Educational Buildings																			
School/University	1.5	1.3	1.5	1.6		1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3		
Library	1.5	1.3	1.5	1.6		1.8	1.3	0.2		1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Card File and Cataloging	1.4
																		Stacks	1.9
																		Reading Area	1.8
Food Service Buildings																			
Dining: Bar Lounge/ Leisure	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.2	2.2	1.0	0.7	0.9	1.1	0.3	1.3		
Dining: Family	1.5	1.3	1.5			1.8	1.3	0.2	1.4	2.2	2.2	1.0	0.7	0.9	1.1	0.3	1.3		
Dining: Cafeteria	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3		

TABLE 9.3.1.2 (Continued)
Lighting Power Densities Using the Space-by-Space Method

Building Type	Officeó Enclosed	Officeó Open Plan	Conference Meeting/Mulitpurpose	Classroom/Lecture/Training	Audience/Seating Area	Lobby	Atriumó first three floors	Atriumó each additional floor	Lounge/Recreation	Dining Area	Food Preparation	Restrooms	Corridor/Transition	Stairsó Active	Active Storage	Inactive Storage	Electrical/Mechanical	Building Specific Space Types and LPDs (W/ft²)	
Hospital/Healthcare Buildings																			
Hospital/Healthcare	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	1.6	0.9	2.9	0.3	1.3	Emergency	2.8
																		Recovery	2.6
																		Nurse Station	1.8
																		Exam/Treatment	1.6
																		Pharmacy	2.3
																		Patient Room	1.2
																		Operating Room	7.6
																		Nursery	1.0
																		Medical Supply	3.0
																		Physical Therapy	1.9
																		Radiology	0.4
																		Laundry-Washing	0.7
Industrial Buildings																			
Workshop	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Workshop	2.5
Automotive Facility	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Garage Service/Repair	1.4
Manufacturing	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.5	0.9	1.1	0.3	1.3	General Low Bay (< 25 ft Floor to Ceiling Height)	2.1
																		General High Bay (≥ 25 ft Floor to Ceiling Height)	3.0
																		Detailed	6.2
																		Equipment Room	0.8
																		Control Room	0.5
Lodging Buildings																			
Hotel	1.5	1.3	1.5	1.6		1.7	1.3	0.2	1.4	1.0	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Guest Rooms	2.5
Motel	1.5	1.3	1.5	1.6		1.8	1.3	0.2	1.4	1.2	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Guest Rooms	2.5
Multi-Family	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Private living space	
Dormitory	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Living Quarters	1.9
Museum Buildings																			
Museum	1.5	1.3	1.5	1.6		1.8	1.3	0.2				1.0	0.7	0.9	1.4	1.4	1.3	General Exhibition	1.6
																		Restoration	2.5

TABLE 9.3.1.2 (Continued)
Lighting Power Densities Using the Space-by-Space Method

Building Type	Space-by-Space Method LPDs																		
	Common Space Types and LPDs (W/ft^2)																	Building Specific Space Types and LPDs (W/ft^2)	
	Officeó Enclosed	Officeó Open Plan	Conference Meeting/Mulitpurpose	Classroom/Lecture/Training	Audience/Seating Area	Lobby	Atriumó first three floors	Atriumó each additional floor	Lounge/Recreation	Dining Area	Food Preparation	Restrooms	Corridor/Transition	Stairsó Active	Active Storage	Inactive Storage	Electrical/Mechanical		
Office Buildings																			
Office	1.5	1.3	1.5	1.6		1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Banking Activity Area	2.4
																		Laboratory	1.8
Penitentiary Buildings																			
Penitentiary	1.5	1.3		1.4	1.9	1.8			1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Confinement Cells	1.1
Religious Buildings																			
Religious Buildings	1.5	1.3	1.5	1.6	3.2	1.8	1.3	0.2	1.4		2.2	1.0	0.7	0.9	1.1	0.3	1.3	Worship-Pulpit, Choir	5.2
																		Fellowship Hall	2.3
Retail Buildings																			
Retail	1.5	1.3	1.5			1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	General Sales Area	2.1
																		For accent lighting, see 9.3.1.2.1.(c)	
																		Mall Concourse	1.8
Sports Arena Building																			
Sports Arena	1.5	1.3	1.5		0.5	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Ring Sports Arena	3.8
																		Court Sports Arena	4.3
																		Indoor Playing Field Area	1.9
Storage Buildings																			
Warehouse	1.5	1.3	1.5			1.8	1.3	0.2				1.0	0.7	0.9	1.1	0.3	1.3	Fine Material Storage	1.6
																		Medium/Bulky Material Storage	1.1
Parking Garage	1.5					1.8						1.0	0.7	0.9	1.1	0.3	1.3	Parking Area - Pedestrian	0.2
																		Parking Area - Attendant only	0.1
Theater Buildings																			
Performing Arts	1.5				1.8	1.2	1.3	0.2	1.4			1.0	0.7	0.9	1.1	0.3	1.3		
Motion Picture					1.3	0.8			1.4			1.0	0.7	0.9	1.1	0.3	1.3		
Transportation Buildings																			
Transportation	1.5	1.3	1.5		1.0	1.8	1.3	0.2	1.4	1.4	2.2	1.0	0.7	0.9	1.1	0.3	1.3	Airport - Concourse	0.7
																		Air/Train/Bus - Baggage Area	1.3
																		Terminal - Ticket counter	1.8

TABLE 9.3.2
Lighting Power Limits for Building Exteriors

Applications	Power Limits
Building entrance with canopy or free standing canopy	3 W/ft^2 of canopied area
Building entrance without canopy	33 W/lin ft of door width
Building exit	20 W/lin ft of door width

9.3.2 Exterior Building Lighting Power. The exterior building facade lighting power shall not exceed 0.25 W/ft^2 of the illuminated area. The ***exterior lighting power allowance*** for all other exterior building applications is the sum of the lighting power limits permitted and specified in Table 9.3.2 for these applications. Exterior lighting for all applications (except those included in the exceptions to 9.1 and 9.3.2) shall comply with the requirements of 9.2.6.

Exceptions to 9.3.2: Lighting used for the following exterior applications is exempt when equipped with an independent ***control device***:

(a) specialized signal, directional, and marker lighting associated with transportation;

(b) lighting used to highlight features of public monuments and registered ***historic*** landmark structures or ***buildings***; and

(c) lighting that is integral to advertising signage.

10. OTHER EQUIPMENT

10.1 General.

All permanently wired electric motors shall meet the requirements of 10.2.

10.2 Mandatory Provisionsó Electric Motors. Electric motors shall comply with the requirements of the Energy Policy Act of 1992 where applicable, as shown in Table 10.2. Motors that are not included in the scope of the Energy Policy Act have no performance requirements in this section.

TABLE 10.2
Minimum Nominal Efficiency for General Purpose *Design A* and *Design B* Motors[a]

	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	-	82.5	80.0	75.5	82.5	80.0
1.5	82.5	84.0	84.0	82.5	84.0	85.5
2	84.0	84.0	85.5	84.0	84.0	86.5
3	84.0	86.5	86.5	85.5	87.5	87.5
5	85.5	87.5	87.5	87.5	87.5	87.5
7.5	87.5	88.5	88.5	88.5	89.5	89.5
10	88.5	89.5	90.2	89.5	89.5	89.5
15	89.5	91.0	90.2	90.2	91.0	90.2
20	90.2	91.0	91.0	90.2	91.0	90.2
25	91.0	91.7	91.7	91.0	92.4	91.7
30	91.0	92.4	92.4	91.0	92.4	91.7
40	91.7	93.0	93.0	91.7	93.0	93.0
50	92.4	93.0	93.0	92.4	93.0	93.0
60	93.0	93.6	93.6	93.0	93.6	93.6
75	93.0	94.1	93.6	93.0	94.1	93.6
100	93.0	94.1	94.1	93.6	94.5	94.1
125	93.6	94.5	94.1	94.5	94.5	94.1
150	93.6	95.0	94.5	94.5	95.0	95.0
200	94.5	95.0	94.5	95.0	95.0	95.0

[a] Nominal efficiencies shall be established in accordance with NEMA Standard MG1.

11. ENERGY COST BUDGET METHOD

11.1 General

11.1.1 Energy Cost Budget Method Scope. The building energy cost budget method is an alternative to the prescriptive provisions of this standard. It may be employed for evaluating the compliance of all proposed designs, except designs with no mechanical system.

11.1.2 Compliance. Compliance with Section 11 will be achieved if

a. all requirements of 5.2, 6.2, 7.2, 8.2, 9.2, and 10.2 are met;

b. the ***design energy cost*** does not exceed the ***energy cost budget*** when calculated in accordance with this section; and

c. the energy efficiency level of components specified in the building design meet or exceed the efficiency levels used to calculate the ***design energy cost.***

Informative Note: The ***energy cost budget*** and the ***design energy cost*** calculations are applicable only for determining compliance with this standard. They are not predictions of actual energy consumption or costs of the ***proposed design*** after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this standard, changes in energy rates between design of the building and occupancy, and precision of the calculation tool.

11.1.3 Trade-Offs Limited to Building Permit. When the building permit being sought applies to less than the whole building, only the calculation parameters related to the systems to which the permit applies shall be allowed to vary. Parameters relating to unmodified existing conditions or to future building components shall be identical for both the ***energy cost budget*** and the ***design energy cost*** calculations. Future building components shall meet the prescriptive requirements of 5.3, 6.3, 7.3, and 9.3.

11.1.4 Envelope Limitation. For new buildings or additions, the building energy cost budget method results shall not be submitted for building permit approval to the ***authority***

having jurisdiction prior to submittal for approval of the building envelope design.

11.1.5 Documentation Requirements. Compliance shall be documented and submitted to the ***authority having jurisdiction***. The information submitted shall include the following:

a. The ***energy cost budget*** for the ***budget building design*** and the ***design energy cost*** for the ***proposed design***.
b. A list of the energy-related features that are included in the design and on which compliance with the provisions of Section 11 is based. This list shall document all energy features that differ between the models used in the ***energy cost budget*** and the ***design energy cost*** calculations.
c. The input and output report(s) from the ***simulation program*** including a breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for both the ***proposed design*** and ***budget building design***.
d. An explanation of any error messages noted in the ***simulation program*** output.

11.2 Simulation General Requirements

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

Note to Adopting Authority: The SSPC 90.1 recommends that a compliance shell implementing the rules of the compliance supplement that controls inputs to, and from, output formats from the required computer analysis program be adopted for the purposes of easier use and simpler compliance. Suggested guidance for the detail that could be included in this compliance shell is included in the User's Manual to this Standard.

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

a. a minimum of 1400 hours per year;
b. hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays;
c. thermal mass effects;
d. Ten or more thermal zones;
e. part-load performance curves for mechanical equipment;
f. capacity and efficiency correction curves for mechanical heating and cooling equipment;
g. air-side and water-side economizers with integrated control; and
h. the ***budget building design*** characteristics specified in 11.4.

11.2.1.2 The simulation program shall have the ability to either (1) directly determine the ***design energy cost*** and ***energy cost budget*** or (2) produce hourly reports of energy use by energy source suitable for determining ***the design energy cost*** and ***energy cost budget*** using a separate calculation engine.

11.2.1.3 The ***simulation program*** shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with 6.2.2 for both the ***proposed design*** and ***budget building design***.

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

11.2.3 Purchased Energy Rates. Annual energy costs shall be determined using rates for purchased energy, such as electricity, gas, oil, propane, steam, and chilled water, and approved by the ***adopting authority***.

Exception to 11.2.3: On-site renewable energy sources or site-recovered energy shall not be considered to be purchased energy and shall not be included in the ***design energy cost***. Where on-site renewable or site-recovered sources are used, the ***budget building design*** shall be based on the energy source used as the backup energy source or electricity if no backup energy source has been specified.

11.2.4 Compliance Calculations: The ***design energy cost*** and ***energy cost budget*** shall be calculated using

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

11.3 Calculation of the *Design Energy Cost*

11.3.1 Proposed Design Model. The simulation model of the ***proposed design*** shall be consistent with the design documents, including proper accounting of window and wall types and area; lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls.

11.3.2 Space Use Classification. The ***building*** type or ***space*** type classifications shall be chosen in accordance with 9.3.1.1 or 9.3.1.2. The user or designer shall specify the space use classifications using either the ***building*** type or ***space*** type categories but shall not combine the two types of categories within a single permit application. More than one ***building*** type category may be used in a ***building*** if it is a mixed-use facility.

11.3.3 Buildings with Incomplete Energy System Designs. When the ***energy cost budget*** method is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the ***proposed design*** so that they minimally comply with applicable mandatory and prescriptive requirements from Sections 5 through 10. Where the space classification for a building is not known, the building shall be categorized as an office building.

11.3.4 Requirement for Both Heating and Cooling. All ***conditioned spaces*** in the ***proposed design*** shall be simulated as being both heated and cooled even if no cooling or heating system is being installed.

11.3.5 HVAC Systems. The HVAC 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 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 6.2.1, if required by the simulation model.

c. Where no heating system exists or no heating system has been specified, the heating system shall be modeled as fossil fuel. The system characteristics shall be identical to the system modeled in the ***budget building design.***

d. Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per ***thermal block***. The system characteristics shall be identical to the system modeled in the ***budget building design.***

11.3.6 Building Envelope. All components of the ***building envelope*** in the ***proposed design*** shall be modeled as shown on architectural drawings or as installed for existing building envelopes.

Exceptions to 11.3.6: The following building elements are permitted to differ from architectural drawings.

(a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type.

(b) Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.

(c) For exterior roofs other than roofs with ventilated attics, 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. The reflectance and emittance shall be tested in accordance with the Exception to 5.3.1.1. All other roof surfaces shall be modeled with a reflectance of 0.3.

11.3.7 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 model shall reflect the actual system type using actual component capacities and efficiencies.

b. Where a service hot water system has been designed, the service hot water model shall be consistent with design documents.

c. Where no service hot water system exists or is specified, no service hot water heating shall be modeled.

11.3.8 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 9.3.

c. Where no lighting exists or is specified, lighting power shall be determined in accordance with the Building Area Method for the appropriate building type.

11.3.9 Other Systems. Other systems, such as motors, covered by Section 10, may be modeled. If they are modeled, performance shall be as indicated on design drawings. Miscellaneous internal loads, such as those due to office and other equipment, shall be estimated based on the building type or space type category as approved by the ***authority having jurisdiction***.

11.3.10 Further Modeling Limitations and Exceptions

11.3.10.1 General. All elements of the ***proposed design*** envelope, HVAC, service water heating, lighting, and electrical systems shall be modeled in the ***proposed design*** in accordance with the requirements of 11.3.4 through 11.3.9.

Exception to 11.3.10.1 Components and systems in the ***proposed design*** may be excluded from the simulation model provided

(a) component energy usage does not affect the energy usage of systems and components that are being considered for trade-off;

(b) the applicable prescriptive requirements of 5.3, 6.3, 7.3, and 9.3 applying to the excluded components are met.

11.3.10.2 Limitations to the *Simulation Program*. If the ***simulation program*** cannot model a component or system included in the ***proposed design***, one of the following methods shall be used with the approval of the ***authority having jurisdiction***:

a. Ignore the component if the energy impact on the trade-offs being considered is not significant.

b. Model the component substituting a thermodynamically similar component model.

c. Model the ***HVAC system*** components or systems using the ***budget building design's HVAC system*** in accordance with 11.4.3.

Whichever method is selected, the component shall be modeled identically for both the ***proposed design*** and ***budget building design*** models.

11.3.10.3 Alterations and Additions. It is acceptable to demonstrate compliance using building models that exclude parts of the existing building provided all of the following conditions are met:

a. Work to be performed under the current permit application in excluded parts of the building shall meet the requirements of Sections 5 through 10.
b. Excluded parts of the building are served by ***HVAC systems*** that are entirely separate from those serving parts of the building that are included in the building model.
c. Design space temperature and HVAC system operating set points and schedules, on either side of the boundary between included and excluded parts of the building, are identical.
d. If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the building are on the same utility meter, the rate shall reflect the utility block or rate for the building plus the addition.

11.3.11 Schedules. The schedule types listed in 11.2.1.1 (b) shall be required input. The schedules shall be typical of the proposed building type as determined by the designer and approved by the ***authority having jurisdiction.*** Required schedules shall be identical for the ***proposed design*** and ***budget building design***.

11.3.12 ***Thermal Blocks. Thermal blocks*** for the ***budget building design*** and ***proposed design*** shall be identical.

11.3.12.1 ***HVAC Zones*** **Designed.** Where ***HVAC zones*** are defined on HVAC design drawings, each HVAC zone shall be modeled as a separate ***thermal block***.

Exception to 11.3.12.1: Different ***HVAC zones*** may be combined to create a single ***thermal block*** or identical ***thermal blocks*** to which multipliers are applied provided all of the following conditions are met:

(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 are within 45 degrees of each other.
(c) All of the zones are served by the same ***HVAC system*** or by the same kind of ***HVAC system***.

11.3.12.2 ***HVAC Zones*** **Not Designed.** Where the ***HVAC zones*** and systems have not yet been designed, ***thermal blocks*** shall be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following guidelines:

a. Separate ***thermal blocks*** shall be assumed for interior and perimeter spaces. Interior spaces shall be those located greater than 15 ft from an exterior wall. Perimeter spaces shall be those located closer than 15 ft from 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 orientations that differ by no more than 45 degrees may be considered to be the same orientation. Each zone shall include all floor area that is 15 ft or less from a glazed perimeter wall, except that floor area within 15 ft of glazed perimeter walls having more than one orientation shall be divided proportionately between zones.
c. Separate ***thermal blocks*** shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.
d. Separate ***thermal blocks*** shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

11.3.12.3 ***Thermal Blocks*** **in Multifamily Residential Buildings.** ***Residential spaces*** shall be modeled using one ***thermal block*** per space except that those 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.

11.4 Calculation of the *Energy Cost Budget*

11.4.1 Budget Building Design. The ***budget building design*** shall be developed by modifying the ***proposed design*** as described in 11.3. Except as specifically instructed in 11.4, all building systems and equipment shall be modeled identically in the ***budget building design*** and ***proposed design***.

11.4.2 Building Envelope. The ***budget building design*** shall have identical conditioned floor area and identical exterior dimensions and orientations as the ***proposed design***, except as noted in a., b., and c. in this clause.

a. ***Opaque*** **assemblies.** ***Opaque*** assemblies such as ***roof, floors, doors,*** and ***walls*** shall be modeled as having the same ***heat capacity*** as the ***proposed design*** but with the minimum U-factor required in 5.3 for new buildings or additions and 4.1.2.2.1 for alterations.
b. ***Roof*** **albedo.** All ***roof*** surfaces shall be modeled with a reflectivity of 0.3.
c. ***Fenestration*****.** No shading projections are to be modeled; ***fenestration*** shall be assumed to be flush with the exterior ***wall*** or ***roof***. If the ***fenestration*** area for new buildings or additions exceeds the maximum allowed by 5.3.2.1, the area shall be reduced proportionally along each exposure until the limit set in 5.3.2.1 is met. ***Fenestration*** U-factor shall be the minimum required for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation. The fenestration model for envelope alterations shall reflect the limitations on area, U-factor and solar heat gain coefficient as described in 4.1.2.2.1.

Exception to 11.4.2: When trade-offs are made between an addition and an existing building as described in Exception (b) to 4.1.2.1, the envelope assumptions for the existing building in the ***budget building design*** shall reflect existing conditions prior to any revisions that are part of this permit.

11.4.3 ***HVAC Systems*****.** The ***HVAC system*** type and related performance parameters for the ***budget building*** design shall be determined from Figure 11.4.3, the system

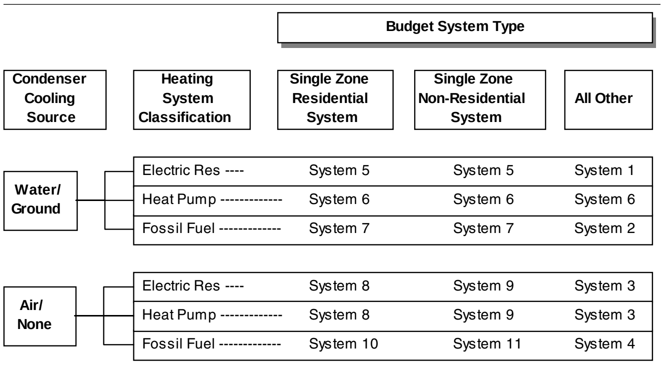

Figure 11.4.3 HVAC Systems Map

descriptions in Table 11.4.3A and accompanying notes, and the following rules:

a. Components and parameters not listed in Figure 11.4.3 and Table 11.4.3A or otherwise specifically addressed in this subsection shall be identical to those in the ***proposed design.***

Exception to 11.4.3a: Where there are specific requirements in 6.2 and 6.3, the component efficiency in the ***budget building design*** shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

b. All HVAC and service water heating equipment in the ***budget building*** shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with 6.2 and 7.2.

c. 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. Supply and return/relief system fans shall be modeled as operating at least whenever the spaces served are occupied except as specifically noted in Table 11.4.3A.

d. Minimum outdoor air ventilation rates shall be the same for both the ***budget building design*** and ***proposed building***. Heat recovery shall be modeled for the ***budget building design*** in accordance with 6.3.6.1.

e. ***Budget building*** systems as listed in Table 11.4.3A shall have outdoor air economizers or water economizers, the same as in the proposed building, in accordance with 6.3.1. The high-limit shutoff shall be in accordance with Table 11.4.3D.

f. Not used.

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

h. System design supply air rates for the ***budget building design*** shall be based on a supply-air-to-room-air temperature difference of 20°F. If return or relief fans are specified in the ***proposed design***, the ***budget building design*** shall also be modeled with the same fan type sized for the budget system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.

i. Fan system efficiency (BHP per cfm of supply air including the effect of belt losses but excluding motor and motor drive losses) shall be the same as the ***proposed design*** or up to the limit prescribed in 6.3.3.1, whichever is smaller. If this limit is reached, each fan shall be proportionally reduced in brake horsepower until the limit is met. Fan electrical power shall then be determined by adjusting the calculated fan HP by the minimum motor efficiency prescribed by 10.2 for the appropriate motor size for each fan.

j. The equipment capacities for ***the budget building design*** shall be sized proportionally to the capacities in the ***proposed design*** based on sizing runs; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the ***proposed design*** and ***budget building design***. Unmet load hours for the ***proposed design*** shall not differ from unmet load hours for the ***budget building design*** by more than 50 hours.

k. Each ***HVAC system*** in a ***proposed design*** is mapped on a one-to-one correspondence with one of eleven ***HVAC systems*** in the ***budget building design***. To determine the budget building system:

TABLE 11.4.3A Budget System Descriptions

	System 1	System 2	System 3
System Type	**Variable air volume with parallel fan-powered boxes (Note 1)**	**Variable air volume with reheat (Note 2)**	**Packaged variable air volume with parallel fan-powered boxes (Note 1)**
Fan Control	VAV (Note 4)	VAV (Note 4)	VAV (Note 4)
Cooling Type	Chilled Water (Note 5)	Chilled Water (Note 5)	Direct Expansion (Note 3)
Heating Type	Electric Resistance	Hot Water Fossil Fuel Boiler (Note 6)	Electric Resistance

	System 4	System 5	System 6
System Type	**Packaged variable air volume with reheat (Note 2)**	**Two-pipe fan-coil**	**Water-source heat pump**
Fan Control	VAV (Note 4)	Constant Volume (Note 9)	Constant Volume (Note 9)
Cooling Type	Direct Expansion (Note 3)	Chilled Water (Note 5)	Direct Expansion (Note 3)
Heating Type	Hot Water Fossil Fuel Boiler (Note 6)	Electric Resistance	Electric Heat Pump and Boiler (Note 7)

TABLE 11.4.3A (Continued) Budget System Descriptions

	System 7	System 8	System 9
System Type	Four-pipe fan coil	Packaged terminal heat pump	Packaged rooftop heat pump
Fan Control	Constant Volume (Note 9)	Constant Volume (Note 9)	Constant Volume (Note 9)
Cooling Type	Chilled Water (Note 5)	Direct Expansion (Note 3)	Direct Expansion (Note 3)
Heating Type	Hot Water Fossil Fuel Boiler (Note 6)	Electric Heat Pump (Note 8)	Electric Heat Pump (Note 8)

	System 10	System 11
System Type	Packaged terminal air conditioner	Packaged rooftop air conditioner
Fan Control	Constant Volume (Note 9)	Constant Volume (Note 9)
Cooling Type	Direct Expansion	Direct Expansion
Heating Type	Hot Water Fossil Fuel Boiler (Note 6)	Fossil Fuel Furnace

NOTES:

1. Fans in parallel VAV fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume set points for fan-powered boxes shall be equal to the minimum rate for the space required for ventilation consistent with 6.3.2.1 Exception (a) 1. Supply air temperature set point shall be constant at the design condition (see 11.4.3 (h)).

2. Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft^2 of floor area consistent with 6.3.2.1 Exception (a) 2. Supply air temperature shall be reset based on zone demand from the design temperature difference to a 10°F temperature difference under minimum load conditions. Design air flow rates shall be sized for the reset supply air temperature, i.e., a 10°F temperature difference.

3. The fuel type for the cooling system shall match that of the cooling system in the ***proposed design***.

4. Constant volume can be modeled if the system qualifies for Exception (b) to 6.3.2.1. When the ***proposed design*** system has a supply, return, or relief fan motor 25 hp or larger, the corresponding fan in the VAV system of the ***budget building design*** shall be modeled assuming a variable speed drive. For smaller fans, a forward-curved centrifugal fan with inlet vanes shall be modeled. If the ***proposed design's*** system has a direct digital control system at the zone level, static pressure set point reset based on zone requirements in accordance with 6.3.3.2.3 shall be modeled.

5. For systems using purchased chilled water, the chillers are not explicitly modeled and chilled water costs shall be based as determined in 11.2.3. Otherwise, the ***budget building design's*** chiller plant shall be modeled with chillers having the number as indicated in Table 11.4.3B as a function of ***budget building*** chiller plant load and type as indicated in Table 11.4.3C as a function of individual chiller load. Where chiller fuel source is mixed, the system in the ***budget building design*** shall have chillers with the same fuel types and with capacities having the same proportional capacity as the ***proposed design's*** chillers for each fuel type. Chilled water supply temperature shall be modeled at 44°F design supply temperature and 56°F return temperature. Piping losses shall not be modeled in either building model. Chilled water supply water temperature shall be reset in accordance with 6.3.4.3. Pump system power for each pumping system shall be the same as the ***proposed design***; if the ***proposed design*** has no chilled water pumps, the ***budget building design*** pump power shall be 22 W/gpm (equal to a pump operating against a 75 ft head, 65% combined impeller and motor efficiency). The chilled water system shall be modeled as primary-only variable flow with flow maintained at the design rate through each chiller using a bypass. Chilled water pumps shall be modeled as riding the pump curve or with variable-speed drives when required in 6.3.4.1. The heat rejection device shall be an axial fan cooling tower with two-speed fans if required in 6.3.5. Condenser water design supply temperature shall be 85°F or 10°F approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. Pump system power for each pumping system shall be the same as the ***proposed design***; if the ***proposed design*** has no condenser water pumps, the ***budget building design*** pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% combined impeller and motor efficiency). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

6. For systems using purchased hot water or steam, the boilers are not explicitly modeled and hot water or steam costs shall be based on actual utility rates. Otherwise, the boiler plant shall use the same fuel as the ***proposed design*** and shall be natural draft. The ***budget building design*** boiler plant shall be modeled with a single boiler if the ***budget building design*** plant load is 600,000 Btu/h and less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Hot water supply temperature shall be modeled at 180°F design supply temperature and 130°F return temperature. Piping losses shall not be modeled in either building model. Hot water supply water temperature shall be reset in accordance with 6.3.4.3. Pump system power for each pumping system shall be the same as the ***proposed design***; if the ***proposed design*** has no hot water pumps, the ***budget building design*** pump power shall be 19 W/gpm (equal to a pump operating against a 60 ft head, 60% combined impeller and motor efficiency). The hot water system shall be modeled as primary-only with continuous variable flow. Hot water pumps shall be modeled as riding the pump curve or with variable speed drives when required by 6.3.4.1.

7. The boiler in the ***budget building design*** system shall use the same fuel as the ***proposed design*** and shall be natural draft. If no boilers exist in the ***proposed design***, the budget building boilers shall be fossil fuel. Other boiler parameters shall be as described in Note 6.

8. Electric air-source heat pumps shall be modeled with electric auxiliary heat. The system shall be controlled with a multi-stage space thermostat and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outside air temperature is less than 40°F.

9. Fans shall be controlled in the same manner as in the ***proposed design***; i.e., fan operation whenever the space is occupied or fan operation cycled on calls for heating and cooling. If the fan is modeled as cycling and the fan energy is included in the energy efficiency rating of the equipment, fan energy shall not be modeled explicitly.

TABLE 11.4.3B
Number of Chillers

Total Chiller Plant Capacity	Number of Chillers
≤300 tons	1
> 300 tons, < 600 tons	2 sized equally
≥600 tons	2 minimum with chillers added so that no chiller is larger than 800 tons, all sized equally

TABLE 11.4.3C
Water Chiller Types

Individual Chiller Plant Capacity	Electric Chiller Type	Fossil Fuel Chiller Type
≤100 tons	Reciprocating	Single-effect absorption, direct fired
>100 tons, <300 tons	Screw	Double-effect absorption, direct fired
≥300 tons	Centrifugal	Double-effect absorption, direct fired

TABLE 11.4.3D
Economizer High Limit Shut-off

Economizer Type	High Limit Shut-Off
Air	Table 6.3.1.1.3B
Water (Integrated)	When its operation will no longer reduce HVAC system energy
Water (Non-Integrated)	When its operation can no longer provide the cooling load

(1) Enter Figure 11.4.3 at "Water" if the ***proposed design*** system condenser is water or evaporatively cooled; enter at "Air" if the condenser is air-cooled. Closed circuit dry-coolers shall be considered air-cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is specified or the mechanical cooling system in the ***proposed design*** does not require heat rejection, the system shall be treated as if the condenser water type were "Air."

(2) Select the path that corresponds to the ***proposed design*** heat source: electric resistance, heat pump (including air-source and water-source), or fuel-fired. Systems utilizing district heating (steam or hot water) shall be treated as if the heating system type were "Fossil Fuel." Systems with no heating capability shall be treated as if the heating system type were "Fossil Fuel." For systems with mixed fuel heating sources, the system or systems that use the secondary heating source type (the one with the smallest total installed output capacity for the spaces served by the system) shall be modeled identically in the ***budget building design*** and the primary heating source type shall be used in Figure 11.4.3 to determine budget system type.

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

11.4.4 Service Hot Water Systems. The service hot water system type and related performance in the ***budget building design*** shall be identical to the ***proposed design*** except where 7.3 applies. In this case the boiler shall be split into a separate space heating boiler and hot water heater with efficiency requirements set to the least efficient allowed.

11.4.5 Lighting. Lighting power in the ***budget 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 9.3. Lighting controls shall be the minimum required.

11.4.6 Other Systems. Other systems, such as motors covered by Section 10, and miscellaneous loads shall be modeled as identical to those in the ***proposed design***. Where there are specific efficiency requirements in Section 10, these systems or components shall be modeled as having the lowest efficiency allowed by those requirements.

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

a. make no change in any input parameter values specified by this standard and the ***adopting authority***;

b. provide input and output documentation that facilitates the enforcement agency's review and meets the formatting and content required by the ***adopting authority***; and

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

12. NORMATIVE REFERENCES

Reference	Title
10 CFR Part 430, App E	Uniform Test Method for Measuring the Energy Consumption of Furnaces
42 USC 6831, et seq., Public Law 102-486	Energy Policy Act of 1992
Air Movement and Control Association International, 30 West University Drive, Arlington Heights, IL 60004-1806	
AMCA 500-1989	Test Methods for Louvers, Dampers, and Shutters
American National Standards Institute, 11 West 42nd Street, New York, NY 10036	
ANSI Z21.10.3-1998	Gas Water Heater, Volume 3, Storage, with Input Ratings above 75,000 Btu/h, Circulating and Instantaneous Water Heaters
ANSI Z21.13a-1993	Gas-Fired Low-Pressure Steam and Hot Water Boilers
ANSI Z21.47-1993	Gas-Fired Central Furnaces (Except Direct Vent and Separated Combustion System Furnaces)
ANSI Z21.66-1994	Automatic Vent Damper Devices for Use with Gas-Fired Appliances
ANSI Z83.8-1990	Gas Unit Heaters
ANSI Z83.9-1990	Gas-Fired Duct Furnaces
Association of Home Appliance Manufacturers, 20 North Wacker Drive, Chicago, IL 60606	
ANSI/AHAM RAC-1-87	Room Air Conditioners
Air-Conditioning and Refrigeration Institute, 4301 N. Fairfax Drive, Suite 425, Arlington, VA 22203	
ARI 210/240-94	Unitary Air Conditioning and Air-Source Heat Pump Equipment
ARI 310/380-93	Packaged Terminal Air-Conditioners and Heat Pumps
ARI 320-98	Water-Source Heat Pumps
ARI 325-98	Ground Water-Source Heat Pumps
ARI 330-98	Ground Source Closed-Loop Heat Pumps
ARI 340/360-2000	Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
ARI 365-94	Commercial and Industrial Unitary Air-Conditioning Condensing Units
ARI 550/590-98	Water-Chilling Packages Using the Vapor Compression Cycle
ARI 560-2000	Absorption Water Chilling and Water Heating Packages
American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle, NE, Atlanta, GA 30329	
ANSI/ASHRAE Standard 62-1999	Ventilation for Acceptable Indoor Air Quality
ANSI/ASHRAE 146-1998	Method of Testing for Rating Pool Heaters
American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10017	
ASME PTC 4.1-1964	Steam Generating Units
American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959	
ASTM C90-96	Standard Specification for Loadbearing Concrete Masonry Units
ASTM C177-85	Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
ASTM C272-91	Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
ASTM C518-91	Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C835-95 (1999)	Standard Test Method for Total Hemispherical Emittance of Surfaces From 20ºC to 1400ºC
ASTM C976-90	Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box
ASTM C1371-98	Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers

ASTM E96-95	Test Methods for Water Vapor Transmission of Materials
ASTM E283-91	Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E408-71 (1996)	Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques
ASTM E903-96	Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres
ASTM E1175-87 (1996)	Standard Test Method for Determining Solar or Photopic Reflectance, Transmittance, and Absorptance of Materials Using a Large Diameter Integrating Sphere
ASTM E1918-97	Standard Test Method for Measuring Solar Reflectance of Horizontal or Low-Sloped Surfaces in the Field
Cooling Technology Institute, 530 Wells Fargo, Suite 218, Houston, TX 77090; P.O. Box 73383, Houston, TX 77273	
CTI ATC-105(97)	Acceptance Test Code for Water Cooling Towers
CTI STD-201 (96)	Standard for Certification of Water Cooling Tower Thermal Performance
Hydronics Institute, 35 Russo Place, P.O. Box 218, Berkeley Heights, NJ 07922	
H.I. Htg. Boiler Std.	Testing and Rating Standard for Heating Boilers
ISO, 1, rue de Varembe, Case postale 56, CH-1211 Geneve 20, Switzerland	
ISO 13256-1 (1998)	Water-Source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-Air and Brine-to-Air Heat Pumps
Door and Access Systems Manufacturers Association, 1300 Sumner Avenue, Cleveland, OH 44115-2851	
ANSI/DASMA 105-1992 (R 1998)	Test Method for Thermal Transmittance and Air Infiltration of Garage Doors
National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209	
ANSI/NEMA MG 1-1993	Motors and Generators
National Fire Protection Association, 1 Battery March Park, P.O. Box 9101, Quincy, MA 02269-9101	
NFPA 96-94	Ventilation Control and Fire Protection of Commercial Cooking Operations
National Fenestration Rating Council, 1300 Spring Street, Suite 500, Silver Springs, MD 20910	
NFRC 100-97	Procedure for Determining Fenestration Product U-Factors (Including 100 Section B—Procedure for Determining Door System Product Thermal Properties)
NFRC 200-95	Procedure for Determining Fenestration Product Solar Heat Gain Coefficients at Normal Incidence
NFRC 300-94	Procedure for Determining Solar Optical Properties of Simple Fenestration Products
NFRC 301-93	Standard Test Method for Emittance of Specular Surfaces Using Spectrometric Measurements
NFRC 400-95	Procedure for Determining Fenestration Product Air Leakage
Underwriters Laboratories, Inc., 333 Pfingsten Rd., Northbrook, IL 60062	
UL 726-90	UL Standard for Safety—Oil-Fired Boiler Assemblies
UL 727-94	UL Standard for Safety—Oil-Fired Central Furnaces
UL 731-95	UL Standard for Safety—Oil-Fired Unit Heaters
UL 795-94	UL Standard for Safety—Commercial-Industrial Gas Heating Equipment

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

NORMATIVE APPENDIX A

ASSEMBLY U-FACTOR, C-FACTOR, AND F-FACTOR DETERMINATION

A1 General

A1.1 Pre-Calculated Assembly U-Factors, C-Factors, F-Factors, or Heat Capacities. The ***U-factors***, ***C-factors, F-factors,*** and ***heat capacities*** for typical construction assemblies are included in A2 through A8. These values shall be used for all calculations unless otherwise allowed by A1.2. Interpolation between values in a particular table in Appendix A is allowed for ***rated R-values of insulation***, including insulated sheathing. Extrapolation beyond values in a table in Appendix A is not allowed.

A1.2 Applicant-Determined Assembly U-Factors, C-Factors, F-Factors, or Heat Capacities. If the ***building official*** determines that the proposed construction assembly is not adequately represented in A2 through A8, the applicant shall determine appropriate values for the assembly using the assumptions in A9. An assembly is deemed to be adequately represented if

TABLE A-1 (Section A2.2)
Assembly U-Factors for Roofs with Insulation Entirely Above Deck

Rated R-Value of Insulation Alone	Overall U-Factor for Entire Assembly
R-0	U-1.282
R-1	U-0.562
R-2	U-0.360
R-3	U-0.265
R-4	U-0.209
R-5	U-0.173
R-6	U-0.147
R-7	U-0.129
R-8	U-0.114
R-9	U-0.102
R-10	U-0.093
R-11	U-0.085
R-12	U-0.078
R-13	U-0.073
R-14	U-0.068
R-15	U-0.063
R-16	U-0.060
R-17	U-0.056
R-18	U-0.053
R-19	U-0.051
R-20	U-0.048
R-21	U-0.046
R-22	U-0.044
R-23	U-0.042
R-24	U-0.040
R-25	U-0.039
R-26	U-0.037
R-27	U-0.036
R-28	U-0.035
R-29	U-0.034
R-30	U-0.032
R-35	U- 0.028
R-40	U-0.025
R-45	U-0.020
R-50	U-0.020
R-55	U-0.018
R-60	U-0.016

a. the interior structure, hereafter referred to as the base assembly, for the ***class of construction*** is the same as described in A2 through A8 and

b. changes in exterior or interior surface ***building materials*** added to the base assembly do not increase or decrease the R-value by more than 2 from that indicated in the descriptions in A2 through A8.

Insulation, including insulated sheathing, is not considered a ***building material.***

A2 Roofs

A2.1 General. The buffering effect of suspended ceilings or attic spaces shall not be included in ***U-factor*** calculations.

A2.2 Roofs with Insulation Entirely Above Deck. ***U-factors*** for ***roofs with insulation entirely above deck*** shall be taken from Table A-1. It is not acceptable to use these ***U-factors*** if the insulation is not entirely above deck or not continuous.

For the purpose of A1.2, the base assembly is ***continuous insulation*** over a structural deck. The ***U-factor*** includes R-0.17 for exterior air film, R-0 for metal deck, and R-0.61 for interior air film heat flow up. Added insulation is continuous and uninterrupted by framing. The framing factor is zero.

A2.3 Metal Building Roofs. ***U-factors*** for ***metal building roofs*** shall be taken from Table A-2. It is not acceptable to use these ***U-factors*** if additional insulated sheathing is not continuous.

For the purpose of A1.2, the base assembly is a ***roof*** where the insulation is draped over the steel structure (purlins) and then compressed when the metal spanning members are attached to the steel structure (purlins). Additional assemblies include ***continuous insulation***, uncompressed and uninterrupted by framing.

A2.4 Attic Roofs with Wood Joists. ***U-factors*** for ***attic roofs*** with wood joists shall be taken from Table A-3. It is not acceptable to use these ***U-factors*** if the framing is not wood. For ***attic roofs*** with steel joists, see A2.5.

For the purpose of A1.2, the base ***attic roof*** assembly is a ***roof*** with a nominal 4 in. deep wood as the lower chord of a roof truss or ceiling joist. The ceiling is attached directly to the lower chord of the truss and the attic space above is ventilated. Insulation is located directly on top of the ceiling, first filling the cavities between the wood and then later covering both the wood and cavity areas. No credit is given for roofing materials. The ***single-rafter roof*** is similar to the base ***attic roof***, with the key difference being that there is a single, deep rafter to which both the ***roof*** and the ceiling are attached. The heat flow path through the rafter is calculated to be the same depth as the insulation. The ***U-factor*** includes R-0.46 for semi-exterior air film, R-0.56 for 0.625 in. gypsum board, and R-0.61 for interior air film heat flow up. ***U-factors*** are provided for the following configurations:

a. ***Attic roof***, ***standard framing***: insulation is tapered around the perimeter with resultant decrease in thermal resistance. Weighting factors are 85% full-depth insulation, 5% half-depth insulation, and 10% joists.

TABLE A-2 (Section A2.3)
Assembly U-Factors for Metal Building Roofs

Insulation System	Rated R-Value of Insulation	Total Rated R-Value of Insulation	Overall U-Factor for Entire Base Roof Assembly	Overall U-Factor for Assembly of Base Roof Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation					
				R-5.6	R-11.2	R-16.8	R-22.4	R-28.0	R-33.6
Standing Seam Roofs with Thermal Blocks									
Single Layer	None	0	**1.280**	0.162	0.087	0.059	0.045	0.036	0.030
	R-6	6	**0.167**	0.086	0.058	0.044	0.035	0.029	0.025
	R-10	10	**0.097**	0.063	0.046	0.037	0.031	0.026	0.023
	R-11	11	**0.092**	0.061	0.045	0.036	0.030	0.026	0.022
	R-13	13	**0.083**	0.057	0.043	0.035	0.029	0.025	0.022
	R-16	16	**0.072**	0.051	0.040	0.033	0.028	0.024	0.021
	R-19	19	**0.065**	0.048	0.038	0.031	0.026	0.023	0.020
Double Layer	R-10 + R-10	20	**0.063**	0.047	0.037	0.031	0.026	0.023	0.020
	R-10 + R-11	21	**0.061**	0.045	0.036	0.030	0.026	0.023	0.020
	R-11 + R-11	22	**0.060**	0.045	0.036	0.030	0.026	0.022	0.020
	R-10 + R-13	23	**0.058**	0.044	0.035	0.029	0.025	0.022	0.020
	R-11 + R-13	24	**0.057**	0.043	0.035	0.029	0.025	0.022	0.020
	R-13 + R-13	26	**0.055**	0.042	0.034	0.029	0.025	0.022	0.019
	R-10 + R-19	29	**0.052**	0.040	0.033	0.028	0.024	0.021	0.019
	R-11 + R-19	30	**0.051**	0.040	0.032	0.027	0.024	0.021	0.019
	R-13 + R-19	32	**0.049**	0.038	0.032	0.027	0.023	0.021	0.019
	R-16 + R-19	35	**0.047**	0.037	0.031	0.026	0.023	0.020	0.018
	R-19 + R-19	38	**0.046**	0.037	0.030	0.026	0.023	0.020	0.018
(Multiple R-values are listed in order from inside to outside)									
Screw Down Roofs									
	R-10	10	**0.153**	0.082	0.056	0.043	0.035	0.029	0.025
	R-11	11	**0.139**	0.078	0.054	0.042	0.034	0.028	0.025
	R-13	13	**0.130**	0.075	0.053	0.041	0.033	0.028	0.024
Filled Cavity with Thermal Blocks									
	R19 + R-10	29	**0.041**	0.033	0.028	0.024	0.021	0.0198	0.017
(Multiple R-values are listed in order from inside to outside)									

TABLE A-3 (Section A2.4)
Assembly U-Factors for Attic Roofs with Wood Joists

Rated R-Value of Insulation Alone	Overall U-Factor for Entire Assembly
Wood-framed attic, standard framing	
None	0.613
R-11	0.091
R-13	0.081
R-19	0.053
R-30	0.034
R-38	0.027
R-49	0.021
R-60	0.017
R-71	0.015
R-82	0.013
R-93	0.011
R-104	0.010
R-115	0.009
R-126	0.008
Wood-framed attic, advanced framing	
None	0.613
R-11	0.088
R-13	0.078
R-19	0.051
R-30	0.032
R-38	0.026
R-49	0.020
R-60	0.016
R-71	0.014
R-82	0.012
R-93	0.011
R-104	0.010
R-115	0.009
R-126	0.008
Wood joists, single rafter roof	
None	0.417
R-11	0.088
R-13	0.078
R-15	0.071
R-19	0.055
R-21	0.052
R-25	0.043
R-30	0.036
R-38	0.028

TABLE A-4 (Section A2.5)
Assembly U-Factors for Attic Roofs with Steel Joists (4.0 ft on center)

Rated R-Value of Insulation Area	Overall U-Factor for Entire Assembly
R-0	U-1.282
R-4	U-0.215
R-5	U-0.179
R-8	U-0.120
R-10	U-0.100
R-11	U-0.093
R-12	U-0.086
R-13	U-0.080
R-15	U-0.072
R-16	U-0.068
R-19	U-0.058
R-20	U-0.056
R-21	U-0.054
R-24	U-0.049
R-25	U-0.048
R-30	U-0.041
R-35	U-0.037
R-38	U-0.035
R-40	U-0.033
R-45	U-0.031
R-50	U-0.028
R-55	U-0.027

b. ***Attic roof*, *advanced framing***: full and even depth of insulation extending to the outside edge of exterior walls. Weighting factors are 90% full-depth insulation and 10% joists.

c. ***Single-rafter roof***: an ***attic roof*** where the roof sheathing and ceiling are attached to the same rafter. Weighting factors are 90% full-depth insulation and 10% joists.

A2.5 Attic Roofs with Steel Joists. ***U-factors*** for ***attic roofs*** with steel joists shall be taken from Table A-4. It is acceptable to use these ***U-factors*** for any ***attic roof*** with steel joists.

For the purpose of A1.2, the base assembly is a roof supported by steel joists with insulation between the joists. The assembly represents a ***roof*** in many ways similar to a ***roof with insulation entirely above deck*** and a ***metal building roof***.

It is distinguished from the ***metal building roof*** category in that there is no metal exposed to the exterior. It is distinguished from the ***roof with insulation entirely above deck*** in that the insulation is located below the deck and is interrupted by metal trusses that provide thermal bypasses to the insulation. The ***U-factor*** includes R-0.17 for exterior air film, R-0 for

TABLE A-5 (Section A3.1)
Assembly U-Factors for Above-Grade Concrete Walls and Masonry Walls

Framing Type and Depth	Rated R-Value of Insulation Alone	Assembly U-Factors for 8 in. Normal Weight 145 lb/ft^3 Solid Concrete Walls	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft^3 Concrete Block Walls: Solid Grouted	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft^3 Concrete Block Walls: Partially Grouted (cores uninsulated except where specified)
No Framing	**R-0**	**U-0.740**	**U-0.580**	**U-0.480**
	Ungrouted Cores Filled with Loose-Fill Insulation	**N.A.**	**N.A.**	**U-0.350**
Continuous metal framing at 24 in. on center horizontally				
3.5 in.	R-11.0	U-0.168	U-0.158	U-0.149
3.5 in.	R-13.0	U-0.161	U-0.152	U-0.144
3.5 in.	R-15.0	U-0.155	U-0.147	U-0.140
4.5 in.	R-17.1	U-0.133	U-0.126	U-0.121
4.5 in.	R-22.5	U-0.124	U-0.119	U-0.114
4.5 in.	R-25.2	U-0.122	U-0.116	U-0.112
5.0 in.	R-19.0	U-0.122	U-0.117	U-0.112
5.0 in.	R-25.0	U-0.115	U-0.110	U-0.106
5.0 in.	R-28.0	U-0.112	U-0.107	U-0.103
5.5 in.	R-19.0	U-0.118	U-0.113	U-0.109
5.5 in.	R-20.9	U-0.114	U-0.109	U-0.105
5.5 in.	R-21.0	U-0.113	U-0.109	U-0.105
5.5 in.	R-27.5	U-0.106	U-0.102	U-0.099
5.5 in.	R-30.8	U-0.104	U-0.100	U-0.096
6.0 in.	R-22.8	U-0.106	U-0.102	U-0.098
6.0 in.	R-30.0	U-0.099	U-0.095	U-0.092
6.0 in.	R-33.6	U-0.096	U-0.093	U-0.090
6.5 in.	R-24.7	U-0.099	U-0.096	U-0.092
7.0 in.	R-26.6	U-0.093	U-0.090	U-0.087
7.5 in.	R-28.5	U-0.088	U-0.085	U-0.083
8.0 in.	R-30.4	U-0.083	U-0.081	U-0.079
1 in. metal clips at 24 in. on center horizontally and 16 in. vertically				
1.0 in.	R-3.8	U-0.210	U-0.195	U-0.182
1.0 in.	R-5.0	U-0.184	U-0.172	U-0.162
1.0 in.	R-5.6	U-0.174	U-0.163	U-0.154
1.5 in.	R-5.7	U-0.160	U-0.151	U-0.143
1.5 in.	R-7.5	U-0.138	U-0.131	U-0.125
1.5 in.	R-8.4	U-0.129	U-0.123	U-0.118
2.0 in.	R-7.6	U-0.129	U-0.123	U-0.118
2.0 in.	R-10.0	U-0.110	U-0.106	U-0.102
2.0 in.	R-11.2	U-0.103	U-0.099	U-0.096
2.5 in.	R-9.5	U-0.109	U-0.104	U-0.101
2.5 in.	R-12.5	U-0.092	U-0.089	U-0.086
2.5 in.	R-14.0	U-0.086	U-0.083	U-0.080
3.0 in.	R-11.4	U-0.094	U-0.090	U-0.088
3.0 in.	R-15.0	U-0.078	U-0.076	U-0.074
3.0 in.	R-16.8	U-0.073	U-0.071	U-0.069
3.5 in.	R-13.3	U-0.082	U-0.080	U-0.077
3.5 in.	R-17.5	U-0.069	U-0.067	U-0.065
3.5 in.	R-19.6	U-0.064	U-0.062	U-0.061

TABLE A-5 (Section A3.1) (Continued)
Assembly U-Factors for Above-Grade Concrete Walls and Masonry Walls

Framing Type and Depth	Rated R-Value of Insulation Alone	Assembly U-Factors for 8 in. Normal Weight 145 lb/ft^3 Solid Concrete Walls	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft^3 Concrete Block Walls: Solid Grouted	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft^3 Concrete Block Walls: Partially Grouted (cores uninsulated except where specified)
No Framing	**R-0**	**U-0.740**	**U-0.580**	**U-0.480**
	Ungrouted Cores Filled with Loose-Fill Insulation	**N.A.**	**N.A.**	**U-0.350**
4.0 in.	R-15.2	U-0.073	U-0.071	U-0.070
4.0 in.	R-20.0	U-0.061	U-0.060	U-0.058
4.0 in.	R-22.4	U-0.057	U-0.056	U-0.054
5.0 in.	R-28.0	U-0.046	U-0.046	U-0.045
6.0 in.	R-33.6	U-0.039	U-0.039	U-0.038
7.0 in.	R-39.2	U-0.034	U-0.034	U-0.033
8.0 in.	R-44.8	U-0.030	U-0.030	U-0.029
9.0 in.	R-50.4	U-0.027	U-0.027	U-0.026
10.0 in.	R-56.0	U-0.024	U-0.024	U-0.024
11.0 in.	R-61.6	U-0.022	U-0.022	U-0.022
Continuous insulation uninterrupted by framing				
No Framing	R-1.0	U-0.425	U-0.367	U-0.324
No Framing	R-2.0	U-0.298	U-0.269	U-0.245
No Framing	R-3.0	U-0.230	U-0.212	U-0.197
No Framing	R-4.0	U-0.187	U-0.175	U-0.164
No Framing	R-5.0	U-0.157	U-0.149	U-0.141
No Framing	R-6.0	U-0.136	U-0.129	U-0.124
No Framing	R-7.0	U-0.120	U-0.115	U-0.110
No Framing	R-8.0	U-0.107	U-0.103	U-0.099
No Framing	R-9.0	U-0.097	U-0.093	U-0.090
No Framing	R-10.0	U-0.088	U-0.085	U-0.083
No Framing	R-11.0	U-0.081	U-0.079	U-0.076
No Framing	R-12.0	U-0.075	U-0.073	U-0.071
No Framing	R-13.0	U-0.070	U-0.068	U-0.066
No Framing	R-14.0	U-0.065	U-0.064	U-0.062
No Framing	R-15.0	U-0.061	U-0.060	U-0.059
No Framing	R-16.0	U-0.058	U-0.056	U-0.055
No Framing	R-17.0	U-0.054	U-0.053	U-0.052
No Framing	R-18.0	U-0.052	U-0.051	U-0.050
No Framing	R-19.0	U-0.049	U-0.048	U-0.047
No Framing	R-20.0	U-0.047	U-0.046	U-0.045
No Framing	R-21.0	U-0.045	U-0.044	U-0.043
No Framing	R-22.0	U-0.043	U-0.042	U-0.042
No Framing	R-23.0	U-0.041	U-0.040	U-0.040
No Framing	R-24.0	U-0.039	U-0.039	U-0.038
No Framing	R-25.0	U-0.038	U-0.037	U-0.037
No Framing	R-30.0	U-0.032	U-0.032	U-0.031
No Framing	R-35.0	U-0.028	U-0.027	U-0.027
No Framing	R-40.0	U-0.024	U-0.024	U-0.024
No Framing	R-45.0	U-0.022	U-0.021	U-0.021
No Framing	R-50.0	U-0.019	U-0.019	U-0.019
No Framing	R-55.0	U-0.018	U-0.018	U-0.018
No Framing	R-60.0	U-0.016	U-0.016	U-0.016

metal deck, and R-0.61 for interior air film heat flow up. The performance of the insulation/framing layer is calculated using the values in Table A-20.

A3 Above-Grade Walls

A3.1 Mass Wall. ***U-factors*** for ***mass walls*** shall be taken from Table A-5 or determined by the procedure in this subsection. It is acceptable to use the ***U-factors*** in Table A-5 for all ***mass walls***, provided that the grouting is equal to or less than that specified. ***Heat capacity*** for ***mass walls*** shall be taken from Table A-6 or A-7.

> **Exception to A3.1:** U-factors for mass walls determined in accordance with 5.3.1.2.

For the purpose of A1.2, the base assembly is a masonry or concrete ***wall***. ***Continuous insulation*** is installed on the interior, exterior, or within the masonry units, or it is installed on the interior or exterior of the concrete. The ***U-factor*** includes R-0.17 for exterior air film and R-0.68 for interior air film, vertical surfaces. For insulated walls, the U-factor also includes R-0.45 for 0.5 in. gypsum board. ***U-factors*** are provided for the following configurations:

a. Concrete ***wall***: 8 in. normal weight concrete wall with a density of 145 lb/ft^3.

b. Solid grouted concrete block ***wall***: 8 in. medium weight ASTM C90 concrete block with a density of 115 lb/ft^3 and solid grouted cores.

c. Partially grouted concrete block ***wall***: 8 in. medium weight ASTM C90 concrete block with a density of 115 lb/ft^3 having reinforcing steel every 32 in. vertically and every 48 in. horizontally, with cores grouted in those areas only. Other cores are filled with insulating material only if there is no other insulation.

If not taken from Table A-5, ***mass wall U-factors*** shall be determined from Tables A-6, A-7, and A-8 using the following procedure.

d. If the ***mass wall*** is uninsulated or only the cells are insulated:
   1. For concrete ***walls***, determine the ***U-factor*** from Table A-6 based on the concrete density and ***wall*** thickness.
   2. For concrete block ***walls***, determine the ***U-factor*** from Table A-7 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated.

e. If the ***mass wall*** has additional insulation:
   1. For concrete ***walls***, determine the $\boldsymbol{R_u}$ from Table A-6 based on the concrete density and ***wall*** thickness. Next, determine the effective R-value for the insulation/framing layer from Table A-8 based on the ***rated R-value of insulation*** installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the ***U-factor*** by adding the $\boldsymbol{R_u}$ and the effective R-value together and taking the inverse of the total.
   2. For concrete block ***walls***, determine the $\boldsymbol{R_u}$ from Table A-7 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated. Next, determine the effective R-value for the insulation/framing layer from Table A-8 based on the ***rated R-value of insulation*** installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the ***U-factor*** by adding the $\boldsymbol{R_u}$ and the effective R-value together and taking the inverse of the total.

A3.2 Metal Building Walls. ***U-factors*** for ***metal building walls*** shall be taken from Table A-9. It is not acceptable to use these ***U-factors*** if additional insulation is not continuous.

For the purpose of A1.2, the base assembly is a ***wall*** where the insulation is compressed between metal wall panels and the metal structure. Additional assemblies include ***continuous insulation***, uncompressed and uninterrupted by framing.

A3.3 Steel-Framed Walls. ***U-factors*** for ***steel-framed walls*** shall be taken from Table A-10. For ***steel-framed walls*** with framing at less than 24 in. on center, use the standard framing values as described in (a) below. For ***steel-framed walls*** with framing from 24 in. to 32 in. on center, use the advanced framing values as described in (b) below. For ***steel-framed walls*** with framing greater than 32 in. on center, use the ***metal building wall*** values in Table A9.

For the purpose of A1.2, the base assembly is a ***wall*** where the insulation is installed within the cavity of the steel stud framing but where there is not a metal exterior surface spanning member. The steel stud framing is a minimum uncoated thickness of 0.043 in. for 18 gauge or 0.054 in. for 16 gauge. The ***U-factor*** includes R-0.17 for exterior air film, R-0.08 for stucco, R-0.56 for 0.625 in.16 mm gypsum board on the exterior, R-0.56 for 0.625 in.16 mm gypsum board on the interior, and R-0.68 for interior vertical surfaces air film. The performance of the insulation/framing layer is calculated using the values in Table A-21. Additional assemblies include ***continuous insulation***, uncompressed and uninterrupted by framing. ***U-factors*** are provided for the following configurations:

a. ***Standard framing***: steel stud framing at 16 in. on center with cavities filled with 16 in. wide insulation for both 3.5 in. deep and 6.0 in. deep wall cavities.

b. ***Advanced framing***: steel stud framing at 24 in. on center with cavities filled with 24 in. wide insulation for both 3.5 in. deep and 6.0 in. deep wall cavities.

A3.4 Wood-Framed Walls. ***U-factors*** for ***wood-framed walls*** shall be taken from Table A-11. For ***wood-framed walls*** with framing at less than 24 in. on center, use the standard framing values as described in (a) below. For ***wood-framed walls*** with framing from 24 in. to 32 in. on center, use the advanced framing values as described in (b) below if the headers are uninsulated or the advanced framing with insulated headers values as described in (c) below if the headers are insulated. For ***wood-framed walls*** with framing greater than 32 in. on center, U-factors shall be determined in accordance with A9.

For the purpose of A1.2, the base assembly is a ***wall*** where the insulation is installed between 2 in. nominal wood fram-

TABLE A-6 (Sections 5.3.1.2, A3.1, and A4.1)
Assembly U-Factors, C-Factors, R_u, R_c, and Heat Capacity for Concrete

Density in lb/ft^3	Properties	Thickness in inches 3	4	5	6	7	8	9	10	11	12
20	U-factor	0.22	0.17	0.14	0.12	0.10	0.09	0.08	0.07	0.07	0.06
	C-factor	0.27	0.20	0.16	0.13	0.11	0.10	0.09	0.08	0.07	0.07
	R_u	4.60	5.85	7.10	8.35	9.60	10.85	12.10	13.35	14.60	15.85
	R_c	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00
	HC	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
30	U-factor	0.28	0.22	0.19	0.16	0.14	0.12	0.11	0.10	0.09	0.09
	C-factor	0.37	0.28	0.22	0.18	0.16	0.14	0.12	0.11	0.10	0.09
	R_u	3.58	4.49	5.40	6.30	7.21	8.12	9.03	9.94	10.85	11.76
	R_c	2.73	3.64	4.55	5.45	6.36	7.27	8.18	9.09	10.00	10.91
	HC	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
40	U-factor	0.33	0.27	0.23	0.19	0.17	0.15	0.14	0.13	0.11	0.11
	C-factor	0.47	0.35	0.28	0.23	0.20	0.18	0.16	0.14	0.13	0.12
	R_u	2.99	3.71	4.42	5.14	5.85	6.56	7.28	7.99	8.71	9.42
	R_c	2.14	2.86	3.57	4.29	5.00	5.71	6.43	7.14	7.86	8.57
	HC	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0
50	U-factor	0.38	0.31	0.26	0.23	0.20	0.18	0.16	0.15	0.14	0.13
	C-factor	0.57	0.43	0.34	0.28	0.24	0.21	0.19	0.17	0.15	0.14
	R_u	2.61	3.20	3.79	4.38	4.97	5.56	6.14	6.73	7.32	7.91
	R_c	1.76	2.35	2.94	3.53	4.12	4.71	5.29	5.88	6.47	7.06
	HC	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0
85	U-factor	0.65	0.56	0.50	0.44	0.40	0.37	0.34	0.31	0.29	0.27
	C-factor	1.43	1.08	0.86	0.71	0.61	0.54	0.48	0.43	0.39	0.36
	R_u	1.55	1.78	2.01	2.25	2.48	2.71	2.94	3.18	3.41	3.64
	R_c	0.70	0.93	1.16	1.40	1.63	1.86	2.09	2.33	2.56	2.79
	HC	4.3	5.7	7.1	8.5	9.9	11.3	12.8	14.2	15.6	17.0
95	U-factor	0.72	0.64	0.57	0.52	0.48	0.44	0.41	0.38	0.36	0.33
	C-factor	1.85	1.41	1.12	0.93	0.80	0.70	0.62	0.56	0.51	0.47
	R_u	1.39	1.56	1.74	1.92	2.10	2.28	2.46	2.64	2.81	2.99
	R_c	0.54	0.71	0.89	1.07	1.25	1.43	1.61	1.79	1.96	2.14
	HC	4.8	6.3	7.9	9.5	11.1	12.7	14.3	15.8	17.4	19.0
105	U-factor	0.79	0.71	0.65	0.59	0.54	0.51	0.47	0.44	0.42	0.39
	C-factor	2.38	1.79	1.43	1.18	1.01	0.88	0.79	0.71	0.65	0.59
	R_u	1.27	1.41	1.557	1.70	1.84	1.98	2.12	2.26	2.40	2.54
	R_c	0.42	0.56	0.70	0.85	0.99	1.13	1.27	1.41	1.55	1.69
	HC	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5	19.3	21.0
115	U-factor	0.84	0.77	0.70	0.65	0.61	0.57	0.53	0.50	0.48	0.45
	C-factor	2.94	2.22	1.75	1.47	1.25	1.10	0.98	0.88	0.80	0.74
	R_u	1.19	1.30	1.42	1.53	1.65	1.76	1.87	1.99	2.10	2.21
	R_c	0.34	0.45	0.57	0.68	0.80	0.91	1.02	1.14	1.25	1.36
	HC	5.8	7.7	9.6	11.5	13.4	15.3	17.3	19.2	21.1	23.0
125	U-factor	0.88	0.82	0.76	0.71	0.67	0.63	0.60	0.56	0.53	0.51
	C-factor	3.57	2.70	2.17	1.79	1.54	1.35	1.20	1.08	0.98	0.90
	R_u	1.13	1.22	1.31	1.41	1.50	1.59	1.68	1.78	1.87	1.96
	R_c	0.28	0.37	0.46	0.56	0.65	0.74	0.83	0.93	1.02	1.11
	HC	6.3	8.3	10.4	12.5	14.6	16.7	18.8	20.8	22.9	25.0
135	U-factor	0.93	0.87	0.82	0.77	0.73	0.69	0.66	0.63	0.60	0.57
	C-factor	4.55	3.33	2.70	2.22	1.92	1.67	1.49	1.33	1.22	1.11
	R_u	1.07	1.15	1.22	1.30	1.37	1.45	1.52	1.60	1.67	1.75
	R_c	0.22	0.30	0.37	0.45	0.52	0.60	0.67	0.75	0.82	0.90
	HC	6.8	9.0	11.3	13.5	15.8	18.0	20.3	22.5	24.8	27.0
144	U-factor	0.96	0.91	0.86	0.81	0.78	0.74	0.71	0.68	0.65	0.63
	C-factor	5.26	4.00	3.23	2.63	2.27	2.00	1.79	1.59	1.45	1.33
	R_u	1.04	1.10	1.16	1.23	1.29	1.35	1.41	1.48	1.54	1.60
	R_c	0.19	0.25	0.31	0.38	0.44	0.50	0.56	0.63	0.69	0.75
	HC	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8

The U-factors and R_u include standard air film resistances.
The C-factors and R_c are for the same assembly without air film resistances.
Note that the following assemblies do not qualify as a mass wall or mass floor:
3 in. thick concrete with densities of 85, 95, 125, and 135 lbs/ft^3.

TABLE A-7 (Sections 5.3.1.2, A3.1, and A4.1)
Assembly U-Factors, C-Factors, R_u, R_c, and Heat Capacity for Concrete Block Walls

Product Size: in.	Density: lb/ft^3	Properties	Concrete Block Grouting and Cell Treatment				
			Solid Grouted	Partly Grouted, Cells Empty	Partly Grouted, Cells Insulated	Unreinforced, Cells Empty	Unreinforced, Cells Insulated
6 in. block	85	U-factor	0.57	0.46	0.34	0.40	0.20
		C-factor	1.11	0.75	0.47	0.60	0.23
		R_u	1.75	2.18	2.97	2.52	5.13
		R_c	0.90	1.33	2.12	1.67	4.28
		HC	10.9	6.7	7.0	4.2	4.6
	95	U-factor	0.61	0.49	0.36	0.42	0.22
		C-factor	1.25	0.83	0.53	0.65	0.27
		R_u	1.65	2.06	2.75	2.38	4.61
		R_c	0.80	1.21	1.90	1.53	3.76
		HC	11.4	7.2	7.5	4.7	5.1
	105	U-factor	0.64	0.51	0.39	0.44	0.24
		C-factor	1.38	0.91	0.58	0.71	0.30
		R_u	1.57	1.95	2.56	2.26	4.17
		R_c	0.72	1.10	1.71	1.41	3.32
		HC	11.9	7.7	7.9	5.1	5.6
	115	U-factor	0.66	0.54	0.41	0.46	0.26
		C-factor	1.52	0.98	0.64	0.76	0.34
		R_u	1.51	1.87	2.41	2.16	3.79
		R_c	0.66	1.02	1.56	1.31	2.94
		HC	12.3	8.1	8.4	5.6	6.0
	125	U-factor	0.70	0.56	0.45	0.49	0.30
		C-factor	1.70	1.08	0.73	0.84	0.40
		R_u	1.44	1.78	2.23	2.04	3.38
		R_c	0.59	0.93	1.38	1.19	2.53
		HC	12.8	8.6	8.8	6.0	6.5
	135	U-factor	0.73	0.60	0.49	0.53	0.35
		C-factor	1.94	1.23	0.85	0.95	0.49
		R_u	1.36	1.67	2.02	1.90	2.89
		R_c	0.51	0.82	1.17	1.05	2.04
		HC	13.2	9.0	9.3	6.5	6.9
8 in. block	85	U-factor	0.49	0.41	0.28	0.37	0.15
		C-factor	0.85	0.63	0.37	0.53	0.17
		R_u	2.03	2.43	3.55	2.72	6.62
		R_c	1.18	1.58	2.70	1.87	5.77
		HC	15.0	9.0	9.4	5.4	6.0
	95	U-factor	0.53	0.44	0.31	0.39	0.17
		C-factor	0.95	0.70	0.41	0.58	0.20
		R_u	1.90	2.29	3.27	2.57	5.92
		R_c	1.05	1.44	2.42	1.72	5.07
		HC	15.5	9.6	10.0	6.0	6.6
	105	U-factor	0.55	0.46	0.33	0.41	0.19
		C-factor	1.05	0.76	0.46	0.63	0.22
		R_u	1.81	2.17	3.04	2.44	5.32
		R_c	0.96	1.32	2.19	1.59	4.47
		HC	16.1	10.2	10.6	6.6	7.2
	115	U-factor	0.58	0.48	0.35	0.43	0.21
		C-factor	1.14	0.82	0.50	0.68	0.25
		R_u	1.72	2.07	2.84	2.33	4.78
		R_c	0.87	1.22	1.99	1.48	3.93
		HC	16.7	10.8	11.2	7.2	7.8
	125	U-factor	0.61	0.51	0.38	0.45	0.24
		C-factor	1.27	0.90	0.57	0.74	0.30
		R_u	1.64	1.96	2.62	2.20	4.20
		R_c	0.79	1.11	1.77	1.35	3.35
		HC	17.3	11.4	11.8	7.8	8.4
	135	U-factor	0.65	0.55	0.42	0.49	0.28
		C-factor	1.44	1.02	0.67	0.83	0.37
		R_u	1.54	1.83	2.35	2.05	3.55
		R_c	0.69	0.98	1.50	1.20	2.70
		HC	17.9	12.0	12.4	8.4	9.0

TABLE A-7 (Sections 5.3.1.2, A3.1, and A4.1) (Continued)
Assembly U-Factors, C-Factors, R_u, R_c, and Heat Capacity for Concrete Block Walls

10 in. block	85	U-factor	0.44	0.38	0.25	0.35	0.13
		C-factor	0.70	0.57	0.31	0.50	0.14
		R_u	2.29	2.61	4.05	2.84	7.87
		R_c	1.44	1.76	3.20	1.99	7.02
		HC	19.0	11.2	11.7	6.5	7.3
	95	U-factor	0.47	0.41	0.27	0.37	0.14
		C-factor	0.77	0.62	0.35	0.55	0.16
		R_u	2.15	2.46	3.73	2.67	6.94
		R_c	1.30	1.61	2.88	1.82	6.09
		HC	19.7	11.9	12.4	7.3	8.1
	105	U-factor	0.49	0.43	0.29	0.39	0.16
		C-factor	0.85	0.68	0.39	0.59	0.19
		R_u	2.03	2.33	3.45	2.54	6.17
		R_c	1.18	1.48	2.60	1.69	5.32
		HC	20.4	12.6	13.1	8.0	8.8
	115	U-factor	0.52	0.45	0.31	0.41	0.18
		C-factor	0.92	0.73	0.42	0.64	0.21
		R_u	1.94	2.22	3.21	2.42	5.52
		R_c	1.09	1.37	2.36	1.57	4.67
		HC	21.1	13.4	13.9	8.7	9.5
	125	U-factor	0.54	0.48	0.34	0.44	0.21
		C-factor	1.01	0.80	0.48	0.70	0.25
		R_u	1.84	2.10	2.95	2.28	4.81
		R_c	0.99	1.25	2.10	1.43	3.96
		HC	21.8	14.1	14.6	9.4	10.2
	135	U-factor	0.58	0.51	0.38	0.47	0.25
		C-factor	1.14	0.90	0.56	0.79	0.32
		R_u	1.72	1.96	2.64	2.12	4.00
		R_c	0.87	1.11	1.79	1.27	3.15
		HC	22.6	14.8	15.3	10.2	11.0
12 in. block	85	U-factor	0.40	0.36	0.22	0.34	0.11
		C-factor	0.59	0.52	0.27	0.48	0.12
		R_u	2.53	2.77	4.59	2.93	9.43
		R_c	1.68	1.92	3.74	2.08	8.58
		HC	23.1	13.3	14.0	7.5	8.5
	95	U-factor	0.42	0.38	0.24	0.36	0.12
		C-factor	0.66	0.57	0.30	0.52	0.13
		R_u	2.3	2.60	4.22	2.76	8.33
		R_c	1.53	1.75	3.37	1.91	7.48
		HC	23.9	14.2	14.8	8.3	9.3
	105	U-factor	0.44	0.41	0.26	0.38	0.14
		C-factor	0.71	0.62	0.33	0.57	0.15
		R_u	2.25	2.47	3.90	2.62	7.35
		R_c	1.40	1.62	3.05	1.77	6.50
		HC	24.7	15.0	15.6	9.1	10.2
	115	U-factor	0.47	0.42	0.28	0.40	0.15
		C-factor	0.77	0.66	0.36	0.61	0.18
		R_u	2.15	2.36	3.63	2.49	6.54
		R_c	1.30	1.51	2.78	1.64	5.69
		HC	25.6	15.8	16.4	10.0	11.0
	125	U-factor	0.49	0.45	0.30	0.42	0.18
		C-factor	0.84	0.72	0.40	0.66	0.21
		R_u	2.04	2.23	3.34	2.36	5.68
		R_c	1.19	1.38	2.49	1.51	4.83
		HC	26.4	16.6	17.3	10.8	11.8
	135	U-factor	0.52	0.48	0.34	0.46	0.21
		C-factor	0.94	0.81	0.47	0.74	0.26
		R_u	1.91	2.08	2.98	2.19	4.67
		R_c	1.06	1.23	2.13	1.34	3.82
		HC	27.2	17.5	18.1	11.6	12.6

TABLE A-8 (Sections A3.1.2 and A4.1.3)
Effective R-Values for Insulation/Framing Layers Added to Above-Grade Mass Walls and Below-Grade Walls

Depth (in.)	Framing Type	Rated R-Value of Insulation																									
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Effective R-value if continuous insulation uninterrupted by framing (includes gypsum board)																											
	None	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5
Effective R-value if insulation is installed in cavity between framing (includes gypsum board)																											
0.5	Wood	1.3	1.3	1.9	2.4	2.7	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	0.9	0.9	1.1	1.1	1.2	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
0.75	Wood	1.4	1.4	2.1	2.7	3.1	3.5	3.8	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	1.0	1.0	1.3	1.4	1.5	1.5	1.6	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
1.0	Wood	1.3	1.5	2.2	2.9	3.4	3.9	4.3	4.6	4.9	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	1.0	1.1	1.4	1.6	1.7	1.8	1.8	1.9	1.9	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
1.5	Wood	1.3	1.5	2.4	3.1	3.8	4.4	4.9	5.4	5.8	6.2	6.5	6.8	7.1	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	1.1	1.2	1.6	1.9	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7	na	na	na	na	na	na	na	na	na	na	na	na	na
2.0	Wood	1.4	1.5	2.5	3.3	4.0	4.7	5.3	5.9	6.4	6.9	7.3	7.7	8.1	8.4	8.7	9.0	9.3	na	na	na	na	na	na	na	na	na
	Metal	1.1	1.2	1.7	2.1	2.3	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.4	na	na	na	na	na	na	na	na	na
2.5	Wood	1.4	1.5	2.5	3.4	4.2	4.9	5.6	6.3	6.8	7.4	7.9	8.4	8.8	9.2	9.6	10.0	10.3	10.6	10.9	11.2	11.5	na	na	na	na	na
	Metal	1.2	1.3	1.8	2.3	2.6	2.8	3.0	3.2	3.3	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.1	na	na	na	na	na
3.0	Wood	1.4	1.5	2.5	3.5	4.3	5.1	5.8	6.5	7.2	7.8	8.3	8.9	9.4	9.9	10.3	10.7	11.1	11.5	11.9	12.2	12.5	12.9	na	na	na	na
	Metal	1.2	1.3	1.9	2.4	2.8	3.1	3.3	3.5	3.7	3.8	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.7	4.8	na	na	na	na
3.5	Wood	1.4	1.5	2.6	3.5	4.4	5.2	6.0	6.7	7.4	8.1	8.7	9.3	9.8	10.4	10.9	11.3	11.8	12.2	12.6	13.0	13.4	13.8	14.1	14.5	14.8	15.1
	Metal	1.2	1.3	2.0	2.5	2.9	3.2	3.5	3.8	4.0	4.2	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.1	5.2	5.2	5.3	5.4	5.4	5.4	5.5
4.0	Wood	1.4	1.6	2.6	3.6	4.5	5.3	6.1	6.9	7.6	8.3	9.0	9.6	10.2	10.8	11.3	11.9	12.4	12.8	13.3	13.7	14.2	14.6	14.9	15.3	15.7	16.0
	Metal	1.2	1.3	2.0	2.6	3.0	3.4	3.7	4.0	4.2	4.5	4.6	4.8	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.8	5.9	5.9	6.0	6.0
4.5	Wood	1.4	1.6	2.6	3.6	4.5	5.4	6.2	7.1	7.8	8.5	9.2	9.9	10.5	11.2	11.7	12.3	12.8	13.3	13.8	14.3	14.8	15.2	15.7	16.1	16.5	16.9
	Metal	1.2	1.3	2.1	2.6	3.1	3.5	3.9	4.2	4.5	4.7	4.9	5.1	5.3	5.4	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.4	6.5	6.6
5.0	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.3	7.2	8.0	8.7	9.4	10.1	10.8	11.5	12.1	12.7	13.2	13.8	14.3	14.8	15.3	15.8	16.3	16.7	17.2	17.6
	Metal	1.2	1.4	2.1	2.7	3.2	3.7	4.1	4.4	4.7	5.0	5.2	5.4	5.6	5.8	5.9	6.1	6.2	6.3	6.5	6.6	6.7	6.8	6.8	6.9	7.0	7.1
5.5	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.4	7.3	8.1	8.9	9.6	10.3	11.0	11.7	12.4	13.0	13.6	14.2	14.7	15.3	15.8	16.3	16.8	17.3	17.8	18.2
	Metal	1.3	1.4	2.1	2.8	3.3	3.8	4.2	4.6	4.9	5.2	5.4	5.7	5.9	6.1	6.3	6.4	6.6	6.7	6.8	7.0	7.1	7.2	7.3	7.4	7.5	7.6

TABLE A-9 (Section A3.2)
Assembly U-Factors for Metal Building Walls

Insulation System	Rated R-Value of Insulation	Total Rated R-Value of Insulation	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation					
				R-5.6	R-11.2	R-16.8	R-22.4	R-28.0	R-33.6
Single Layer of Mineral Fiber									
	None	0	**1.180**	0.161	0.086	0.059	0.045	0.036	0.030
	R-6	6	**0.184**	0.091	0.060	0.045	0.036	0.030	0.026
	R-10	10	**0.134**	0.077	0.054	0.041	0.033	0.028	0.024
	R-11	11	**0.123**	0.073	0.052	0.040	0.033	0.028	0.024
	R-13	13	**0.113**	0.069	0.050	0.039	0.032	0.027	0.024
Double Layer of Mineral Fiber (Second layer inside of girts) (Multiple layers are listed in order from inside to outside)									
	R-6 + R-13	19	**0.070**	na	na	na	na	na	na
	R-10 + R-13	23	**0.061**	na	na	na	na	na	na
	R-13 + R-13	26	**0.057**	na	na	na	na	na	na
	R-19 + R-13	32	**0.048**	na	na	na	na	na	na

ing. Cavity insulation is full depth, but values are taken from Table A-24 for R-19 insulation, which is compressed when installed in a 5.5 in. cavity. Headers are double 2 in. nominal wood framing. The ***U-factor*** includes R-0.17 for exterior air film, R-0.08 for stucco, R-0.56 for 0.625 in. gypsum board on the exterior, R-0.56 for 0.625 in. gypsum board on the interior, and R-0.68 for interior air film, vertical surfaces. Additional assemblies include ***continuous insulation***, uncompressed and uninterrupted by framing. ***U-factors*** are provided for the following configurations:

a. ***Standard framing***: wood framing at 16 in. on center with cavities filled with 14.5 in. wide insulation for both 3.5 in. deep and 5.5 in. deep wall cavities. Double headers leave no cavity. Weighting factors are 75% insulated cavity, 21% studs, plates, and sills, and 4% headers.
b. ***Advanced framing***: wood framing at 24 in. on center with cavities filled with 22.5 in. wide insulation for both 3.5 in. deep and 5.5 in. deep wall cavities. Double headers leave uninsulated cavities. Weighting factors are 78% insulated cavity, 18% studs, plates, and sills, and 4% headers.
c. ***Advanced framing with insulated headers***: wood framing at 24 in. on center with cavities filled with 22.5 in. wide insulation for both 3.5 in. deep and 5.5 in. deep wall cavities. Double header cavities are insulated. Weighting factors are 78% insulated cavity, 18% studs, plates, and sills, and 4% headers.

A4 Below-Grade Walls. ***C-factors*** for ***below-grade walls*** shall be taken from Table A-12 or determined by the procedure described in this subsection. It is acceptable to use the ***C-factors*** in Table A-12 for all ***below-grade walls***.

The base assembly is 8 in. medium-weight concrete block with a density of 115 lb/ft^3 and solid grouted cores. ***Continuous insulation*** is installed on the interior or exterior. In contrast to the ***U-factor*** for ***above-grade walls***, the ***C-factor*** for ***below-grade walls*** does not include R-values for exterior or interior air films or for soil. For insulated walls, the ***C-factor*** does include R-0.45 for 0.5 in. gypsum board.

If not taken from Table A-12, ***below-grade wall C-factors*** shall be determined from Tables A-6, A-7, and A-8 using the following procedure:

a. If the ***below-grade wall*** is uninsulated or only the cells are insulated:
   (1) For concrete ***walls***, determine the ***C-factor*** from Table A-6 based on the concrete density and ***wall*** thickness.
   (2) For concrete block ***walls***, determine the ***C-factor*** from Table A-7 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated.
b. If the ***mass wall*** has additional insulation:
   (1) For concrete ***walls***, determine the R_c from Table A-6 based on the concrete density and ***wall*** thickness. Next, determine the effective R-value for the insulation/framing layer from Table A-8 based on the ***rated R-value of insulation*** installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the ***C-factor*** by adding the R_c and the effective R-value together and taking the inverse of the total.
   (2) For concrete block ***walls***, determine the R_c from Table A-7 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated. Next, determine the effective R-value for the insulation/framing layer from Table A-8

TABLE A-10 (Section A3.3)
Assembly U-Factors for Steel Frame Walls

Framing Type and Spacing Width (actual depth)	Cavity Insulation R-Value: Rated/ (effective installed [see Table A-21])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (uninterrupted by framing), Rated R-Value of Continuous Insulation																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Steel Framing at 16 in. OC																						
(3.5 in. depth)	None (0.0)	**0.352**	0.260	0.207	0.171	0.146	0.128	0.113	0.102	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
	R-11 (5.5)	**0.132**	0.117	0.105	0.095	0.087	0.080	0.074	0.069	0.064	0.060	0.057	0.054	0.051	0.049	0.046	0.044	0.036	0.031	0.027	0.024	0.021
	R-13 (6.0)	**0.124**	0.111	0.100	0.091	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.050	0.048	0.045	0.043	0.036	0.030	0.026	0.023	0.021
	R-15 (6.4)	**0.118**	0.106	0.096	0.087	0.080	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.035	0.030	0.026	0.023	0.021
(6.0 in. depth)	R-19 (7.1)	**0.109**	0.099	0.090	0.082	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.050	0.047	0.045	0.043	0.041	0.034	0.029	0.026	0.023	0.020
	R-21 (7.4)	**0.106**	0.096	0.087	0.080	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.022	0.020
Steel Framing at 24 in. OC																						
(3.5 in. depth)	None (0.0)	**0.338**	0.253	0.202	0.168	0.144	0.126	0.112	0.100	0.091	0.084	0.077	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
	R-11 (6.6)	**0.116**	0.104	0.094	0.086	0.079	0.073	0.068	0.064	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.035	0.030	0.026	0.023	0.021
	R-13 (7.2)	**0.108**	0.098	0.089	0.082	0.075	0.070	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.023	0.020
	R-15 (7.8)	**0.102**	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.034	0.029	0.025	0.022	0.020
(6.0 in. depth)	R-19 (8.6)	**0.094**	0.086	0.079	0.073	0.068	0.064	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.033	0.028	0.025	0.022	0.020
	R-21 (9.0)	**0.090**	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.050	0.048	0.045	0.043	0.042	0.040	0.038	0.032	0.028	0.024	0.022	0.020

TABLE A-11 (Section A3.4)
Assembly U-Factors for Wood Frame Walls

Framing Type and Spacing Width (actual depth)	Cavity Insulation R-Value: Rated/(effective installed [see Table A-24])	Overall U-Factor for Entire Base Wall	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Wood Studs at 16 in. OC																						
(3.5 in. depth)	None (0.0)	**0.292**	0.223	0.181	0.152	0.132	0.116	0.104	0.094	0.086	0.079	0.073	0.068	0.064	0.060	0.056	0.053	0.042	0.035	0.030	0.026	0.023
	R-11 (11.0)	**0.096**	0.087	0.079	0.073	0.068	0.063	0.059	0.056	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.038	0.032	0.028	0.024	0.022	0.020
	R-13 (13.0)	**0.089**	0.080	0.074	0.068	0.063	0.059	0.056	0.053	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.037	0.031	0.027	0.024	0.021	0.019
	R-15 (15.0)	**0.083**	0.075	0.069	0.064	0.060	0.056	0.053	0.050	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.030	0.026	0.023	0.020	0.019
(5.5 in. depth)	R-19 (18.0)	**0.067**	0.062	0.058	0.054	0.051	0.048	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.027	0.024	0.021	0.019	0.018
	R-21 (21.0)	**0.063**	0.058	0.054	0.051	0.048	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.032	0.031	0.030	0.026	0.023	0.021	0.019	0.017
(+ R-10 headers)	R-19 (18.0)	**0.063**	0.059	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.031	0.027	0.024	0.021	0.019	0.017
	R-21 (21.0)	**0.059**	0.055	0.051	0.049	0.046	0.044	0.042	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.026	0.023	0.020	0.018	0.017
Wood Studs at 24 in. OC																						
(3.5 in. depth)	None (0.0)	**0.298**	0.227	0.183	0.154	0.133	0.117	0.105	0.095	0.086	0.079	0.074	0.068	0.064	0.060	0.057	0.054	0.042	0.035	0.030	0.026	0.023
	R-11 (11.0)	**0.094**	0.085	0.078	0.072	0.067	0.062	0.059	0.055	0.052	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.032	0.027	0.024	0.022	0.019
	R-13 (13.0)	**0.086**	0.078	0.072	0.067	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.031	0.026	0.023	0.021	0.019
	R-15 (15.0)	**0.080**	0.073	0.067	0.062	0.058	0.055	0.052	0.049	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.029	0.026	0.023	0.020	0.018
(5.5 in. depth)	R-19 (18.0)	**0.065**	0.060	0.056	0.053	0.050	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.027	0.024	0.021	0.019	0.018
	R-21 (21.0)	**0.060**	0.056	0.052	0.049	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.026	0.023	0.020	0.018	0.017
(+ R-10 headers)	R-19 (18.0)	**0.062**	0.058	0.054	0.051	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.034	0.033	0.032	0.031	0.027	0.024	0.021	0.019	0.017
	R-21 (21.0)	**0.057**	0.053	0.050	0.047	0.045	0.043	0.041	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.029	0.025	0.023	0.020	0.018	0.017

TABLE A-12 (Section A4)
Assembly C-Factors for Below-Grade Walls

Framing Type and Depth	Rated R-Value of Insulation Alone	Specified C-Factors (wall only, without soil and air films)
No Framing	R-0	C-1.140
Exterior Insulation, continuous and uninterrupted by framing		
No Framing	R-5.0	C-0.170
No Framing	R-7.5	C-0.119
No Framing	R-10.0	C-0.092
No Framing	R-12.5	C-0.075
No Framing	R-15.0	C-0.063
No Framing	R-17.5	C-0.054
No Framing	R-20.0	C-0.048
No Framing	R-25.0	C-0.039
No Framing	R-30.0	C-0.032
No Framing	R-35.0	C-0.028
No Framing	R-40.0	C-0.025
No Framing	R-45.0	C-0.022
No Framing	R-50.0	C-0.020
Continuous metal framing at 24 in. on center horizontally		
3.5 in.	R-11.0	C-0.182
3.5 in.	R-13.0	C-0.174
3.5 in.	R-15.0	C-0.168
5.5 in.	R-19.0	C-0.125
5.5 in.	R-21.0	C-0.120
1 in. metal clips at 24 in. on center horizontally and 16 in. vertically		
1.0 in.	R-3.8	C-0.233
1.0 in.	R-5.0	C-0.201
1.0 in.	R-5.6	C-0.189
1.5 in.	R-5.7	C-0.173
1.5 in.	R-7.5	C-0.147
1.5 in.	R-8.4	C-0.138
2.0 in.	R-7.6	C-0.138
2.0 in.	R-10.0	C-0.116
2.0 in.	R-11.2	C-0.108
2.5 in.	R-9.5	C-0.114
2.5 in.	R-12.5	C-0.096
2.5 in.	R-14.0	C-0.089
3.0 in.	R-11.4	C-0.098
3.0 in.	R-15.0	C-0.082
3.0 in.	R-16.8	C-0.076
3.5 in.	R-13.3	C-0.085
3.5 in.	R-17.5	C-0.071
3.5 in.	R-19.6	C-0.066
4.0 in.	R-15.2	C-0.076
4.0 in.	R-20.0	C-0.063
4.0 in.	R-22.4	C-0.058

based on the ***rated R-value of insulation*** installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the ***C-factor*** by adding the R_c and the effective R-value together and taking the inverse of the total.

A5 Floors

A5.1 General. The buffering effect of crawl spaces or parking garages shall not be included in ***U-factor*** calculations. See A6 for ***slab-on-grade floors.***

A5.2 Mass Floors. ***U-factors*** for ***mass floors*** shall be taken from Table A-13. It is not acceptable to use these ***U-factors*** if the insulation is not continuous.

For the purpose of A1.2, the base assembly is ***continuous insulation*** over or under a solid concrete ***floor***. The ***U-factor*** includes R-0.92 for interior air film—heat flow down, R-1.23 for carpet and rubber pad, R-0.50 for 8 in. concrete, and R-0.46 for semi-exterior air film. Added insulation is continuous and uninterrupted by framing. Framing factor is zero.

A5.3 Steel Joist Floors. ***U-factors*** for ***steel joist floors*** shall be taken from Table A-14. It is acceptable to use these ***U-factors*** for any ***steel joist floor***.

For the purpose of A1.2, the base assembly is a ***floor*** where the insulation is either placed between the steel joists or is sprayed on the underside of the ***floor*** and the joists. In both cases, the steel provides a thermal bypass to the insulation. The ***U-factor*** includes R-0.92 for interior air film—heat flow down, R-1.23 for carpet and pad, R-0.25 for 4 in. concrete, R-0 for metal deck, and R-0.46 for semi-exterior air film. The performance of the insulation/framing layer is calculated using the values in Table A-20.

A5.4 Wood-Framed Floors. ***U-factors*** for ***wood-framed floors*** shall be taken from Table A-15. It is not acceptable to use these ***U-factors*** if the framing is not wood.

For the purpose of A1.2, the base assembly is a ***floor*** attached directly to the top of the wood joist and with insulation located directly below the ***floor***, with a ventilated airspace below the insulation. The heat flow path through the joist is calculated to be the same depth as the insulation. The ***U-factor*** includes R-0.92 for interior air film—heat flow down, R-1.23 for carpet and pad, R-0.94 for 0.75 in. wood subfloor, and R-0.46 for semi-exterior air film. The weighting factors are 91% insulated cavity and 9% framing.

A6 Slab-on-Grade Floors. ***F-factors*** for ***slab-on-grade floors*** shall be taken from Table A-16. These ***F-factors*** are acceptable for all ***slab-on-grade floors***.

For the purpose of A1.2, the base assembly is a slab floor of 6 in. concrete poured directly on to the earth, the bottom of the slab is at grade line, and soil conductivity is 0.75 Btu/h·ft^2·°F. In contrast to the ***U-factor*** for ***floors***, the ***F-factor*** for ***slab-on-grade floors*** is expressed per lineal foot of building perimeter. ***F-factors*** are provided for unheated slabs and for heated slabs. ***Unheated slab-on-grade floors*** do not have heating elements, and ***heated slab-on-grade***

TABLE A-13 (Section A5.2)
Assembly U-Factors for Mass Floors

Framing Type and Spacing Width (actual depth)	Cavity Insulation R-Value: Rated/ (effective installed)	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation																			
			R-1.00	**R-2.00**	**R-3.00**	**R-4.00**	**R-5.00**	**R-6.00**	**R-7.00**	**R-8.00**	**R-9.00**	**R-10.00**	**R-11.00**	**R-12.00**	**R-13.00**	**R-14.00**	**R-15.00**	**R-20.00**	**R-25.00**	**R-30.00**	**R-35.00**	**R-40.00**
Concrete Floor with Rigid Foam																						
	None (0.0)	**0.322**	0.243	0.196	0.164	0.141	0.123	0.110	0.099	0.090	0.083	0.076	0.071	0.066	0.062	0.058	0.055	0.043	0.036	0.030	0.026	0.023
Concrete Floor with Pinned Boards																						
	R-4.2 (4.2)	**0.137**	0.121	0.108	0.097	0.089	0.081	0.075	0.070	0.065	0.061	0.058	0.055	0.052	0.049	0.047	0.045	0.037	0.031	0.027	0.024	0.021
	R-6.3 (6.3)	**0.107**	0.096	0.088	0.081	0.075	0.070	0.065	0.061	0.058	0.054	0.052	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.023	0.020
	R-8.3 (8.3)	**0.087**	0.080	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.032	0.027	0.024	0.022	0.019
	R-10.4 (10.4)	**0.074**	0.069	0.064	0.060	0.057	0.054	0.051	0.049	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.030	0.026	0.023	0.021	0.019
	R-12.5 (12.5)	**0.064**	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.028	0.025	0.022	0.020	0.018
	R-14.6 (14.6)	**0.056**	0.053	0.051	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.033	0.032	0.031	0.027	0.023	0.021	0.019	0.017
	R-16.7 (16.7)	**0.051**	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.032	0.031	0.030	0.030	0.029	0.025	0.022	0.020	0.018	0.017
Concrete Floor with Spray-on Insulation																						
(1 in.)	R-4 (4.0)	**0.141**	0.123	0.110	0.099	0.090	0.083	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.050	0.047	0.045	0.037	0.031	0.027	0.024	0.021
(2 in.)	R-8 (8.0)	**0.090**	0.083	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.032	0.028	0.024	0.022	0.020
(3 in.)	R-12 (12.0)	**0.066**	0.062	0.058	0.055	0.052	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.037	0.036	0.034	0.033	0.028	0.025	0.022	0.020	0.018
(4 in.)	R-16 (16.0)	**0.052**	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.026	0.023	0.020	0.018	0.017
(5 in.)	R-20 (20.0)	**0.043**	0.041	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.023	0.021	0.019	0.017	0.016
(6 in.)	R-24 (24.0)	**0.037**	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.021	0.019	0.018	0.016	0.015

TABLE A-14 (Section A5.3)
Assembly U-Factors for Steel Joist Floors

Framing Type and Spacing Width (actual depth)	Cavity Insulation R-Value: Rated/ (effective installed [See Table A-20])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Steel Joist Floor with Rigid Foam																						
	None (0.0)	**0.350**	0.259	0.206	0.171	0.146	0.127	0.113	0.101	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
Steel Joist Floor with Spray-on Insulation																						
(1 in.)	R-4 (3.88)	**0.148**	0.129	0.114	0.103	0.093	0.085	0.078	0.073	0.068	0.064	0.060	0.056	0.053	0.051	0.048	0.046	0.037	0.032	0.027	0.024	0.021
(2 in.)	R-8 (7.52)	**0.096**	0.088	0.081	0.075	0.070	0.065	0.061	0.058	0.054	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.033	0.028	0.025	0.022	0.020
(3 in.)	R-12 (10.80)	**0.073**	0.068	0.064	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.030	0.026	0.023	0.021	0.019
(4 in.)	R-16 (13.92)	**0.060**	0.056	0.053	0.051	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.032	0.031	0.027	0.024	0.021	0.019	0.018
(5 in.)	R-20 (17.00)	**0.050**	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.030	0.029	0.025	0.022	0.020	0.018	0.017
(6 in.)	R-24 (19.68)	**0.044**	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.024	0.021	0.019	0.017	0.016
Steel Joist Floor with Batt Insulation																						
	None (0.0)	**0.350**	0.259	0.206	0.171	0.146	0.127	0.113	0.101	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
	R-11 (10.01)	**0.078**	0.072	0.067	0.063	0.059	0.056	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.030	0.026	0.023	0.021	0.019
	R-13 (11.70)	**0.069**	0.064	0.060	0.057	0.054	0.051	0.049	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.029	0.025	0.022	0.020	0.018
	R-15 (13.20)	**0.062**	0.059	0.055	0.052	0.050	0.047	0.045	0.043	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.028	0.024	0.022	0.020	0.018
	R-19 (16.34)	**0.052**	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.026	0.023	0.020	0.018	0.017
	R-21 (17.64)	**0.049**	0.047	0.044	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.025	0.022	0.020	0.018	0.017
	R-25 (20.25)	**0.043**	0.041	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.028	0.027	0.026	0.023	0.021	0.019	0.017	0.016
	R-30C(23.70)	**0.038**	0.036	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.026	0.025	0.025	0.024	0.021	0.019	0.018	0.016	0.015
	R-30 (23.70)	**0.038**	0.036	0.035	0.034	0.033	0.032	0.031	0.030	0.029	0.028	0.027	0.027	0.026	0.025	0.025	0.024	0.021	0.019	0.018	0.016	0.015
	R-38C(28.12)	**0.032**	0.031	0.030	0.029	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.020	0.018	0.016	0.015	0.014
	R-38 (28.12)	**0.032**	0.031	0.030	0.029	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.020	0.018	0.016	0.015	0.014

TABLE A-15 (Section A5.4)
Assembly U-Factors for Wood Joist Floors

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

TABLE A-16 (Section A6)
Assembly F-Factors for Slab-on-Grade Floors

Insulation Description	R-0	R-5	R-7.5	R-10	R-15	R-20	R-25	R-30	R-35	R-40	R-45	R-50	R-55
	Rated R-Value of Insulation												
Unheated Slabs													
None	0.73												
12 in. horizontal		0.72	0.71	0.71	0.71								
24 in. horizontal		0.70	0.70	0.70	0.69								
36 in. horizontal		0.68	0.67	0.66	0.66								
48 in. horizontal		0.67	0.65	0.64	0.63								
12 in. vertical		0.61	0.60	0.58	0.57	0.567	0.565	0.564					
24 in. vertical		0.58	0.56	0.54	0.52	0.510	0.505	0.502					
36 in. vertical		0.56	0.53	0.51	0.48	0.472	0.464	0.460					
48 in. vertical		0.54	0.51	0.48	0.45	0.434	0.424	0.419					
Fully insulated slab		0.46	0.41	0.36	0.30	0.261	0.233	0.213	0.198	0.186	0.176	0.168	0.161
Heated Slabs													
None	1.35												
12 in. horizontal		1.31	1.31	1.30	1.30								
24 in. horizontal		1.28	1.27	1.26	1.25								
36 in. horizontal		1.24	1.21	1.20	1.18								
48 in. horizontal		1.20	1.17	1.13	1.11								
12 in. vertical		1.06	1.02	1.00	0.98	0.968	0.964	0.961					
24 in. vertical		0.99	0.95	0.90	0.86	0.843	0.832	0.827					
36 in. vertical		0.95	0.89	0.84	0.79	0.762	0.747	0.740					
48 in. vertical		0.91	0.85	0.78	0.72	0.688	0.671	0.659					
Fully insulated slab		0.74	0.64	0.55	0.44	0.373	0.326	0.296	0.273	0.255	0.239	0.227	0.217

floors do have heating elements within or beneath the slab. ***F-factors*** are provided for three insulation configurations:

a. **Horizontal insulation: *continuous insulation*** is applied directly to the underside of the slab and extends inward horizontally from the perimeter for the distance specified or ***continuous insulation*** is applied downward from the top of the slab and then extends horizontally to the interior or the exterior from the perimeter for the distance specified.

b. **Vertical insulation: *continuous insulation*** is applied directly to the slab exterior, extending downward from the top of the slab for the distance specified.

c. **Fully insulated slab: *continuous insulation*** extends downward from the top of the slab and along the entire perimeter and completely covers the entire area under the slab.

A7 Opaque Doors. All ***opaque doors*** with ***U-factors*** determined, certified, and labeled in accordance with NFRC 100 as specified in 5.2.2 shall be assigned those ***U-factors***. ***Unlabeled opaque doors*** shall be assigned the following ***U-factors***:

a. Uninsulated single-layer metal ***swinging doors*** or ***non-swinging doors***, including single-layer uninsulated access hatches and uninsulated smoke vents: 1.45

b. Uninsulated double-layer metal ***swinging doors*** or ***non-swinging doors***, including double-layer uninsulated access hatches and uninsulated smoke vents: 0.70

c. Insulated metal ***swinging doors***, including fire-rated ***doors***, insulated access hatches, and insulated smoke vents: 0.50

d. Wood ***doors***, minimum nominal thickness of 1 3/4 in., including panel ***doors*** with minimum panel thickness of 1 1/8 in., solid core flush ***doors***, and hollow core flush ***doors***: 0.50.

e. Any other wood ***door***: 0.60

No credit shall be given for any other features, including thermal breaks in metal door slabs (the operable part of the door) or frames, other than as determined in accordance with 5.2.2.

A8 Fenestration. All ***fenestration*** with ***U-factors, SHGC,*** or visible light transmittance determined, certified, and labeled in accordance with NFRC 100, 200, and 300, respectively, as specified in 5.2.2 shall be assigned those values.

A8.1 Unlabeled Skylights. ***Unlabeled skylights*** shall be assigned the ***U-factors*** in Table A-17 and are allowed to use the ***SHGCs*** and visible light transmittances in Table A-18. The metal with thermal break frame category shall not be used unless all frame members have a thermal break equal to or greater than 1/4 in.

A8.2 Unlabeled Vertical Fenestration. ***Unlabeled vertical fenestration***, both operable and fixed, shall be assigned the ***U-factors, SHGCs,*** and visible light transmittances in Table A-19. No credit shall be given for any other features, including metal frames with thermal breaks, low-emissivity coatings, gas fillings, or insulating spacers, other than as determined in accordance with 5.2.2.

A9 Determination of Alternate Assembly U-Factors, C-Factors, F-Factors, or Heat Capacities

A9.1 General. ***U-factors*** for ***fenestration*** shall be determined in accordance with 5.2.2 or A.8 only. ***U-factors*** for ***opaque doors*** shall be determined in accordance with 5.2.2 or A7 only. Component ***U-factors*** for other opaque assemblies shall be determined in accordance with A9 only if approved by the ***building official*** in accordance with A1.2. The procedures required for each class of construction are specified in A9.2. Testing shall be performed in accordance with A9.3. Calculations shall be performed in accordance with A9.4.

A9.2 Required Procedures. Two- or three-dimensional finite difference and finite volume computer models shall be an acceptable alternative method to calculating the thermal performance values for all assemblies and constructions listed below. The following procedures shall also be permitted to determine all alternative ***U-factors***, ***F-factors***, and ***C-factors***:

a. **Roofs**.
   (1) ***Roofs with insulation entirely above deck***: testing or series calculation method.
   (2) ***Metal building roofs***: testing.
   (3) ***Attic roofs***, wood joists: testing or parallel path calculation method.
   (4) ***Attic roofs***, steel joists: testing or parallel path calculation method using the insulation/framing layer adjustment factors in Table A-20 or modified zone calculation method.
   (5) ***Attic roofs***, concrete joists: testing or parallel path calculation method if concrete is solid and uniform or isothermal planes calculation method if concrete has hollow sections.
   (6) Other ***attic roofs and other roofs***: testing or two-dimensional calculation method.

b. **Above-Grade Walls**.
   (1) ***Mass walls***: testing or the isothermal planes calculation method or two-dimensional calculation method. The parallel path calculation method is not acceptable.
   (2) ***Metal building walls***: testing.
   (3) ***Steel-framed walls***: testing or parallel path calculation method using the insulation/framing layer adjustment factors in Table A-21 or the modified zone method.
   (4) ***Wood-framed walls***: testing or parallel path calculation method.
   (5) Other ***walls***: testing or two-dimensional calculation method.

c. **Below-Grade Walls**.
   (1) ***Mass walls***: testing or the isothermal planes calculation method or two-dimensional calculation method. The parallel path calculation method is not acceptable.
   (2) ***Other walls***: testing or two-dimensional calculation method.

d. **Floors**.
   (1) ***Mass floors***: testing or parallel path calculation method if concrete is solid and uniform or isothermal planes calculation method if concrete has hollow sections.
   (2) ***Steel joist floors***: testing or modified zone calculation method.
   (3) ***Wood joist floors***: testing or parallel path calculation method or isothermal planes calculation method.
   (4) Other ***floors***: testing or two-dimensional calculation method.

e. **Slab-on-Grade Floors**: no testing or calculations allowed.

A9.3 Testing Procedures.

A9.3.1 Building Material Thermal Properties. If ***building material*** R-values or thermal conductivities are determined by testing, one of the following test procedures shall be used:

a. ASTM C177,

b. ASTM C236,

c. ASTM C518, or

d. ASTM C976.

For concrete, the oven-dried conductivity shall be multiplied by 1.2 to reflect the moisture content as typically installed.

A9.3.2 Assembly U-Factors. If assembly ***U-factors*** are determined by testing, one of the following test procedures shall be used:

a. ASTM C236 or

b. ASTM C976.

Product samples tested shall be production line material or representative of material as purchased by the consumer or contractor. If the assembly is too large to be tested at one time in its entirety, then either a representative portion shall be tested or different portions shall be tested separately and a weighted average determined. To be representative, the portion tested shall include edges of panels, joints with other panels, typical framing percentages, and thermal bridges.

A9.4 Calculation Procedures and Assumptions. The following procedures and assumptions shall be used for all calculations. R-values for air films, insulation, and ***building materials*** shall be taken from A9.4.1 through A9.4.3, respectively. In addition, the appropriate assumptions listed in A2 through A8, including framing factors, shall be used.

A9.4.1 Air Films: Prescribed R-values for air films shall be as follows:

TABLE A-17 (Section A8.1)
Assembly U-Factors for Unlabeled Skylights

	Product Type	Sloped Installation						
		Unlabeled Skylight with Curb (Includes glass/plastic, flat/domed, fixed/operable)				Unlabeled Skylight without Curb (Includes glass/plastic, flat/domed, fixed/operable)		
	Frame Type	Aluminum without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/Vinyl	Aluminum without Thermal Break	Aluminum with Thermal Break	Structural Glazing
ID	Glazing Type							
	Single Glazing							
1	1/8" glass	1.98	1.89	1.75	1.47	1.36	1.25	1.25
2	1/4" acrylic/polycarb	1.82	1.73	1.60	1.31	1.21	1.10	1.10
3	1/8" acrylic/polycarb	1.90	1.81	1.68	1.39	1.29	1.18	1.18
	Double Glazing							
4	1/4" airspace	1.31	1.11	1.05	0.84	0.82	0.70	0.66
5	1/2" airspace	1.30	1.10	1.04	0.84	0.81	0.69	0.65
6	1/4" argon space	1.27	1.07	1.00	0.80	0.77	0.66	0.62
7	1/2" argon space	1.27	1.07	1.00	0.80	0.77	0.66	0.62
	Double Glazing, ***e***=0.60 on surface 2 or 3							
8	1/4" airspace	1.27	1.08	1.01	0.81	0.78	0.67	0.63
9	1/2" airspace	1.27	1.07	1.00	0.80	0.77	0.66	0.62
10	1/4" argon space	1.23	1.03	0.97	0.76	0.74	0.63	0.58
11	1/2" argon space	1.23	1.03	0.97	0.76	0.74	0.63	0.58
	Double Glazing, ***e***=0.40 on surface 2 or 3							
12	1/4" airspace	1.25	1.05	0.99	0.78	0.76	0.64	0.60
13	1/2" airspace	1.24	1.04	0.98	0.77	0.75	0.64	0.59
14	1/4" argon space	1.18	0.99	0.92	0.72	0.70	0.58	0.54
15	1/2" argon space	1.20	1.00	0.94	0.74	0.71	0.60	0.56
	Double Glazing, ***e***=0.20 on surface 2 or 3							
16	1/4" airspace	1.20	1.00	0.94	0.74	0.71	0.60	0.56
17	1/2" airspace	1.20	1.00	0.94	0.74	0.71	0.60	0.56
18	1/4" argon space	1.14	0.94	0.88	0.68	0.65	0.54	0.50
19	1/2" argon space	1.15	0.95	0.89	0.68	0.66	0.55	0.51
	Double Glazing, ***e***=0.10 on surface 2 or 3							
20	1/4" airspace	1.18	0.99	0.92	0.72	0.70	0.58	0.54
21	1/2" airspace	1.18	0.99	0.92	0.72	0.70	0.58	0.54
22	1/4" argon space	1.11	0.91	0.85	0.65	0.63	0.52	0.47
23	1/2" argon space	1.13	0.93	0.87	0.67	0.65	0.53	0.49
	Double Glazing, ***e***=0.05 on surface 2 or 3							
24	1/4" airspace	1.17	0.97	0.91	0.70	0.68	0.57	0.52
25	1/2" airspace	1.17	0.98	0.91	0.71	0.69	0.58	0.53
26	1/4" argon space	1.09	0.89	0.83	0.63	0.61	0.50	0.45
27	1/2" argon space	1.11	0.91	0.85	0.65	0.63	0.52	0.47
	Triple Glazing							
28	1/4" airspaces	1.12	0.89	0.84	0.64	0.64	0.53	0.48
29	1/2" airspaces	1.10	0.87	0.81	0.61	0.62	0.51	0.45
30	1/4" argon spaces	1.09	0.86	0.80	0.60	0.61	0.50	0.44
31	1/2" argon spaces	1.07	0.84	0.79	0.59	0.59	0.48	0.42
	Triple Glazing, ***e***=0.20 on surface 2,3,4, or 5							
32	1/4" airspaces	1.08	0.85	0.79	0.59	0.60	0.49	0.43
33	1/2" airspaces	1.05	0.82	0.77	0.57	0.57	0.46	0.41
34	1/4" argon spaces	1.02	0.79	0.74	0.54	0.55	0.44	0.38
35	1/2" argon spaces	1.01	0.78	0.73	0.53	0.54	0.43	0.37

TABLE A-17 (Section A8.1) (Continued)
Assembly U-Factors for Unlabeled Skylights

	Triple Glazing, ***e***=0.20 on surfaces 2 or 3 and 4 or 5							
36	1/4" airspaces	1.03	0.80	0.75	0.55	0.56	0.45	0.39
37	1/2" airspaces	1.01	0.78	0.73	0.53	0.54	0.43	0.37
38	1/4" argon spaces	0.99	0.75	0.70	0.50	0.51	0.40	0.35
39	1/2" argon spaces	0.97	0.74	0.69	0.49	0.50	0.39	0.33
	Triple Glazing, ***e***=0.10 on surfaces 2 or 3 and 4 or 5							
40	1/4" airspaces	1.01	0.78	0.73	0.53	0.54	0.43	0.37
41	1/2" airspaces	0.99	0.76	0.71	0.51	0.52	0.41	0.36
42	1/4" argon spaces	0.96	0.73	0.68	0.48	0.49	0.38	0.32
43	1/2" argon spaces	0.95	0.72	0.67	0.47	0.48	0.37	0.31
	Quadruple Glazing, ***e***=0.10 on surfaces 2 or 3 and 4 or 5							
44	1/4" airspaces	0.97	0.74	0.69	0.49	0.50	0.39	0.33
45	1/2" airspaces	0.94	0.71	0.66	0.46	0.47	0.36	0.30
46	1/4" argon spaces	0.93	0.70	0.65	0.45	0.46	0.35	0.30
47	1/2" argon spaces	0.91	0.68	0.63	0.43	0.44	0.33	0.28
48	1/4" krypton spaces	0.88	0.65	0.60	0.40	0.42	0.31	0.25

TABLE A-18 (Section A8.1)
Assembly Solar Heat Gain Coefficients (SHGC) and
Assembly Visible Light Transmittances (VLT) for Unlabeled Skylights

Glass Type	Glazing Type: Number of glazing layers Number and emissivity of coatings (glazing is glass except where noted)	Unlabeled Skylights (includes glass/plastic, flat/domed, fixed/operable)						
		Frame:	Metal without thermal break		Metal with thermal break		Wood/vinyl/ fiberglass	
		Characteristic:	SHGC	VLT	SHGC	VLT	SHGC	VLT
Clear	Single glazing, 1/8 in. glass		0.82	0.76	0.78	0.76	0.73	0.73
	Single glazing, 1/4 in. glass		0.78	0.75	0.74	0.75	0.69	0.72
	Single glazing, acrylic/polycarbonate		0.83	0.92	0.83	0.92	0.83	0.92
	Double glazing		0.68	0.66	0.64	0.66	0.59	0.64
	Double glazing, E=0.40 on surface 2 or 3		0.71	0.65	0.67	0.65	0.62	0.63
	Double glazing, E=0.20 on surface 2 or 3		0.66	0.61	0.62	0.61	0.57	0.59
	Double glazing, E=0.10 on surface 2 or 3		0.59	0.63	0.55	0.63	0.51	0.61
	Double glazing, acrylic/polycarbonate		0.77	0.89	0.77	0.89	0.77	0.89
	Triple glazing		0.60	0.59	0.56	0.59	0.52	0.57
	Triple glazing, E=0.40 on surface 2, 3, 4, or 5		0.64	0.60	0.60	0.60	0.56	0.57
	Triple glazing, E=0.20 on surface 2, 3, 4, or 5		0.59	0.55	0.55	0.55	0.51	0.53
	Triple glazing, E=0.10 on surface 2, 3, 4, or 5		0.54	0.56	0.50	0.56	0.46	0.54
	Triple glazing, E=0.40 on surfaces 3 and 5		0.62	0.57	0.58	0.57	0.53	0.55
	Triple glazing, E=0.20 on surfaces 3 and 5		0.56	0.51	0.52	0.51	0.48	0.49
	Triple glazing, E=0.10 on surfaces 3 and 5		0.47	0.54	0.43	0.54	0.40	0.52
	Triple glazing, acrylic/polycarbonate		0.71	0.85	0.71	0.85	0.71	0.85
	Quadruple glazing, E=0.10 on surfaces 3 and 5		0.41	0.48	0.37	0.48	0.33	0.46
	Quadruple glazing, acrylic/polycarbonate		0.65	0.81	0.65	0.81	0.65	0.81
Tinted	Single glazing, 1/8 in. glass		0.70	0.58	0.66	0.58	0.62	0.56
	Single glazing, 1/4 in. glass		0.61	0.45	0.56	0.45	0.52	0.44
	Single glazing, acrylic/polycarbonate		0.46	0.27	0.46	0.27	0.46	0.27
	Double glazing		0.50	0.40	0.46	0.40	0.42	0.39
	Double glazing, E=0.40 on surface 2 or 3		0.59	0.50	0.55	0.50	0.50	0.48
	Double glazing, E=0.20 on surface 2 or 3		0.47	0.37	0.43	0.37	0.39	0.36
	Double glazing, E=0.10 on surface 2 or 3		0.43	0.38	0.39	0.38	0.35	0.37
	Double glazing, acrylic/polycarbonate		0.37	0.25	0.37	0.25	0.37	0.25
	Triple glazing		0.42	0.22	0.37	0.22	0.34	0.21
	Triple glazing, E=0.40 on surface 2, 3, 4, or 5		0.53	0.45	0.49	0.45	0.45	0.44
	Triple glazing, E=0.20 on surface 2, 3, 4, or 5		0.42	0.33	0.38	0.33	0.35	0.32
	Triple glazing, E=0.10 on surface 2, 3, 4, or 5		0.39	0.34	0.35	0.34	0.31	0.33
	Triple glazing, E=0.40 on surfaces 3 and 5		0.51	0.43	0.47	0.43	0.43	0.42
	Triple glazing, E=0.20 on surfaces 3 and 5		0.40	0.31	0.36	0.31	0.32	0.29
	Triple glazing, E=0.10 on surfaces 3 and 5		0.34	0.32	0.30	0.32	0.27	0.31
	Triple glazing, acrylic/polycarbonate		0.30	0.23	0.30	0.23	0.30	0.23
	Quadruple glazing, E=0.10 on surfaces 3 and 5		0.30	0.29	0.26	0.29	0.23	0.28
	Quadruple glazing, acrylic/polycarbonate		0.27	0.25	0.27	0.25	0.27	0.25

TABLE A-19 (Section A8.2)
Assembly U-Factors, Assembly Solar Heat Gain Coefficients (SHGC), and Assembly Visible Light Transmittances (VLT) for Unlabeled Vertical Fenestration

Frame Type	Glazing Type	Unlabeled Vertical Fenestration					
		Clear Glass			Tinted Glass		
		U-Factor	SHGC	VLT	U-Factor	SHGC	VLT
All frame types							
	Single glazing	1.25	0.82	0.76	1.25	0.70	0.58
	Glass block	0.60	0.56	0.56	n.a.	n.a.	n.a.
Wood, vinyl, or fiberglass frame							
	Double glazing	0.60	0.59	0.64	0.60	0.42	0.39
	Triple glazing	0.45	0.52	0.57	0.45	0.34	0.21
Metal and other frame type							
	Double glazing	0.90	0.68	0.66	0.90	0.50	0.40
	Triple glazing	0.70	0.60	0.59	0.70	0.42	0.22

TABLE A-20 (Section A9.2 and A9.4.2)
Effective Insulation/Framing Layer R-Values for Roof and Floor Insulation Installed Between Metal Framing (4 ft on center)

Rated R-Value of Insulation	Correction Factor	Framing/Cavity R-Value	Rated R-Value of Insulation	Correction Factor	Framing/Cavity R-Value
0.00	1.00	0.00	20.00	0.85	17.00
4.00	0.97	3.88	21.00	0.84	17.64
5.00	0.96	4.80	24.00	0.82	19.68
8.00	0.94	7.52	25.00	0.81	20.25
10.00	0.92	9.20	30.00	0.79	23.70
11.00	0.91	10.01	35.00	0.76	26.60
12.00	0.90	10.80	38.00	0.74	28.12
13.00	0.90	11.70	40.00	0.73	29.20
15.00	0.88	13.20	45.00	0.71	31.95
16.00	0.87	13.92	50.00	0.69	34.50
19.00	0.86	16.34	55.00	0.67	36.85

TABLE A-21 (Sections A9.2 and A9.4.2)
Effective Insulation/Framing Layer R-Values for Wall Insulation Installed Between Steel Framing

Nominal Depth of Cavity (in.)	Actual Depth of Cavity (in.)	Rated R-Value of Airspace or Insulation	Effective Framing/Cavity R-Value at 16 in. on center	Effective Framing/Cavity at 24 in. on center
Empty cavity, no insulation				
4	3.5	R-0.91	0.79	0.91
Insulated Cavity				
4	3.5	R-11	5.5	6.6
4	3.5	R-13	6.0	7.2
4	3.5	R-15	6.4	7.8
6	6.0	R-19	7.1	8.6
6	6.0	R-21	7.4	9.0
8	8.0	R-25	7.8	9.6

R-Value	Condition
0.17	All exterior surfaces
0.46	All semi-exterior surfaces
0.61	Interior horizontal surfaces, heat flow up
0.92	Interior horizontal surfaces, heat flow down
0.68	Interior vertical surfaces

Exterior surfaces are areas exposed to the wind. Semi-exterior surfaces are protected surfaces that face attics, crawl spaces, and parking garages with natural or mechanical ventilation. Interior surfaces are surfaces within enclosed spaces.

The R-value for cavity airspaces shall be taken from Table A-23 based on the emissivity of the cavity from Table A-22. No credit shall be given for airspaces in cavities that contain any insulation or less than 0.5 in. The values for 3.5 in. cavities shall be used for cavities of that width and greater.

A9.4.2 Insulation R-values: Insulation R-values shall be determined as follows:

a. For insulation that is not compressed, the ***rated R-value of insulation*** shall be used.

b. For calculation purposes, the effective R-value for insulation that is uniformly compressed in confined cavities shall be taken from Table A-24.

c. For calculation purposes, the effective R-value for insulation installed in cavities in attic roofs with steel joists shall be taken from Table A-20.

d. For calculation purposes, the effective R-value for insulation installed in cavities in steel-framed walls shall be taken from Table A-21.

A9.4.3 Building Material Thermal Properties: R-values for ***building materials*** shall be taken from Table A-25. Concrete block R-values shall be calculated using the isothermal planes method or a two-dimensional calculation program, thermal conductivities from Table A-26, and dimensions from ASTM C90. The parallel path calculation method is not acceptable.

Exception to A9.4.3: R-values for ***building materials*** or thermal conductivities determined from testing in accordance with A9.3

A9.4.4 Building Material Heat Capacities: The ***heat capacity*** of assemblies shall be calculated using published values for the unit weight and specific heat of all building material components that make up the assembly.

TABLE A-22 (Section A9.4.1)
Emittance Values of Various Surfaces and Effective Emittances of Air Spaces

Surface	Average Emittance *e*	Effective Emittance *e eff* of Air Space: One Surface *e*; Other, 0.9	Effective Emittance *e eff* of Air Space: Both Surfaces Emittance *e*
Aluminum foil, bright	0.05	0.05	0.03
Aluminum foil, with condensate just visible (>0.7 gr/ft^2)	0.30	0.29	-
Aluminum foil, with condensate clearly visible (>2.9 gr/ft^2)	0.70	0.65	-
Aluminum sheet	0.12	0.12	0.06
Aluminum coated paper, polished	0.20	0.20	0.11
Steel, galv., bright	0.25	0.24	0.15
Aluminum paint	0.50	0.47	0.35
Bldg materials: wood, paper, masonry, nonmetallic paints	0.90	0.82	0.82
Regular glass	0.84	0.77	0.72

TABLE A-23 (Section A9.4.1)
R-Values for Cavity Air Spaces

		R-Value				
		Effective Emissivity				
Component	Airspace Thickness (in.)	0.03	0.05	0.20	0.50	0.82
Roof	0.50	2.13	2.04	1.54	1.04	0.77
	0.75	2.33	2.22	1.64	1.09	0.80
	1.50	2.53	2.41	1.75	1.13	0.82
	3.50	2.83	2.66	1.88	1.19	0.85
Wall	0.50	2.54	2.43	1.75	1.13	0.82
	0.75	3.58	3.32	2.18	1.30	0.90
	1.50	3.92	3.62	2.30	1.34	0.93
	3.50	3.67	3.40	2.21	1.31	0.91
Floor	0.50	2.55	1.28	1.00	0.69	0.53
	0.75	1.44	1.38	1.06	0.73	0.54
	1.50	2.49	2.38	1.76	1.15	0.85
	3.50	3.08	2.90	2.01	1.26	0.90

TABLE A-24 (Section A9.4.2)
Effective R-Values for Fiberglass

Insulation R-Value at Standard Thickness									
Rated R-Value		**38**	**30**	**22**	**21**	**19**	**15**	**13**	**11**
Standard Thickness (in.)		**12**	**9.5**	**6.5**	**5.5**	**6**	**3.5**	**3.5**	**3.5**
Nominal Lumber Size (in.)	**Actual Depth of Cavity (in.)**	**Effective Insulation R-Values when Installed in a Confined Cavity**							
2×12	11.25	37	-	-	-	-	-	-	-
2×10	9.25	32	30	-	-	-	-	-	-
2×8	7.25	27	26	22	21	19	-	-	-
2×6	5.5	-	21	20	21	18	-	-	-
2×4	3.5	-	-	14	-	13	15	13	11
	2.5	-	-	-	-	-	-	9.8	-
	1.5	-	-	-	-	-	-	6.3	6

TABLE A-25 (Section A9.4.3)
R-Values for Building Materials

Material	Nominal Size (in.)	Actual Size (in.)	R-Value
Carpet and rubber pad	-	-	1.23
Concrete at R-0.0625/in.	-	2	0.13
	-	4	0.25
	-	6	0.38
	-	8	0.5
	-	10	0.63
	-	12	0.75
Flooring, wood subfloor	-	0.75	0.94
Gypsum board	-	0.5	0.45
	-	0.625	0.56
Metal deck	-	-	0
Roofing, built-up	-	0.375	0.33
Sheathing, vegetable fiber board, 0.78 in.	-	0.78	2.06
Soil at R-0.104/in.	-	12	1.25
Steel, mild		1	0.0031807
Stucco	-	0.75	0.08
Wood, 2 × 4 at R-1.25/in.	4	3.5	4.38
Wood, 2 × 6 at R-1.25/in.	6	5.5	6.88
Wood, 2 × 8 at R-1.25/in.	8	7.25	9.06
Wood, 2 × 10 at R-1.25/in.	10	9.25	11.56
Wood, 2 × 12 at R-1.25/in.	12	11.25	14.06
Wood, 2 × 14 at R-1.25/in.	14	13.25	16.56

TABLE A-26 (Section A9.4.3)
Thermal Conductivity of Concrete Block Material

Concrete Block Density in lb/ft^3	Thermal Conductivity in Btu in./h ft^2 °F
80	3.7
85	4.2
90	4.7
95	5.1
100	5.5
105	6.1
110	6.7
115	7.2
120	7.8
125	8.9
130	10.0
135	11.8
140	13.5

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

NORMATIVE APPENDIX B

BUILDING ENVELOPE CRITERIA

This normative appendix contains the building envelope requirements for each climate. The criteria tables are listed in numerical order according to climate as indicated in Figure B-1 below. CDD50 and HDD65 values for U.S., Canadian, and international locations may be found in Normative Appendix D. (See 5.1.3 for additional information regarding the selection of climate data.) The table numbers are also included in Normative Appendix D for each weather site listed. The numbers in Figure B-1 correspond to the tables numbered B-n to identify criteria for those corresponding to the heating degree-days and cooling degree-days shown, where ***n*** = 1,2,3....26. The following definitions apply: ci = continuous insulation (see Section 3.2), NR = no (insulation) requirements.

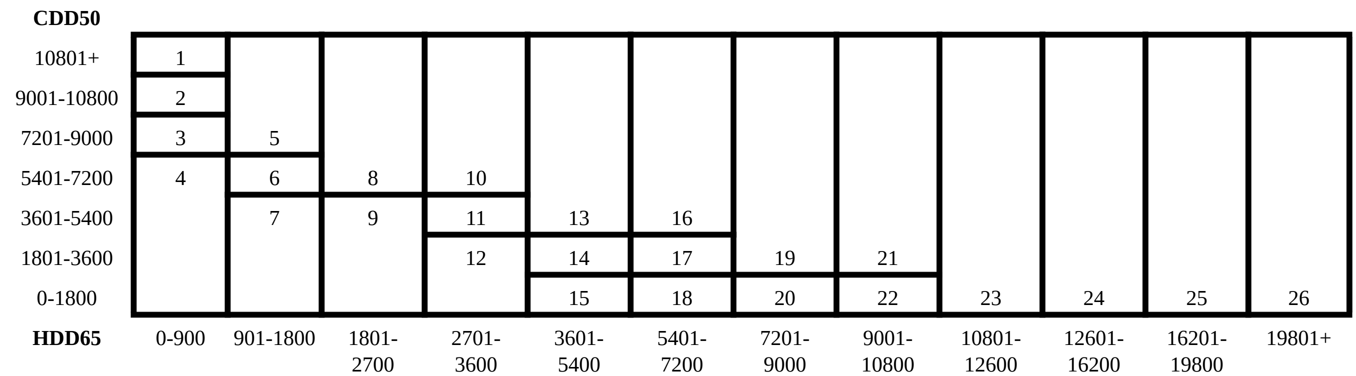

Figure B-1 Climates for building envelope requirements.

TABLE B-1
Building Envelope Requirements (HDD65: 0-900, CDD50: 10801+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.048	R-20 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.055	R-13.0 + R-13.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	NR
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22	$SHGC_{all}$-0.19	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-NR
10.1-20.0%	U_{fixed}-1.22	$SHGC_{all}$-0.19	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-NR
20.1-30.0%	U_{fixed}-1.22	$SHGC_{all}$-0.19	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.44	U_{oper}-1.27	$SHGC_{north}$-0.44	U_{oper}-1.27	$SHGC_{north}$-NR
30.1-40.0%	U_{fixed}-1.22	$SHGC_{all}$-0.19	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.44	U_{oper}-1.27	$SHGC_{north}$-0.44	U_{oper}-1.27	$SHGC_{north}$-NR
40.1-50.0%	U_{fixed}-1.22	$SHGC_{all}$-0.14	U_{fixed}-1.22	$SHGC_{all}$-0.19	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.34	U_{oper}-1.27	$SHGC_{north}$-0.33	U_{oper}-1.02	$SHGC_{north}$-NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-2
Building Envelope Requirements (HDD65: 0-900, CDD50: 9001-10800)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	NR
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.44	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.44	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.19 $SHGC_{north}$-0.33	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.19 $SHGC_{north}$-0.33	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-3
Building Envelope Requirements (HDD65: 0-900, CDD50: 7201-9000)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	NR
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.19 $SHGC_{north}$-0.47	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.31 $SHGC_{north}$-0.47	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-4
Building Envelope Requirements (HDD65: 0-900, CDD50: 0-7200)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.093	R-10.0 ci	U-0.063	R-15.0 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.614	NR
Walls, Above Grade						
Mass	U-0.580	NR	U-0.580	NR	U-0.580	NR
Metal Building	U-0.123	R-11.0	U-0.113	R-13.0	U-1.180	NR
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.44 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.44 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.40 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.31 $SHGC_{north}$-0.46	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.30 $SHGC_{north}$-0.46	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.61	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.25	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.61	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.25	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-5
Building Envelope Requirements (HDD65: 901-1800, CDD50: 7201+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	R-4.2 ci	U-0.107	R-6.3 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-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.17 $SHGC_{north}$-0.44	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.17 $SHGC_{north}$-0.43	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-6
Building Envelope Requirements (HDD65: 901-1800, CDD50: 5401-7200)

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	R-4.2 ci	U-0.107	R-6.3 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-0051	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-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	

Fenestration	Nonresidential Assembly Max. U (Fixed/ Operable)	Nonresidential Assembly Max. SHGC (All Orientations/ North-Oriented)	Residential Assembly Max. U (Fixed/ Operable)	Residential Assembly Max. SHGC (All Orientations/ North-Oriented)	Semiheated Assembly Max. U (Fixed/ Operable)	Semiheated Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-0.44	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-0.44	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-0.40	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22	$SHGC_{all}$-0.17	U_{fixed}-1.22	$SHGC_{all}$-0.29	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.42	U_{oper}-1.27	$SHGC_{north}$-0.41	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.25	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.25	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-7
Building Envelope Requirements (HDD65: 901-1800, CDD50: 0-5400)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.093	R-10.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.072	R-16.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	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-0.066	R-13.0	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-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	

Fenestration	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.82	U_{oper}-1.27	$SHGC_{north}$-0.82	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22	$SHGC_{all}$-0.44	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22	$SHGC_{all}$-0.44	U_{fixed}-1.22	$SHGC_{all}$-0.44	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22	$SHGC_{all}$-0.31	U_{oper}-1.22	$SHGC_{all}$-0.31	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.39	U_{oper}-1.27	$SHGC_{north}$-0.37	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.61	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.61	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-8
Building Envelope Requirements (HDD65: 1801-2700, CDD50: 5401+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.580	NR	U-0.123	R-7.6 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	R-4.2 ci	U-0.107	R-6.3 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-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.15 $SHGC_{north}$-0.38	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.14 $SHGC_{north}$-0.36	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-9
Building Envelope Requirements (HDD65: 1801-2700, CDD50: 0-5400)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	R-4.2 ci	U-0.107	R-6.3 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-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.34 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.34 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.20 $SHGC_{north}$-0.30	U_{fixed}-0.73 U_{oper}-0.81	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.61	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.61	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-10
Building Envelope Requirements (HDD65: 2701-3600, CDD50: 5401+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.123	R-7.6 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.19	U_{fixed}-0.46	$SHGC_{all}$-0.19	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.26	U_{oper}-0.47	$SHGC_{north}$-0.26	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.17	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.19	U_{all}-1.17	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.69	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-11
Building Envelope Requirements (HDD65: 2701-3600, CDD50: 3601-5400)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.123	R-7.6 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-0.950	R-7.5 for 24 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.39	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.27 $SHGC_{north}$-0.32	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.26 $SHGC_{north}$-0.36	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.17	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.17	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-12
Building Envelope Requirements (HDD65: 2701-3600, CDD50: 0-3600)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.093	R-10.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.123	R-7.6 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
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-1.020	R-7.5 for 12 in.	F-0.950	R-7.5 for 24 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.61 $SHGC_{north}$-0.82	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.73 U_{oper}-0.81	$SHGC_{all}$-0.39 $SHGC_{north}$-0.61	U_{fixed}-0.73 U_{oper}- 0.81	$SHGC_{all}$-0.51 $SHGC_{north}$-0.72	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.82	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.61	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.61	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.61	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-13
Building Envelope Requirements (HDD65: 3601-5400, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.104	R-9.5 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0
Steel Framed	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.950	R-7.5 for 24 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.25 $SHGC_{north}$-0.36	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.25 $SHGC_{north}$-0.36	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-0.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.58	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-14
Building Envelope Requirements (HDD65: 3601-5400, CDD50: 1801-3600)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.104	R-9.5 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.950	R-7.5 for 24 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.26 $SHGC_{north}$-0.36	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.26 $SHGC_{north}$-0.36	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.77	U_{all}-1.30	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.62	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-15
Building Envelope Requirements (HDD65: 3601-5400, CDD50: 0-1800)

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.123	R-7.6 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.950	R-7.5 for 24 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.36	U_{fixed}-0.46	$SHGC_{all}$-0.39	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.68	U_{all}-1.17	$SHGC_{all}$-0.68	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.83	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.77	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies.

TABLE B-16
Building Envelope Requirements (HDD65: 5401-7200, CDD50: 3601+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.123	R-7.6 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	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-0.087	R-8.3 ci	U-0.074	R-10.4 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10.0 for 36 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.39 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.23 $SHGC_{north}$-0.36	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.26 $SHGC_{north}$-0.36	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-0.98	$SHGC_{all}$-0.32	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.10	$SHGC_{all}$-0.62	U_{all}-1.10	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.10	$SHGC_{all}$-0.34	U_{all}-1.10	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.46	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.58	$SHGC_{all}$-0.32	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-17
Building Envelope Requirements (HDD65: 5401-7200, CDD50: 1801-3600)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.123	R-7.6 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.087	R-8.3 ci	U-0.074	R-10.4 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.36	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.10	$SHGC_{all}$-0.62	U_{all}-1.10	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-18
Building Envelope Requirements (HDD65: 5401-7200, CDD50: 0-1800)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.123	R-7.6 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.123	R-11.0
Steel Framed	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.49	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.49	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.49	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.68	U_{all}-1.17	$SHGC_{all}$-0.68	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-19
Building Envelope Requirements (HDD65: 7201-9000, CDD50: 1801+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.104	R-9.5 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	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-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 ci	U-0.064	R-12.5 ci	U-0.322	NR
Steel Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-.0066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.74	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-0.58	U_{all}-0.74	$SHGC_{all}$-0.55	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-20
Building Envelope Requirements (HDD65: 7201-9000, CDD50: 0-1800)

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.104	R-9.5 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	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-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 ci	U-0.074	R-10.4 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	

Fenestration	Nonresidential Assembly Max. U (Fixed/ Operable)	Nonresidential Assembly Max. SHGC (All Orientations/ North-Oriented)	Residential Assembly Max. U (Fixed/ Operable)	Residential Assembly Max. SHGC (All Orientations/ North-Oriented)	Semiheated Assembly Max. U (Fixed/ Operable)	Semiheated Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.64	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.64	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.68	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-0.77	U_{all}-0.74	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.74	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.64	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-21
Building Envelope Requirements (HDD65: 9001-10800, CDD50: 1801+)

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.048	R-20.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.055	R-13.0 + R-13.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.090	R-11.4 ci	U-0.071	R-15.2 ci	U-0.580	NR
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.074	R-10.4 ci	U-0.064	R-12.5 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-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.46 $SHGC_{north}$-0.64	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.46 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.46	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.46	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.46	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.35 U_{oper}-0.39	$SHGC_{all}$-0.32 $SHGC_{north}$-0.46	U_{fixed}-0.35 U_{oper}-0.39	$SHGC_{all}$-0.32 $SHGC_{north}$-0.64	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-0.98	$SHGC_{all}$-0.68	U_{all}-0.98	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.98	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.74	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.74	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.58	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.46	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.58	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-22
Building Envelope Requirements (HDD65: 9001-10800, CDD50: 0-1800)

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.090	R-11.4 ci	U-0.080	R-13.3 ci	U-0.580	NR
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 ci	U-0.064	R-12.5 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-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	

Fenestration	Nonresidential Assembly Max. U (Fixed/ Operable)	Nonresidential Assembly Max. SHGC (All Orientations/ North-Oriented)	Residential Assembly Max. U (Fixed/ Operable)	Residential Assembly Max. SHGC (All Orientations/ North-Oriented)	Semiheated Assembly Max. U (Fixed/ Operable)	Semiheated Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-0.57 U_{oper}-0.67	$SHGC_{all}$-0.49 $SHGC_{north}$-0.64	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.64	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-0.36 $SHGC_{north}$-0.64	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.68	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-0.77	U_{all}-0.61	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.61	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-0.69	$SHGC_{all}$-0.64	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.64	U_{all}-0.69	$SHGC_{all}$-0.64	U_{all}-1.36	$SHGC_{all}$-NR

TABLE B-23
Building Envelope Requirements (HDD65: 10801-12600, CDD50: 0+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.048	R-20.0 ci	U-0.119	R-7.6 ci
Metal Building	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.083	R-13.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.090	R-11.4 ci	U-0.071	R-15.2 ci	U-0.151[a]	R-5.7 ci[a]
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
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-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.074	R-10.4 ci	U-0.064	R-12.5 ci	U-0.137	R-4.2 ci
Steel Joist	U-0.038	R-30.0	U-0.032	R-38.0	U-0.052	R-19.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	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-0.730	NR
Heated	F-0.780	R-10 for 48 in.	F-0.780	R-10.0 for 48 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.35	$SHGC_{all}$-NR	U_{fixed}-0.35	$SHGC_{all}$-NR	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.39	$SHGC_{north}$-NR	U_{oper}-0.39	$SHGC_{north}$NR	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-1.36	$SHGC_{all}$-NR

[a] Exception 5.3.1.2a applies.

TABLE B-24
Building Envelope Requirements (HDD65: 12601-16200, CDD50: 0+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 ci	U-0.048	R-20.0 ci	U-0.093	R-10.0 ci
Metal Building	U-0.049	R-13.0 + R-19.0	U-0.049	R-13.0 + R-19.0	U-0.072	R-16.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	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-0.151[a]	R-5.7 ci[a]
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.051	R-13.0 + R-7.5 ci	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.064	R-12.5 ci	U-0.057	R-14.6 ci	U-0.137	R-4.2 ci
Steel Joist	U-0.038	R-30.0	U-0.032	R-38.0	U-0.052	R-19.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	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-0.730	NR
Heated	F-0.780	R-10 for 48 in.	F-0.780	R-10 for 48 in.	F-0.950	R-7.5 for 24 in.
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-0.46 U_{oper}-0.47	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.35 U_{oper}-0.39	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-0.35 U_{oper}-0.39	$SHGC_{all}$-NR $SHGC_{north}$-NR	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR

[a] Exception 5.3.1.2a applies.

TABLE B-25
Building Envelope Requirements (HDD65: 16201-19800, CDD50: 0+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 ci	U-0.048	R-20.0 ci	U-0.093	R-10.0 ci
Metal Building	U-0.049	R-13.0 + R-19.0	U-0.049	R-13.0 + R-19.0	U-0.072	R-16.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.034	R-30.0
Walls, Above Grade						
Mass	U-0.071	R-15.2 ci	U-0.071	R-15.2 ci	U-0.123	R-7.6 ci
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.055	R-16.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.045	R-13.0 + R-18.0 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.051	R-13.0 + R-7.5 ci	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.075	R-12.5 ci	C-1.140	NR
Floors						
Mass	U-0.064	R-12.5 ci	U-0.051	R-16.7 ci	U-0.107	R-6.3 ci
Steel Joist	U-0.032	R-38.0	U-0.032	R-38.0	U-0.052	R-19.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.520	R-15 for 24 in.	F-0.520	R-15 for 24 in.	F-0.730	NR
Heated	F-0.780	R-10 for 48 in.	F-0.780	R-10 for 48 in.	F-0.950	R-7.5 for 24 in.
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-0.43	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-0.44	$SHGC_{north}$NR	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.33	$SHGC_{all}$-NR	U_{fixed}-0.33	$SHGC_{all}$-NR	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.34	$SHGC_{north}$NR	U_{oper}-0.34	$SHGC_{north}$NR	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-0.95	$SHGC_{all}$-NR	U_{all}-0.95	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.95	$SHGC_{all}$-NR	U_{all}-0.95	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR

TABLE B-26
Building Envelope Requirements (HDD65: 19801+, CDD50: 0+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.039	R-25.0 ci	U-0.048	R-20.0 ci	U-0.093	R-10.0 ci
Metal Building	U-0.047	R-16.0 + R-19.0	U-0.049	R-13.0 + R-19.0	U-0.065	R-19.0
Attic and Other	U-0.017	R-60.0	U-0.017	R-60.0	U-0.034	R-30.0
Walls, Above Grade						
Mass	U-0.071	R-15.2 ci	U-0.071	R-15.2 ci	U-0.104	R-9.5 ci
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.055	R-16.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.055	R-13.0 + R-10.0 ci	U-0.040	R-13.0 + R-21.6 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-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.063	R-15.0 ci	C-1.140	NR
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-0.032	R-38.0	U-0.052	R-19.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.520	R-15 for 24 in.	F-0.510	R-20 for 24 in.	F-0.730	NR
Heated	F-0.780	R-10 for 48 in.	F-0.780	R-10 for 48 in.	F-0.840	R-10.0 for 36 in.
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.73	$SHGC_{all}$-NR
	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.81	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.73	$SHGC_{all}$-NR
	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.81	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.73	$SHGC_{all}$-NR
	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.81	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.32	$SHGC_{all}$-NR	U_{fixed}-0.73	$SHGC_{all}$-NR
	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.36	$SHGC_{north}$NR	U_{oper}-0.81	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.25	$SHGC_{all}$-NR	U_{fixed}-0.25	$SHGC_{all}$-NR	U_{fixed}-0.58	$SHGC_{all}$-NR
	U_{oper}-0.29	$SHGC_{north}$NR	U_{oper}-0.29	$SHGC_{north}$NR	U_{oper}-0.65	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-0.88	$SHGC_{all}$-NR	U_{all}-0.88	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.88	$SHGC_{all}$-NR	U_{all}-0.88	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.55	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR

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

NORMATIVE APPENDIX C

METHODOLOGY FOR BUILDING ENVELOPE TRADE-OFF OPTION IN SUBSECTION 5.4

C1 Minimum Information. The following minimum information shall be specified for the proposed design:

C1.1 At the Building Level: The floor area, broken down by ***space-conditioning categories***.

C1.2 At the Exterior Surface Level: The classification, gross area, orientation, ***U-factor***, and exterior conditions. For ***mass walls*** only: ***heat capacity*** and insulation position. Each surface is associated with a ***space-conditioning category*** as defined in C1.1.

C1.3 For Fenestration: The classification, area, ***U-factor***, ***solar heat gain coefficient*** (SHGC), visible light transmittance (VLT), overhang ***projection factor*** for ***vertical fenestration***, and width, depth, and height for ***skylight wells***. (See Figure C1.3 for definition of width, depth, and height for ***skylight wells***.) Each ***fenestration*** element is associated with a surface (defined in C1.2) and has the orientation of that surface.

C1.4 For Opaque Doors: The classification, area, ***U-factor***, ***heat capacity***, and insulation position. Each ***opaque door*** is associated with a surface (defined in C1.2) and has the orientation of that surface.

C1.5 For Below-Grade Walls: The area, average depth to the bottom of the wall, and ***C-factor***. Each ***below-grade wall*** is associated with a ***space-conditioning category*** as defined in C1.1.

C1.6 For Slab-On-Grade Floor: The perimeter length and ***F-factor***. Each ***slab-on-grade floor*** is associated with a ***space-conditioning category*** as defined in C1.1.

C2 Output Requirements: Output reports shall contain the following information.

C2.1 Tables summarizing the minimum information described in C1.

C2.2 The ***envelope performance factor*** differential broken down by envelope component. The differential is the difference between the ***envelope performance factor*** of the proposed building and the ***envelope performance factor*** of the base envelope design. Envelope components include the ***opaque roof***, ***skylights***, ***opaque above-grade walls*** including ***vertical fenestration*** and ***opaque doors***, ***below-grade walls, floors***, and ***slab-on-grade floors***.

C3 Base Envelope Design Specification

C3.1 The base envelope design shall have the same building floor area, ***building envelope floor area***, ***slab-on-grade floor*** perimeter, below-grade floor area, gross ***wall area***, ***opaque door area***, and ***gross roof area*** as the proposed design. The distribution of these areas among ***space-conditioning categories*** shall be the same as the proposed design.

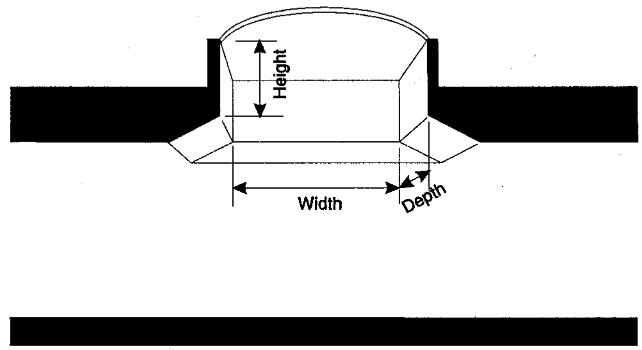

Figure C1.3 Skylight well dimensions.

C3.2 The ***U-factor*** of each ***opaque*** element of the base envelope design shall be equal to the criteria from Tables B-1 through B-26 for the appropriate climate for each construction classification. ***The heat capacity*** of ***mass wall*** elements in the base envelope design shall be identical to the proposed design. ***Mass walls*** in the base envelope design shall have interior insulation, when required.

C3.3 The ***vertical fenestration area*** of each ***space-conditioning category*** in the base envelope design shall be the same as the proposed building or 40% of the ***gross wall area***, whichever is less. The distribution of ***vertical fenestration*** among ***space-conditioning categories*** and surface orientations shall be the same as the proposed design. If the ***vertical fenestration area*** of any ***space-conditioning category*** is greater than 40% of the ***gross wall area*** of that ***space-conditioning category***, then the area of each ***fenestration*** element shall be reduced in the base envelope design by the same percentage so that the total ***vertical fenestration area*** is exactly equal to 40% of the ***gross wall area***.

C3.4 The ***skylight area*** of each space category in the base envelope design shall be the same as the proposed building or 5% of the ***gross roof area***, whichever is less. This distribution of ***skylights*** among ***space conditioning categories*** shall be the same as the proposed design. If the ***skylight area*** of any space category is greater than 5% of the ***gross roof area*** of that ***space-conditioning category***, then the area of each ***skylight*** shall be reduced in the base envelope design by the same percentage so that the total ***skylight area*** is exactly equal to 5% of the ***gross roof area***.

C3.5 The ***U-factor*** for ***fenestration*** in the base envelope design shall be equal to the criteria from Tables B-1 through B-26 for the appropriate climate. The ***solar heat gain coefficient (SHGC)*** for ***fenestration*** in the base envelope design shall be equal to the criteria from Tables B-1 through B-22 for climates with 0-10800 HDD65 and, for climates with greater than 10800 HDD65, shall be equal to 0.64 for ***north-oriented*** and 0.46 for all other ***vertical fenestration***, 0.77 for plastic ***skylights*** on a curb, and 0.72 for all other ***skylights*** with a curb and without. The visible light transmittance (VLT) for ***fenestration*** in the base envelope design shall be the VLT factor from Table C3.5 times the ***SHGC*** criteria as determined in this subsection.

TABLE C3.5
VLT Factor for the Base Envelope Design

Climate Bin	Vertical Fenestration	Glass Skylights	Plastic Skylights
1	1.00	1.27	1.20
2	1.00	1.27	1.20
3	1.00	1.27	1.20
4	1.00	1.27	1.20
5	1.00	1.27	1.20
6	1.00	1.27	1.20
7	1.00	1.27	1.20
8	1.00	1.27	1.20
9	1.00	1.27	1.20
10	1.27	1.27	1.20
11	1.27	1.27	1.20
12	1.00	1.27	1.20
13	1.27	1.27	1.20
14	1.27	1.27	1.20
15	1.27	1.27	1.20
16	1.27	1.27	1.20
17	1.27	1.27	1.20
18	1.27	1.27	1.20
19	1.27	1.27	1.20
20	1.00	1.00	1.20
21	1.00	1.00	1.20
22	1.00	1.00	1.20
23	1.00	1.00	1.20
24	1.00	1.00	1.20
25	1.00	1.00	1.20
26	1.00	1.00	1.20

C4 Zoning and Building Geometry. No information about thermal zones needs to be entered to perform the calculations, but when the calculations are performed the building shall be divided into thermal zones according to the following procedure.

C4.1 Determine the ratio (R_c) of the ***gross floor area*** to the ***gross wall area*** for each ***space-conditioning category***. The index "c" refers to the ***space-conditioning category***, either ***nonresidential conditioned***, ***residential conditioned***, or ***semiheated***.

C4.2 Create a perimeter zone for each unique combination of ***space-conditioning category*** and ***wall*** orientation. The ***floor area*** of each perimeter zone shall be the ***gross wall area*** of the zone times R_c or 1.25, whichever is smaller.

C4.3 For ***space-conditioning categories*** where R_c is greater than 1.25, interior zones shall be created and used in the trade-off procedure. The ***floor area*** of the interior zone shall be the total floor area for the ***space-conditioning category*** less the floor area of the perimeter zones created in C4.2 for that ***space-conditioning category***.

C4.4 ***Roof area***, ***floor area***, ***below-grade wall area***, and ***slab-on-grade floor*** perimeter associated with each ***space-conditioning category*** shall be prorated among the zones according to ***floor area***.

C4.5 ***Skylights*** shall be assigned to the interior zone of ***space-conditioning category***. If the ***skylight area*** is larger than the ***roof area*** of the interior zone, then the ***skylight area*** in the interior zone shall be equal to the ***roof area*** in the interior zone and the remaining ***skylight area*** shall be prorated among the perimeter zones based on ***floor area***.

C5 Modeling Assumptions. The following are modeling assumptions for the purposes of this appendix only and are not requirements for building operation.

C5.1 The ***residential conditioned*** and ***nonresidential conditioned space-conditioning categories*** shall be modeled with both heating and cooling systems for both the base envelope design and the proposed design. The thermostat set points for ***residential*** and ***nonresidential spaces*** shall be 70°F for heating and 75°F for cooling, with night setback temperatures of 55°F for heating and 99°F for cooling.

C5.2 The ***semiheated*** space categories shall be modeled with heating-only systems for both the base envelope design and the proposed design. The thermostat set point shall be 50°F for all hours.

C5.3 Both the base envelope design and the proposed design shall be modeled with the same heating, ventilating, and air-conditioning (HVAC) systems. The system shall consist of a packaged rooftop system serving each thermal zone. Cooling shall be provided by a direct expansion air conditioner (EER = 9.5, $COP_{cooling}$ = 2.78). Heating shall be provided by a gas furnace (AFUE = 0.78).

C5.4 The electrical systems shall be the same for both the base envelope design and the proposed design. The lighting power density shall be 1.20 W/ft^2 for ***nonresidential conditioned spaces***, 1.00 W/ft^2 for ***residential conditioned spaces,*** and 0.50 W/ft^2 for ***semiheated spaces***. The equipment power density shall be 0.75 W/ft^2 for ***nonresidential conditioned spaces***, 0.25 W/ft^2 for ***residential conditioned spaces***, and 0.25 W/ft^2 for ***semiheated spaces***. Continuous daylight dimming shall be assumed in all spaces and be activated at 50 fc for ***nonresidential conditioned spaces*** and ***residential conditioned spaces*** and 30 fc for ***semiheated spaces***.

C5.5 Surface reflectances for daylighting calculations shall be 80% for ceilings, 50% for walls, and 20% for floors.

C5.6 ***Envelope performance factor*** is defined in the following equation.

$$\text{Envelope Performance Factor} = \frac{\text{MBtu} \times 6600 + \text{kWh} \times 80}{\text{Total Building Floor Area}} \quad \text{(C-1)}$$

C5.7 The ***U-factor*** entered for surfaces adjacent to crawl spaces, attics, and parking garages with mechanical or natural ventilation shall be adjusted by adding R-2 to the ***thermal resistance*** to account for the buffering effect.

C5.8 Heat transfer for ***below-grade walls*** shall be based on the temperature difference between indoor and outdoor temperature conditions and a heat transfer path at the average wall depth below grade.

C6 Equations for Envelope Trade-Off Calculations. The procedure defined in this subsection shall be used in all building envelope trade-off calculations.

C6.1 Inputs. Building descriptions shall be converted to equation variables using Table C6.1.

C6.2 Envelope Performance Factor. The ***envelope performance factor (EPF)*** of a building shall be calculated using Equation C-2.

$$EPF = FAF \times [\Sigma HVAC_{surface} + \Sigma Lighting_{zone}] \qquad \text{(C-2)}$$

where

FAF	=	floor area factor for the entire building
$\Sigma HVAC_{surface}$	=	sum of HVAC for each surface calculated using Equation C-3
$\Sigma Lighting_{zone}$	=	sum of lighting for each zone calculated using Equation C-4

C6.3 HVAC. The HVAC term for each ***exterior*** or ***semi-exterior*** surface in the building shall be calculated using Equation C-3.

$$HVAC_{surface} = COOL + HEAT \qquad \text{(C-3)}$$

where

COOL	=	cooling factor for the surface calculated according to the appropriate equation in C-9, C-10 or C-11
HEAT	=	heating factor for the surface calculated according to the appropriate equation in C-9, C-10, or C-11

If either the HEAT or COOL term in Equation C-3 is less than zero, that term shall be set to zero for the calculation of $HVAC_{surface}$.

C6.4 Lighting. The lighting term for each zone in the building as defined in C4 shall be calculated using Equation C-4.

$$Lighting_{zone} = LPDadj_{zone} \times AREA_{zone} \times 216 \qquad \text{(C-4)}$$

where

$LPDadj_{zone}$	=	lighting power density for the zone adjusted for daylighting potential using Equation C-9

TABLE C6.1
Input Variables

Variable	Description	IP Units
$Area_{surface}$	Area of surface	ft^2
$Area_{zone}$	Gross floor area of zone as defined in C.5	ft^2
C-factor	C-factor for below-grade walls	$Btu/h \cdot ft^2 \cdot {}^oF$
CDD50	Cooling degree-days	Base $50^oF \cdot day$
CDD65	Cooling degree-days	Base $65^oF \cdot day$
CDH80	Cooling degree-hours	Base $80^oF \cdot hour$
CFA	Conditioned floor area	ft^2
Depth	Depth of bottom of below-grade wall	ft
DI	Artificial lighting design illuminance from C.5.4	Footcandles
DR	Daily range (average outdoor maximum-minimum in hottest month)	^oF
EPD	Miscellaneous equipment power density from C.5.4	W/ft^2
F-factor	F-factor for slab-on-grade floors	$Btu/h \cdot ft \cdot {}^oF$
FAF	Building floor area factor	1000/CFA, ft^2
HC	Wall heat capacity	$Btu/ft^2 \cdot {}^oF$
HDD50	Heating degree-days	Base $50^oF \cdot day$
HDD65	Heating degree-days	Base $65^oF \cdot day$
Length	Length of slab-on-grade floor perimeter	ft
LPD	Lighting power density from C.5.4	W/ft^2
R-Value	Effective R-value of soil for below-grade walls	$h \cdot ft^2 \cdot {}^oF/Btu$
U-factor	U-factor	$Btu/h \cdot ft^2 \cdot {}^oF$
VS	Annual average daily incident solar radiation on vertical surface	$Btu/ft^2 \cdot day$

C6.5 Solar and Visible Aperture.

C6.5.1 Solar and Visible Aperture of Vertical Fenestration. The visible aperture (VA), solar aperture for cooling (SA_c), and solar aperture for heating (SA_h) of each ***vertical fenestration*** shall be calculated using Equations C-5, C-6, and C-7.

$$VA = Area_{vf} \times VLT_{vf} \times (1 + PCC1 \times PF + PCC2 \times PF^2) \quad \text{(C-5)}$$

$$SA_c = Area_{vf} \times 1.163 \times SHGC \times (1 - PCC1 \times PF + PCC2 \times PF^2) \quad \text{(C-6)}$$

$$SA_h = Area_{vf} \times 1.163 \times SHGC \times (1 + PCH1 \times PF + PCH2 \times PF^2) \quad \text{(C-7)}$$

where

$Area_{vf}$ = ***glazing area*** of the ***vertical fenestration***

SHGC = the ***solar heat gain*** coefficient of the ***vertical fenestration*** assembly

VLT_{vf} = the visible light transmittance of the ***vertical fenestration*** assembly

PF = the ***projection factor*** for the overhang shade on the ***vertical fenestration***

PCH1, PCH2,
PCC1, and PCC2 = overhang projection coefficients for the ***vertical fenestration orientation*** from Table C6.5.1.

TABLE C6.5.1
Overhang Projection Coefficients

Orientation	PCC1	PCC2	PCH1	PCH2
North	-0.5	0.22	0	0
East, South, West	-0.97	0.38	0	0

C6.5.2 Visible Aperture of Skylights. The visible aperture (VA) of a ***skylight*** shall be calculated using Equation C-8.

$$VA = Area_{sky} \times VLT_{sky} \times 10^{(-0.250 \times (5 \times D \times (W + L) / (W \times L))} \quad \text{(C-8)}$$

where

$Area_{sky}$ = ***fenestration area*** of the ***skylight*** assembly

VLT_{sky} = the visible light transmittance of the ***skylight*** assembly

D = average depth of skylight well from ***fenestration*** to ceiling

W = width of skylight well

L = length of skylight well

C6.6 Adjusted Lighting Power (LPDadj).

The adjusted lighting power for each zone shall be calculated using Equation C-9.

$$LPDadj_{zone} = LPD \times (1 - \boldsymbol{Kd}_{zone}) \quad \text{(C-9)}$$

where

$\boldsymbol{Kd}_{zone}$ = daylight potential fraction calculated using Equation C-10

If a zone has both ***skylight***s and ***vertical fenestration***, the larger of the ***Kd*** calculated independently for each shall be used to calculate LPDadj.

$$Kd_{zone} = \left(\Phi 1 + \left(\frac{\Phi 2 \times DI \times VA}{Area_{fen}}\right)\right) \times (1 - e^{((\Phi 3 + \Phi 4 \times DI) \times VA)/Area_{surface}}) \quad \text{(C-10)}$$

where

$Area_{fen}$ = total ***fenestration area*** of the ***vertical fenestration*** or ***skylight*** assemblies in the zone

VA = total visible aperture of the ***vertical fenestration*** or ***skylights*** in the zone, as calculated in C-5

$Area_{surface}$ = ***gross wall area*** of the zone for ***vertical fenestration*** or ***gross roof area*** of the zone for ***skylights.***

and the coefficients Φ1 through Φ4 are defined in Table C6.6.

TABLE C6.6
Coefficients for Calculating K_d

Coefficient	Skylight	Vertical Fenestration
Φ1	0.589	0.737
Φ2	5.18E-07	-3.17E-04
Φ3	-220	-24.71
Φ4	2.29	0.234

C6.7 Delta Load Factors for Mass Walls in the Exterior Building Envelope.

Adjustments to cooling and heating loads for use in Equations C-14 and C-16 due to the mass properties of each ***mass wall*** component shall be calculated using Equations C-11 and C-12.

$$CMC = 1.43 \times Area_{mw} \times [1 - e^{-CP_1(HC-1)}] \times \left[CP_2 + CP_3 U - \left(\frac{CP_4}{1 + (CP_5 + CP_6 U)e^{-(CP_7 + CP_8 U^2)(HC-1)}}\right)\right] \quad \text{(C-11)}$$

where

CMC = cooling delta load factor

$Area_{mw}$ = net ***opaque area*** of this ***mass*** wall

A_c = CDH80/10000 + 2

B = DR/10 + 1

HC = wall heat capacity

DR = average daily temperature range for warmest month

B = DR/10 +1

CP_1 = C_5

CP_2 = $C_{15}/B^3 + C_{16}/(A_C{}^2B^2) + C_{17}$

CP_3 = $C_1/A_C{}^3 + C_2B^3 + C_2B^3 + C^3/ (A_C{}^2 \sqrt{B}) + C_4$

CP_4 = $C_{12}(A_C{}^2B^2) + C_{13}/B^3 + C_{14}$

U = area average of ***U-factors*** of ***mass walls*** in the zone

CP_5 = C_{18}

CP_6 = $C_6 \sqrt{B}\, LN(A_C) + C_7$

LN = natural logarithm

CP_7 = $C_{19}/(A_C{}^2B^2) + C_{20}/(A_CB) + C_{21}A_C{}^2 \sqrt{B} + C_{22}$

CP_8 = $C_8/(A_C{}^2B^2) + C_9/(A_CB) + C_{10}A_C{}^2 \sqrt{B} + C_{11}$

The coefficients C_1 through C_{22} depend on insulation position in the wall and are taken from Table C6.7A.

TABLE C6.7A
Cooling Delta Load Coefficients

Variable	Insulation Position		
	Exterior	Integral	Interior
C_1	220.7245	139.1057	181.6168
C_2	-0.0566	-0.0340	-0.0552
C_3	-118.8354	-10.3267	-34.1590
C_4	-13.6744	-20.8674	-25.5919
C_5	0.2364	0.2839	0.0810
C_6	0.9596	0.3059	1.4190
C_7	-0.2550	0.0226	0.4324
C_8	-905.6780	-307.9438	-1882.9268
C_9	425.1919	80.2096	443.1958
C_{10}	-2.5106	0.0500	0.4302
C_{11}	-43.3880	-5.9895	-28.2851
C_{12}	-259.7234	-11.3961	-63.5623
C_{13}	-33.9755	0.3669	20.8447
C_{14}	20.4882	30.2535	9.8175
C_{15}	-26.2092	8.8337	24.4598
C_{16}	-241.1734	-22.2546	-70.3375
C_{17}	18.8978	29.3297	9.8843
C_{18}	-0.3538	-0.0239	-0.1146
C_{19}	156.3056	63.3228	326.3447
C_{20}	-74.0990	-16.3347	-77.6355
C_{21}	0.4454	-0.0111	-0.0748
C_{22}	7.4967	1.2956	5.2041

$$HMC = 1.43 \times \text{Area}_{mw} \times [1 - e^{-HP_1(HC-1)}]$$
$$\times \left[HP_2 + HP_3 U - \left(\frac{HP_4}{1 + (HP_5 + HP_6 U)e^{-(HP_7 + HP_8 U^2)(HC-1)}}\right)\right] \quad \text{(C-12)}$$

where

HMC = heating delta load factor

HC = wall heat capacity

Area_{mw} = net ***opaque area*** of this ***mass*** wall

HP_1 = H_6

A_H = HDD65/100 + 2

HP_2 = $H_{14}LN(A_H) + H_{15}$

LN = natural logarithm

HP_3 = $H_1A_H^3 + H_2A_H^2 + H_3/\sqrt{A} + H_4\sqrt{A} + H_5$

U = area average of ***U-factors*** of ***mass walls*** in the zone

HP_4 = $H_{11}A_H^2 + H_{12}/A_H^2 + H_{13}$

HP_5 = H_{16}

HP_6 = $H_7A_H + H_8$

HP_7 = $H_{17}/A_H + H_{18}$

HP_8 = $H_9/A_H^3 + H_{10}$

TABLE C6.7B
Heating Delta Load Coefficients

Variable	Insulation Position		
	Exterior	Integral	Interior
H_1	0.0000	0.0000	0.0000
H_2	-0.0015	-0.0018	-0.0015
H_3	13.3886	15.1161	19.8314
H_4	1.9332	2.1056	1.4579
H_5	-11.8967	-13.3053	-15.5620
H_6	0.4643	0.1840	0.0719
H_7	0.0094	0.0255	0.0264
H_8	-0.1000	0.0459	0.7754
H_9	-1223.3962	-622.0801	0.2008
H_{10}	-0.9454	-0.5192	-0.6379
H_{11}	-0.0001	-0.0001	0.0000
H_{12}	3.8585	4.1379	2.4243
H_{13}	7.5829	6.2380	7.9804
H_{14}	-0.7774	-0.7711	-0.1699
H_{15}	9.0147	7.7229	8.5854
H_{16}	0.2007	0.2083	-0.0386
H_{17}	206.6382	105.9849	3.1397
H_{18}	0.2573	0.1983	0.1863

The coefficients H_1 through H_{18} depend on the position of the insulation in the wall and are taken from Table C6.7B. If the ***U-factor*** of ***mass wall*** is greater than 0.4 Btu/(h·ft^2·°F), then the ***U-factor*** shall be set to 0.4 Btu/(h·ft^2·°F). If the ***U-factor*** of the ***mass wall*** is less than 0.05 Btu/(h·ft^2·°F), than the ***U-Factor*** shall be set to 0.5 Btu/(h·ft^2·°F). If the wall heat capacity (HC) of the ***mass wall*** is greater than 20 Btu/(ft^2·°F), then HC = 20 Btu/(ft^2·°F) shall be used.

C6.8 Walls and Vertical Fenestration in the Exterior Building Envelope. Equations C-14 and C-16 shall be used to calculate COOL and HEAT for ***exterior walls*** and ***vertical fenestration*** in the ***exterior building envelope*** except walls next to crawl spaces, attics, and parking garages with natural or mechanical ventilation. ***Walls*** next to crawl spaces, attics, and parking garages with natural or mechanical ventilation shall use the equations in subsection C6.10 and they shall not be included in calculations in subsection C6.8. Zones shall be constructed according to C4 and the HEAT and COOL for the combination of all ***exterior walls*** and ***vertical fenestration*** in the zone shall be calculated using Equations C-14 and C-16, which include interactive effects. For a zone having a cardinal ***orientation*** (north, east, south or west), Equations C-14 and C-15 shall be applied directly. For zones with NE, NW, SW, and SE ***orientation***s, EC shall be determined by finding the average of the values for the two closest cardinal ***orientations***; for instance, COOL for a ***wall*** facing NE is calculated by taking the average of COOL for a north-facing wall and COOL for an east-facing ***wall***.

C6.8.1 Effective Internal Gain. The effective internal gain to the zone G shall be calculated using Equation C-13.

$$G = EPD \times LPDadj_{zone} \quad \text{(C-13)}$$

where

$LPDadj_{zone}$ = lighting power density adjusted for daylighting, from Equation C-9

C6.8.2 Cooling Factor. The cooling factor for the surfaces in the zone shall be calculated using Equation C-14.

$$COOL = 0.005447 \times [CLU + CLUO + CLXUO + CLM + CLG + CLS + CLC] \quad \text{(C-14)}$$

where

$$CLU = Area_{opaque} \times U_{ow} \times [CU1 \times CDH80 + CU2 \times CDH80^2 + CU3 \times (VS \times CDH80)^2 + CU4 \text{ x } DR]$$

$$CLUO = Area_{grosswall} \times UO \times [CUO1 \times EA_C \times VS \times CDD50 + CUO2 \times G + CUO3 \times G^2 \times EA_C^2 \times VS \times CDD50 + CUO4 \times G^2 \times EA_C^2 \times VS \times CDD65]$$

$$CLXUO = Area_{grosswall} / UO \times [CXUO1 \times EA_C \times VS \times CDD50 + CXUO2 \times EA_C \times (VS \times CDD50)^2 + CXUO3 \times G \times CDD50 + CXUO4 \times G^2 \times EA_C^2 \times VS \times CDD50 + CXUO5 \times G^2 \times CDD65]$$

$$CLM = Area_{opaque} \times SCMC \times [CM1 + CM2 \times EA_C \times VS \times CDD50 + CM3 \times EA_C \times VS \times CDD65 + CM4 \times EA_C^2 \times VS \times CDD50 + CM5 \times G^2 \times CDD65 + CM6 \times G \times CDD50 + CM7 \times G \times CDD65 + CM8 \times G \times EA_C \times VS \times CDD50]$$

$$CLG = Area_{grosswall} \times \{G \times [CG1 + CG2 \times CDD50 + CG3 \times EA_C \times (VS \times CDD50)^2 + CG4 \times EA_C^2 \times VS \times CDD50 + CG5 \times CDD65 + CG6 \times CDD50^3 + CG7 \times CDD65^3] + G^2 \times [CG8 \times EA_C \times VS \times CDD50 + CG9 \times EA_C^2 \times VS \times CDD50]\}$$

$$CLS = Area_{grosswall} \times \{EA_C \times [CS1 + CS2 \times VS \times CDD50 + CS3 \times (VS \times CDD50)^2 + CS4 \times VS \times CDD65 + CS5 \times (VS \times CDD65)^2] + EA_C^2 \times [CS6 + CS7 \times (VS \times CDD65)^2]\}$$

$$CLC = Area_{grosswall} \times [CC1 \times CDD50 + CC2 \times CDD50^2 + CC3 \times CDH80 + CC4 \times CDH80^2 + CC5 \times CDD65 + CC6 \times (VS \times CDD65)^2 + CC7 \times VS \times CDD50 + CC8 \times (VS \times CDD50)^2 + CC9 \times (VS \times CDH80)^2 + CC10 \times VS + CC11 \times DR + CC12 \times DR^2 + CC13]$$

where

$Area_{grosswall}$ = total gross area of all ***walls*** and ***vertical fenestration*** in the zone, including ***opaque*** and ***fenestration areas***

$Area_{opaque}$ = total ***opaque area*** of all ***walls*** in the zone

U_{ow} = area average of ***U-factors*** of ***opaque walls*** (including those of mass construction) in the zone

VS = annual average daily incident solar energy on surface

DR = average daily temperature range for the warmest month

UO = area average of ***U-factor*** of ***opaque walls*** and ***vertical fenestration*** in the zone

SCMC = sum of the CMC from Equation C-11 for each ***mass wall*** in the zone

G = effective internal gain to space, from Equation C-13

EA_C = effective solar aperture fraction for zone calculated using Equation C-15

$$EA_C = \frac{\sum SA_C}{Area_{grosswall}} \quad \text{(C-15)}$$

where ΣSA_c= the sum of SA_c from Equation C.6.6 for all ***vertical fenestration*** in the zone.

The coefficients used in the above equations depend on the ***orientation*** of the surface and shall be found in Table C6.8.2.

C6.8.3 Heating Factor. The heating factor for the surfaces in the zone shall be calculated using Equation C6.16.

$$HEAT = 0.007669 \times [HLU + HLUO + HLXUO + HLM + HLG + HLS + HLC] \quad \text{(C-16)}$$

where

$$HLU = Area_{opaque} \times U_{ow} \times [HU1 \times HDD50 + HU2 \times (VS \times HDD65)^2]$$

$$HLUO = Area_{grosswall} \times UO \times [HUO1 \times HDD50 + HUO2 \times HDD65 + HUO3 \times EA_H \times VS \times HDD65]$$

$$HLXUO = Area_{grosswall} \times \{(1/UO) \times [HXUO1 \times EA_H \times (VS \times HDD50)^2 + HXUO2 \times EA_H \times (VS \times HDD65)^2] + (1/UO^2) \times [HXUO3 \times EA_H^2 \times VS \times HDD65]\}$$

$$HLM = Area_{opaque} \times SHMC \times [HM1 + HM2 \times G \times UO \times HDD65 + HM3 \times G^2 \times EA_H^2 \times VS \times HDD50 + HM4 \times UO \times EA_H \times VS \times HDD65 + HM5 \times UO \times HDD50 + HM6 \times EA_H \times (VS \times HDD65)^2 + HM7 \times EA_H^2 \times VS \times HDD65/UO]$$

$$HLG = Area_{grosswall} \times \{G \times [HG1 \times HDD65 + HG2 \times UO \times HDD65 + HG3 \times EA_H \times VS \times HDD65 + HG4 \times EA_H^2 \times VS \times HDD50] \times G^2 \times [HG5 \times HDD65 + HG6 \times EA_H^2 \times VS \times HDD65]\}$$

$$HLS = Area_{grosswall} \times \{EA_H \times [HS1 \times VS \times HDD65 + HS2 \times (VS \times HDD50)^2] + EA_H^2 \times [HS3 \times VS \times HDD50 + HS4 \times VS \times HDD65]\}$$

$$HLC = Area_{grosswall} \times [HC1 + HC2 \times HDD65 + HC3 \times HDD65^2 + HC4 \times VS^2 + HC5 \times VS \times HDD50 + HC6 \times VS \times HDD65 + HC7 \times (VS \times HDD50)^2]$$

where

VS = annual average daily incident solar energy on surface

SHMC = sum of the HMC from Equation C-12 for each ***mass wall*** in the zone

EA_H = effective solar aperture fraction for zone calculated using Equation C-17.

$$EA_H = \frac{\sum SA_H}{Area_{grosswall}} \quad \text{(C-17)}$$

ΣSA_h = the sum of SA_h from Equation C-7 for all ***vertical fenestration*** in the zone.

TABLE C6.8.2
Cooling Coefficients for the Exterior Wall Equation

Variable	Orientation of Surface North	East	South	West
CU1	0.001539	0.003315	0.003153	0.00321
CU2	-3.0855E-08	-8.9662E-08	-7.1299E-08	-8.1053E-08
CU3	7.99493E-14	3.7928E-14	1.83083E-14	3.3981E-14
CU4	-0.079647	0.163114	0.286458	0.11178
CM1	0.32314	0.515262	0.71477	0.752643
CM2	1.5306E-06	1.38197E-06	1.6163E-06	1.42228E-06
CM3	-2.0432E-06	-1.6024E-06	-2.1106E-06	-1.9794E-06
CM4	-7.5367E-07	-7.6785E-07	-6.6443E-07	-7.4007E-07
CM5	-1.0047E-06	0	8.01057E-06	3.15193E-06
CM6	3.66708E-05	3.56503E-05	4.48106E-05	2.96012E-05
CM7	-6.7305E-05	-6.4094E-05	-0.000119	-7.6672E-05
CM8	-2.3834E-08	-4.7253E-08	-4.9747E-08	0
CUO1	-6.5109E-06	-8.3867E-06	-8.89E-06	-7.5647E-06
CUO2	-1.040207	-1.507235	-1.512625	-1.238545
CUO3	-4.3825E-06	-2.7883E-06	-2.3135E-06	-4.1257E-06
CUO4	0.000012658	8.09874E-06	7.36219E-06	1.06712E-05
CXUO1	1.03744E-06	1.19338E-06	1.18588E-06	1.23251E-06
CXUO2	-1.3218E-13	-1.3466E-13	-1.1625E-13	-1.3E-13
CXUO3	2.75554E-05	2.02621E-05	2.02365E-05	2.36964E-05
CXUO4	9.7409E-08	1.175E-07	9.39207E-08	1.36276E-07
CXUO5	-1.1825E-05	-9.0969E-06	-9.0919E-06	-1.1108E-05
CG1	0.891286	0.583388	0.393756	0.948654
CG2	0.001479	0.001931	0.002081	0.001662
CG3	-5.5204E-13	-2.8214E-13	-2.8477E-13	-4.5572E-13
CG4	2.52311E-06	3.70821E-06	4.30536E-06	5.91511E-06
CG5	-0.001151	-0.001745	-0.001864	-0.00153
CG6	1.95243E-12	0	-2.9606E-12	3.16358E-12
CG7	-8.3581E-12	1.01089E-11	3.30027E-11	0
CG8	1.41022E-06	7.53875E-07	7.133E-07	9.70752E-07
CG9	-2.3889E-06	-1.6496E-06	-1.6393E-06	-1.9736E-06
CS1	46.9871	33.9683	18.32016	29.3089
CS2	3.48091E-05	3.74118E-05	0.000034049	5.02498E-05
CS3	0	0	2.71313E-12	0
CS4	-1.6641E-05	6.94779E-06	-2.8218E-05	-2.7716E-05
CS5	8.42765E-12	0	-3.0468E-12	2.91137E-12
CS6	-56.5446	0	26.9954	14.9771
CS7	-1.3476E-11	-5.881E-12	-6.5009E-12	-7.8922E-12
CC1	0.002747	0	0.010349	0.001865
CC2	0	3.18928E-07	-3.0441E-07	0
CC3	-0.000348	0.000319	0.00024	0.000565
CC4	1.22123E-08	-7.7532E-08	-2.7144E-08	-5.4438E-08
CC5	0.012112	0.011894	0.013248	0.009236
CC6	1.04027E-12	-6.2266E-13	-2.0518E-12	0
CC7	-1.2401E-05	-7.0628E-06	-1.6538E-05	-6.0269E-06
CC8	0	0	8.20869E-13	0
CC9	-3.758E-14	6.06235E-14	1.97598E-14	3.89425E-14
CC10	0.030056	0.023121	0.0265	0.01704
CC11	0	0	-0.271026	-0.244274
CC12	0.002138	0.001103	0.006368	0.007323
CC13	-12.8674	-13.16522	-18.271	-10.1285

The coefficients used in the above equations depend on the ***orientation*** of the surface and shall be found in Table C6.8.3. Terms not defined for Equation C-16 are found under Equation C-14.

C6.9 Skylights in the Exterior Building Envelope. HEAT and COOL shall be calculated for ***skylights*** in ***nonresidential conditioned*** and ***residential conditioned*** zones using Equations C-18 and C-19.

$$HEAT = Area_{sky} \times HDD65 \times 0.66 \times (H_2 \times U_{sky} + H_3 \times 1.163 \times SHGC) \quad (C\text{-}18)$$

$$COOL = Area_{sky} \times C_2 \times CDD50 \times 0.093 \times SHGC \quad (C\text{-}19)$$

where

$Area_{sky}$ = ***fenestration*** area of the ***skylight*** assembly

SHGC = the ***solar heat gain coefficien***t of the ***skylight*** assembly

U_{sky} = ***U-factor*** of ***skylight*** assembly

The coefficients used in the equations depend on the space type and shall be taken from Table C6.9.

TABLE C6.8.3
Heating Coefficients for the Exterior Wall Equation

Variable	Orientation of Surface			
	North	East	South	West
HU1	0.006203	0.007691	0.006044	0.006672
HU2	-1.3587E-12	-5.7162E-13	-2.69E-13	-4.3566E-13
HM1	0.531005	0.545732	0.837901	0.616936
HM2	0.000152	0.000107	0.000208	0.00015
HM3	-5.3183E-07	-1.0619E-07	-6.8253E-07	-2.6457E-07
HM4	-7.7381E-07	-1.4787E-06	2.11938E-06	-4.5783E-07
HM5	-0.000712	-0.000484	-0.001042	-0.000625
HM6	3.34859E-13	4.95762E-14	7.7019E-14	7.37105E-14
HM7	2.39071E-07	2.75045E-07	-3.8989E-07	0
HUO1	0.004943	0.008683	0.009028	0.008566
HUO2	0.013686	0.011055	0.010156	0.01146
HUO3	-1.1018E-05	-8.6896E-06	-7.3232E-06	-8.9867E-06
HXUO1	1.2694E-12	7.85644E-14	-2.8202E-13	3.04904E-14
HXUO2	-7.3058E-13	-8.109E-14	7.45599E-14	-7.4718E-14
HXUO3	1.9709E-07	1.94026E-07	9.87587E-08	1.95776E-07
HG1	-0.001051	-0.000983	-0.000981	-0.000948
HG2	-0.001063	-0.00093	-0.000815	-0.000975
HG3	2.99013E-06	2.62269E-06	2.4188E-06	2.49976E-06
HG4	7.49049E-07	-1.1106E-06	-2.1669E-06	-8.5605E-07
HG5	0.000109	0.000093431	9.75523E-05	8.62389E-05
HG6	-5.5591E-07	-3.158E-07	-2.61E-07	-2.9133E-07
HS1	-2.1825E-05	-2.0922E-05	-2.1089E-05	-2.0205E-05
HS2	3.39179E-12	1.905E-12	1.48388E-12	2.18215E-12
HS3	-6.5325E-06	-2.2341E-05	-1.8473E-05	-2.4049E-05
HS4	2.23087E-05	2.41331E-05	2.45412E-05	2.30538E-05
HC1	-0.106468	-5.19297	-3.66743	-5.29681
HC2	0.00729	0.007684	0.007175	0.007672
HC3	-2.976E-07	-3.0784E-07	-2.6419E-07	-3.0713E-07
HC4	2.01569E-06	6.3035E-06	3.32112E-06	6.43491E-06
HC5	1.29061E-05	4.77552E-06	3.25089E-06	4.83233E-06
HC6	-1.2859E-05	-6.1854E-06	-4.6309E-06	-6.251E-06
HC7	2.75861E-12	8.20051E-13	4.38148E-13	8.09106E-13

TABLE C6.9
Heating and Cooling Coefficients for *Skylights*

Coefficient	Nonresidential	Residential
C_2	1.09E-02	1.64E-02
H_2	2.12E-04	2.91E-04
H_3	-1.68E-04	-2.96E-04

C6.10 Calculations for Other Exterior and Semi-Exterior Surfaces. For all ***exterior*** and ***semi-exterior*** surfaces not covered in C6.8 and C6.9, the cooling factor, COOL, and heating factor, HEAT, shall be calculated using the procedure in this subsection.

C6.10.1 U-Factor for Below-Grade Walls. The effective ***U-factor*** of ***below-grade walls*** shall be calculated using Equation C-20. R_{soil} shall be selected from Table C6.10.1

based on the average depth of the bottom of the wall below the surface of the ground.

$$\text{U-factor} = 1 / \left(1/(\text{C-factor}) + 0.85 + R_{soil}\right) \qquad \text{(C-20)}$$

where

R_{soil} = effective R-value of the soil from Table C6.10.1

C6.10.2 Adjustment for Other Protected Elements of the Exterior Envelope. The adjusted ***U-factor*** for ***exterior envelope*** surfaces, which are protected from outdoor conditions by crawl spaces, attics, or parking garages with natural or mechanical ventilation, shall be adjusted using Equation C-21 before calculating HEAT and COOL.

$$U_{adj} = 1 / \left((1 / \text{U-factor}) + 2\right) \qquad \text{(C-21)}$$

C6.10.3 Calculation of COOL and HEAT. COOL and HEAT shall be calculated for each surface using Equations C-22 and C-23 and coefficients from Table C6.10.3, which depend on surface classification and ***space-conditioning category***.

$$\text{COOL} = \text{Size} \times \text{Factor} \times 0.08 \times (\text{Ccoef1} \times \text{CDD50} + \text{Ccoef2}) \qquad \text{(C-22)}$$

$$\text{HEAT} = \text{Size} \times \text{Hcoef} \times \text{Factor} \times \text{HDD65} \times 0.66 \qquad \text{(C-23)}$$

where

Size = area of surface or length of exposed ***slab-on-grade floor*** perimeter in the building

Ccoef1, Ccoef2 = coefficients, from Table C6.10.3

Hcoef = coefficient, from Table C6.10.3

Factor = ***U-factor*** except U_{adj} calculated using Equation C-21 for protected surfaces and for ***slab-on-grade floors***, perimeter ***F-factor***

TABLE C6.10.1
Effective R-Value of Soil for Below-Grade Walls

Depth	R_{soil} (h ft^2 F/Btu)
1 ft	0.86
2 ft	1.6
3 ft	2.2
4 ft	2.9
5 ft	3.4
6 ft	4.0
7 ft	4.5
8 ft	5.1
9 ft	5.6
10 ft	6.1

TABLE 6.10.3
Heating and Cooling Coefficients for Other Exterior and Semi-Exterior Surfaces

Building Envelope Classification	Exterior						Semi-Exterior		
Space-Conditioning Type	**Nonresidential**			**Residential**			**All**		
Surface Type	**Ccoef1**	**Ccoef2**	**HCoef**	**Ccoef1**	**Ccoef2**	**HCoef**	**Ccoef1**	**Ccoef2**	**HCoef**
Roof	0.001153	5.56	2.28E-04	0.001656	9.44	3.37E-04	0	0	8.08E-05
Wall, Above-Grade and Opaque Doors	6.04E-04	0	2.28E-04	1.18E-03	0	3.37E-04	0	0	7.56E-05
Wall, Below-Grade	2.58E-04	0	2.29E-04	6.80E-04	0	3.35E-04	NA	0	7.85E-05
Mass Floor	6.91E-04	0	2.39E-04	1.01E-03	0	3.60E-04	0	0	7.14E-05
Other Floor	7.09E-04	0	2.43E-04	9.54E-04	0	3.66E-04	0	0	7.14E-05
Slab-on-Grade Floor	0	0	2.28E-04	0	0	3.37E-04	0	0	6.80E-05
Vertical Fenestration	NA	0	NA	NA	0	NA	0	0	7.56E-05
Skylights	NA	0	NA	NA	0	NA	0	0	8.08E-05

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

NORMATIVE APPENDIX D
CLIMATIC DATA

This normative appendix contains the climatic data necessary to determine building envelope and mechanical requirements for various U.S, Canadian, and international locations. (See 5.1.3 for additional information regarding the selection of climatic data.) The following definition applies: N.A. = Not Available. Table numbers corresponding to the envelope criteria tables in Normative Appendix B are also included.

TABLE D-1
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Alabama (AL)												
Alexander City	B-11	32.95	N	85.93	W	640	2,910	5,102	N.A.	N.A.	N.A.	N.A.
Anniston FAA AP	B-11	33.58	N	85.85	W	611	2,854	5,217	19	93	76	N.A.
Auburn Agronomy Farm	B-8	32.60	N	85.50	W	652	2,612	5,428	N.A.	N.A.	N.A.	N.A.
Birmingham FAA AP	B-11	33.57	N	86.75	W	625	2,918	5,206	18	92	75	760
Dothan	B-6	31.32	N	85.45	W	400	1,703	6,659	28	93	76	N.A.
Gadsden Steam Plant	B-11	34.03	N	86.00	W	565	3,317	4,805	N.A.	N.A.	N.A.	N.A.
Huntsville WSO AP	B-11	34.65	N	86.77	W	624	3,323	4,855	15	92	74	N.A.
Mobile WSO AP	B-6	30.68	N	88.25	W	211	1,702	6,761	26	92	76	774
Montgomery WSO AP	B-8	32.30	N	86.40	W	221	2,224	5,990	24	93	76	734
Selma	B-8	32.42	N	87.00	W	147	2,249	6,080	N.A.	N.A.	N.A.	N.A.
Talladega	B-11	33.43	N	86.08	W	555	2,790	5,097	N.A.	N.A.	N.A.	N.A.
Tuscaloosa FAA AP	B-8	33.23	N	87.62	W	169	2,661	5,624	20	94	77	N.A.
Alaska (AK)												
Anchorage WSCMO AP	B-22	61.17	N	150.02	W	114	10,570	688	-14	68	57	521
Barrow WSO AP	B-26	71.30	N	156.78	W	31	20,226	0	-41	52	49	N.A.
Fairbanks WSFO AP	B-24	64.82	N	147.87	W	436	13,940	1,040	-47	77	59	682
Juneau AP	B-20	58.37	N	134.58	W	12	8,897	559	4	69	58	540
Kodiak WSO AP	B-20	57.75	N	152.50	W	111	8,817	451	7	65	56	384
Nome WSO AP	B-24	64.50	N	165.43	W	13	14,129	274	-31	65	55	210
Arizona (AZ)												
Douglas FAA AP	B-11	31.47	N	109.60	W	4,098	2,767	4,786	N.A.	N.A.	N.A.	N.A.
Flagstaff WSO AP	B-18	35.13	N	111.67	W	7,006	7,131	1,661	1	83	55	N.A.
Kingman	B-11	35.20	N	114.02	W	3,539	3,212	5,040	22	97	63	N.A.
Nogales	B-11	31.42	N	110.95	W	3,560	2,928	4,554	N.A.	N.A.	N.A.	N.A.
Phoenix WSFO AP	B-5	33.43	N	112.02	W	1,110	1,350	8,425	34	108	70	746

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude	Longitude	Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Prescott	B-14	34.57 N	112.43 W	5,205	4,995	2,875	15	91	60	725
Tucson WSO AP	B-6	32.13 N	110.93 W	2,584	1,678	6,921	31	102	65	716
Winslow WSO AP	B-13	35.02 N	110.73 W	4,890	4,776	3,681	10	93	60	634
Yuma WSO AP	B-5	32.67 N	114.60 W	206	927	8,897	40	109	72	697
Arkansas (AR)										
Blytheville AFB	B-13	35.97 N	89.95 W	256	3,656	5,133	12	95	77	N.A.
Camden	B-11	33.60 N	92.82 W	116	2,953	5,309	N.A.	N.A.	N.A.	N.A.
Fayetteville	B-13	36.00 N	94.17 W	1,250	4,040	4,452	6	93	75	N.A.
Ft Smith WSO AP	B-11	35.33 N	94.37 W	449	3,478	5,078	13	96	76	547
Hot Springs	B-11	34.52 N	93.05 W	680	3,181	5,243	N.A.	N.A.	N.A.	N.A.
Jonesboro	B-11	35.88 N	90.70 W	390	3,504	5,118	N.A.	N.A.	N.A.	N.A.
Little Rock FAA AP	B-11	34.73 N	92.23 W	257	3,155	5,299	16	95	77	626
Pine Bluff	B-10	34.22 N	92.02 W	215	3,016	5,467	N.A.	N.A.	N.A.	N.A.
Texarkana FAA AP	B-8	33.45 N	94.00 W	361	2,295	6,152	20	95	77	N.A.
California (CA)										
Bakersfield WSO AP	B-8	35.42 N	119.05 W	495	2,182	6,049	32	101	69	848
Blythe FAA Airport	B-5	33.62 N	114.72 W	390	1,144	8,789	N.A.	N.A.	N.A.	N.A.
Burbank Hollywood	B-6	34.20 N	118.37 W	774	1,204	5,849	39	95	69	N.A.
Chico University Farm	B-11	39.70 N	121.82 W	185	2,953	4,454	N.A.	N.A.	N.A.	N.A.
Crescent City	B-15	41.77 N	124.20 W	40	4,397	1,628	N.A.	N.A.	N.A.	N.A.
El Centro	B-5	32.77 N	115.57 W	-30	1,156	8,132	N.A.	N.A.	N.A.	N.A.
Eureka WSO City	B-15	40.80 N	124.17 W	60	4,496	1,529	N.A.	N.A.	N.A.	N.A.
Fairfield/Travis AFB	B-9	38.27 N	121.93 W	62	2,556	4,223	31	94	67	N.A.
Fresno WSO AP	B-9	36.77 N	119.72 W	328	2,556	5,350	30	101	70	785
Laguna Beach	B-9	33.55 N	117.78 W	35	2,157	3,881	N.A.	N.A.	N.A.	N.A.
Livermore	B-11	37.67 N	121.77 W	480	2,909	3,810	N.A.	N.A.	N.A.	N.A.
Lompoc	B-9	34.65 N	120.45 W	95	2,651	3,240	N.A.	N.A.	N.A.	N.A.
Long Beach WSO AP	B-7	33.82 N	118.15 W	34	1,430	5,281	40	88	67	1502
Los Angeles WSO AP	B-7	33.93 N	118.38 W	100	1,458	4,777	43	81	64	1849
Merced/Castle AFB	B-9	37.37 N	120.57 W	187	2,687	4,694	30	97	69	N.A.
Monterey	B-12	36.60 N	121.90 W	385	3,125	2,574	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Napa State Hospital	B-12	38.28	N	122.27	W	60	2,844	3,463	N.A.	N.A.	N.A.	N.A.
Needles FAA Airport	B-5	34.77	N	114.62	W	914	1,309	8,645	N.A.	N.A.	N.A.	N.A.
Oakland/Intl	B-9	37.73	N	122.20	W	7	2,644	3,126	N.A.	N.A.	N.A.	1905
Oceanside Marina	B-9	33.22	N	117.40	W	10	2,010	4,069	N.A.	N.A.	N.A.	N.A.
Ontario/Intl	B-6	34.05	N	117.62	W	961	1,488	5,823	35	98	70	N.A.
Oxnard	B-9	34.20	N	119.18	W	49	1,992	3,980	39	79	64	N.A.
Palm Springs	B-5	33.83	N	116.50	W	425	985	8,555	N.A.	N.A.	N.A.	N.A.
Palmdale	B-11	34.58	N	118.10	W	2,596	2,948	4,863	N.A.	N.A.	N.A.	N.A.
Pasadena	B-6	34.15	N	118.15	W	864	1,453	5,476	N.A.	N.A.	N.A.	N.A.
Petaluma Fire Stn 3	B-12	38.23	N	122.63	W	27	3,050	3,188	N.A.	N.A.	N.A.	N.A.
Pomona Cal Poly	B-7	34.07	N	117.82	W	740	1,713	5,145	N.A.	N.A.	N.A.	N.A.
Redding WSO	B-11	40.50	N	122.30	W	502	2,855	4,964	N.A.	N.A.	N.A.	N.A.
Redlands	B-8	34.05	N	117.18	W	1,318	1,875	5,435	N.A.	N.A.	N.A.	N.A.
Richmond	B-9	37.93	N	122.35	W	55	2,574	3,285	N.A.	N.A.	N.A.	N.A.
Riverside/March AFB	B-9	33.90	N	117.25	W	1,535	1,861	5,295	34	98	68	N.A.
Sacramento FAA AP	B-11	38.52	N	121.50	W	18	2,749	4,474	30	97	68	990
Salinas FAA AP	B-12	36.67	N	121.60	W	69	2,964	2,951	33	78	62	N.A.
San Bernardino/Norton	B-8	34.10	N	117.23	W	1,155	1,821	5,450	34	101	70	N.A.
San Diego WSO AP	B-7	32.73	N	117.17	W	13	1,256	5,223	44	81	67	1911
San Francisco WSO AP	B-12	37.62	N	122.38	W	8	3,016	2,883	37	78	62	1796
San Jose	B-9	37.35	N	121.90	W	67	2,387	3,935	35	89	66	N.A.
San Luis Obispo Poly	B-9	35.30	N	120.67	W	315	2,498	3,492	N.A.	N.A.	N.A.	N.A.
Santa Ana Fire Station	B-6	33.75	N	117.87	W	135	1,238	5,430	N.A.	N.A.	N.A.	N.A.
Santa Barbara FAA AP	B-9	34.43	N	119.83	W	9	2,438	3,449	34	80	64	N.A.
Santa Cruz	B-12	36.98	N	122.02	W	130	2,969	2,913	N.A.	N.A.	N.A.	N.A.
Santa Maria WSO AP	B-12	34.90	N	120.45	W	254	2,984	2,918	32	82	62	2016
Santa Monica Pier	B-9	34.00	N	118.50	W	14	1,819	4,145	N.A.	N.A.	N.A.	N.A.
Santa Paula	B-9	34.32	N	119.15	W	237	2,039	4,114	N.A.	N.A.	N.A.	N.A.
Santa Rosa	B-12	38.45	N	122.70	W	167	2,883	3,432	N.A.	N.A.	N.A.	N.A.
Stockton WSO AP	B-11	37.90	N	121.25	W	22	2,707	4,755	30	97	68	N.A.
Ukiah	B-11	39.15	N	123.20	W	623	2,954	3,868	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Visalia	B-9	36.33	N	119.30	W	325	2,511	5,186	N.A.	N.A.	N.A.	N.A.
Yreka	B-14	41.72	N	122.63	W	2,625	5,386	2,611	N.A.	N.A.	N.A.	N.A.
Colorado (CO)												
Alamosa WSO AP	B-20	37.45	N	105.87	W	7,536	8,749	1,374	-17	82	55	N.A.
Boulder	B-17	40.03	N	105.28	W	5,420	5,554	2,820	N.A.	N.A.	N.A.	N.A.
Colorado Sprgs WSO AP	B-17	38.82	N	104.72	W	6,090	6,415	2,312	-2	87	58	725
Denver WSFO AP	B-17	39.77	N	104.87	W	5,286	6,020	2,732	-3	90	59	739
Durango	B-17	37.28	N	107.88	W	6,600	6,911	1,942	N.A.	N.A.	N.A.	N.A.
Ft Collins	B-17	40.58	N	105.08	W	5,004	6,368	2,411	N.A.	N.A.	N.A.	N.A.
Grand Junction WSO AP	B-16	39.10	N	108.55	W	4,849	5,548	3,632	2	94	60	518
Greeley UNC	B-17	40.42	N	104.70	W	4,715	6,306	2,698	N.A.	N.A.	N.A.	N.A.
La Junta FAA AP	B-13	38.05	N	103.52	W	4,190	5,265	3,795	N.A.	N.A.	N.A.	N.A.
Pueblo WSO AP	B-17	38.28	N	104.52	W	4,640	5,413	3,358	-1	94	62	720
Sterling	B-17	40.62	N	103.22	W	3,938	6,541	2,809	N.A.	N.A.	N.A.	N.A.
Trinidad FAA AP	B-17	37.25	N	104.33	W	5,746	5,483	2,976	-2	90	60	N.A.
Connecticut (CT)												
Bridgeport WSO AP	B-17	41.17	N	73.13	W	10	5,537	2,997	8	84	72	N.A.
Hartford-Brainard Fld	B-17	41.73	N	72.65	W	15	6,155	2,768	2	88	72	598
Norwalk Gas Plant	B-17	41.12	N	73.42	W	37	5,865	2,768	N.A.	N.A.	N.A.	N.A.
Norwich Pub Util Plt	B-17	41.53	N	72.07	W	20	5,869	2,687	N.A.	N.A.	N.A.	N.A.
Delaware (DE)												
Dover	B-13	39.15	N	75.52	W	30	4,337	3,894	14	89	75	N.A.
Wilmington WSO AP	B-14	39.67	N	75.60	W	79	4,937	3,557	10	89	74	617
Florida (FL)												
Belle Glade Exp Stn	B-3	26.67	N	80.63	W	16	451	8,285	N.A.	N.A.	N.A.	N.A.
Daytona Beach WSO AP	B-5	29.18	N	81.05	W	29	909	7,567	34	90	77	641
Ft Lauderdale	B-2	26.07	N	80.15	W	10	171	9,735	46	90	78	N.A.
Ft Myers FAA AP	B-3	26.58	N	81.87	W	15	418	8,924	42	93	77	N.A.
Ft Pierce	B-3	27.47	N	80.35	W	25	490	8,448	N.A.	N.A.	N.A.	N.A.
Gainesville Mun AP	B-6	29.68	N	82.27	W	138	1,267	7,009	30	92	77	N.A.
Jacksonville WSO AP	B-6	30.50	N	81.70	W	26	1,434	6,847	29	93	77	674

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Key West WSO AP	B-2	24.55	N	81.75	W	4	100	10,174	55	89	79	N.A.
Lakeland	B-3	28.02	N	81.92	W	145	588	8,472	N.A.	N.A.	N.A.	N.A.
Miami WSCMO AP	B-2	25.80	N	80.30	W	12	200	9,474	46	90	77	259
Ocala	B-5	29.20	N	82.08	W	75	930	7,696	N.A.	N.A.	N.A.	N.A.
Orlando WSO Mc Coy	B-3	28.43	N	81.33	W	91	686	8,227	37	93	76	571
Panama City/Tyndall	B-6	30.07	N	85.58	W	16	1,216	7,023	33	89	79	N.A.
Pensacola FAA AP	B-6	30.47	N	87.20	W	112	1,617	6,816	28	92	78	N.A.
St Augustine WFOY	B-5	29.90	N	81.32	W	8	1,040	7,261	N.A.	N.A.	N.A.	N.A.
St Petersburg	B-3	27.77	N	82.63	W	8	603	8,537	43	93	79	N.A.
Tallahassee WSO AP	B-6	30.38	N	84.37	W	55	1,705	6,639	25	93	76	747
Tampa WSCMO AP	B-3	27.97	N	82.53	W	19	725	8,239	36	91	77	592
West Palm Beach WSO AP	B-2	26.68	N	80.12	W	18	323	9,049	43	90	78	308
Georgia (GA)												
Albany	B-8	31.53	N	84.13	W	180	2,205	6,020	27	95	76	N.A.
Americus	B-8	32.05	N	84.25	W	490	2,430	5,634	N.A.	N.A.	N.A.	N.A.
Athens WSO AP	B-11	33.95	N	83.32	W	802	2,893	5,079	20	92	75	N.A.
Atlanta WSO AP	B-11	33.65	N	84.43	W	1,010	2,991	5,038	18	91	74	749
Augusta WSO AP	B-8	33.37	N	81.97	W	148	2,565	5,519	21	94	76	774
Brunswick	B-6	31.17	N	81.50	W	13	1,578	6,729	30	91	79	N.A.
Columbus WSO AP	B-8	32.52	N	84.95	W	449	2,261	6,052	23	93	75	N.A.
Dalton	B-11	34.75	N	84.95	W	700	3,552	4,546	N.A.	N.A.	N.A.	N.A.
Dublin	B-8	32.50	N	82.90	W	215	2,476	5,664	N.A.	N.A.	N.A.	N.A.
Gainesville	B-11	34.30	N	83.85	W	1,170	3,500	4,310	N.A.	N.A.	N.A.	N.A.
La Grange	B-9	33.05	N	85.02	W	715	2,667	5,216	N.A.	N.A.	N.A.	N.A.
Macon WSO AP	B-8	32.70	N	83.65	W	354	2,334	5,826	23	94	75	787
Savannah WSO AP	B-8	32.13	N	81.20	W	46	1,847	6,389	26	93	76	N.A.
Valdosta/Moody AFB	B-5	30.97	N	83.20	W	233	1,552	7,216	30	94	77	N.A.
Waycross	B-8	31.25	N	82.32	W	145	2,025	6,172	29	94	76	N.A.
Hawaii (HI)												
Hilo (Hawaii)	B-3	19.72	N	155.07	W	36	0	8,759	61	84	74	153
Honolulu WSFO AP (Oahu)	B-2	21.33	N	157.92	W	7	0	9,949	61	88	73	69
Kaneohe Mauka (Oahu)	B-3	21.42	N	157.82	W	190	0	8,955	67	85	74	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Idaho (ID)												
Boise WSFO AP	B-17	43.57	N	116.22	W	2,838	5,861	2,807	2	94	63	647
Burley FAA AP	B-17	42.53	N	113.77	W	4,157	6,745	2,174	-5	90	62	N.A.
Coeur D'Alene R S	B-17	47.68	N	116.75	W	2,158	6,239	2,216	N.A.	N.A.	N.A.	N.A.
Idaho Falls FAA AP	B-19	43.52	N	112.07	W	4,730	8,063	1,853	-12	89	60	N.A.
Lewiston WSO AP	B-14	46.38	N	117.02	W	1,436	5,270	2,964	6	93	64	748
Moscow-Univ of Idaho	B-18	46.73	N	116.97	W	2,660	6,782	1,789	N.A.	N.A.	N.A.	N.A.
Mountain Home	B-17	43.13	N	115.70	W	3,190	6,176	2,725	0	96	62	N.A.
Pocatello WSO AP	B-17	42.92	N	112.60	W	4,454	7,180	2,142	-7	90	60	546
Twin Falls WSO	B-17	42.55	N	114.35	W	3,960	6,769	1,995	N.A.	N.A.	N.A.	N.A.
Illinois (IL)												
Aurora	B-17	41.75	N	88.35	W	644	6,699	2,880	N.A.	N.A.	N.A.	N.A.
Belleville/Scott AFB	B-13	38.55	N	89.85	W	453	4,878	4,146	3	93	77	N.A.
Carbondale Sewage Plt	B-13	37.73	N	89.17	W	390	4,865	3,934	N.A.	N.A.	N.A.	N.A.
Champaign	B-16	40.03	N	88.28	W	755	5,689	3,697	N.A.	N.A.	N.A.	N.A.
Chicago Midway AP	B-17	41.73	N	87.77	W	620	6,176	3,251	N.A.	N.A.	N.A.	N.A.
Chicago O'Hare WSO AP	B-17	41.98	N	87.90	W	674	6,536	2,941	-6	88	73	613
Chicago University	B-17	41.78	N	87.60	W	594	5,753	3,391	N.A.	N.A.	N.A.	N.A.
Danville	B-17	40.13	N	87.65	W	558	5,610	3,471	-4	90	77	N.A.
Decatur	B-16	39.83	N	89.02	W	620	5,522	3,652	-2	91	75	N.A.
Dixon	B-17	41.83	N	89.52	W	700	6,873	2,965	N.A.	N.A.	N.A.	N.A.
Freeport Waste Wtr Plt	B-17	42.30	N	89.60	W	750	7,169	2,739	N.A.	N.A.	N.A.	N.A.
Galesburg	B-17	40.95	N	90.38	W	771	6,314	3,249	N.A.	N.A.	N.A.	N.A.
Joliet Brandon Rd Dam	B-17	41.50	N	88.10	W	543	6,463	3,025	N.A.	N.A.	N.A.	N.A.
Moline WSO AP	B-17	41.45	N	90.50	W	582	6,474	3,207	-8	90	74	640
Mt Vernon	B-13	38.35	N	88.87	W	490	5,189	3,818	N.A.	N.A.	N.A.	N.A.
Peoria WSO AP	B-17	40.67	N	89.68	W	650	6,148	3,339	-6	89	74	N.A.
Quincy FAA AP	B-17	39.93	N	91.20	W	763	5,763	3,574	-4	91	75	N.A.
Rantoul	B-17	40.32	N	88.17	W	740	6,183	3,288	N.A.	N.A.	N.A.	N.A.
Rockford WSO AP	B-17	42.20	N	89.10	W	724	6,969	2,852	-10	88	73	N.A.
Springfield WSO AP	B-16	39.85	N	89.68	W	594	5,688	3,635	-4	91	75	600
Waukegan	B-17	42.35	N	87.88	W	700	7,136	2,515	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
										Dry-Bulb	Wet-Bulb	
									99.6%	1.0%	1.0%	55<Tdb<69
Indiana (IN)												
Anderson Sewage Plant	B-17	40.10	N	85.72	W	847	5,916	3,091	N.A.	N.A.	N.A.	N.A.
Bloomington Indiana U	B-14	39.17	N	86.52	W	825	5,309	3,585	N.A.	N.A.	N.A.	N.A.
Columbus	B-17	39.20	N	85.92	W	621	5,536	3,353	N.A.	N.A.	N.A.	N.A.
Evansville WSO AP	B-13	38.05	N	87.53	W	380	4,708	4,074	3	92	76	611
Ft Wayne WSO AP	B-17	41.00	N	85.20	W	797	6,273	3,077	-4	88	73	601
Goshen College	B-17	41.57	N	85.83	W	805	6,282	2,941	N.A.	N.A.	N.A.	N.A.
Hobart	B-17	41.53	N	87.25	W	600	6,043	3,168	N.A.	N.A.	N.A.	N.A.
Indianapolis WSFO	B-17	39.73	N	86.27	W	792	5,615	3,453	-3	88	74	N.A.
Kokomo	B-17	40.42	N	86.05	W	855	6,429	2,978	N.A.	N.A.	N.A.	N.A.
Lafayette	B-17	40.35	N	86.87	W	600	6,228	3,069	-5	90	75	N.A.
Marion	B-17	40.57	N	85.67	W	790	6,260	2,996	N.A.	N.A.	N.A.	N.A.
Muncie Ball State Univ	B-17	40.22	N	85.42	W	940	6,027	3,196	N.A.	N.A.	N.A.	N.A.
Peru/Grissom AFB	B-17	40.65	N	86.15	W	814	5,908	3,439	-3	89	75	N.A.
Richmond Wtr Wks	B-17	39.88	N	84.88	W	1,015	5,963	3,004	N.A.	N.A.	N.A.	N.A.
Shelbyville Sewage Plt	B-17	39.52	N	85.78	W	750	5,784	3,291	N.A.	N.A.	N.A.	N.A.
South Bend WSO AP	B-17	41.70	N	86.32	W	773	6,331	2,920	-2	87	72	635
Terre Haute	B-17	39.35	N	87.42	W	555	5,581	3,490	-3	90	76	N.A.
Valparaiso Waterworks	B-17	41.52	N	87.03	W	800	6,267	2,942	N.A.	N.A.	N.A.	N.A.
Iowa (IA)												
Ames	B-17	42.03	N	93.80	W	1,099	6,776	3,079	N.A.	N.A.	N.A.	N.A.
Burlington	B-17	40.78	N	91.12	W	597	5,943	3,601	-4	91	76	649
Cedar Rapids FAA AP	B-17	41.88	N	91.70	W	863	6,924	3,003	-11	89	74	N.A.
Clinton	B-17	41.80	N	90.27	W	585	6,324	3,291	N.A.	N.A.	N.A.	N.A.
Des Moines WSFO AP	B-17	41.53	N	93.65	W	938	6,497	3,371	-9	90	74	667
Dubuque WSO AP	B-19	42.40	N	90.70	W	1,065	7,327	2,672	N.A.	N.A.	N.A.	N.A.
Ft Dodge	B-19	42.50	N	94.20	W	1,115	7,261	2,902	-13	88	73	N.A.
Iowa City	B-17	41.65	N	91.53	W	640	6,227	3,434	N.A.	N.A.	N.A.	N.A.
Keokuk Lock and Dam	B-17	40.40	N	91.37	W	527	5,969	3,467	N.A.	N.A.	N.A.	N.A.
Marshalltown	B-17	42.07	N	92.93	W	870	7,170	2,813	N.A.	N.A.	N.A.	N.A.
Mason City FAA AP	B-19	43.17	N	93.33	W	1,194	7,837	2,653	-15	88	73	610

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature Dry-Bulb	Cooling Design Temperature Wet-Bulb	No. Hrs. 8 a.m.-4 p.m.
									99.6%	1.0%	1.0%	55<Tdb<69
Newton	B-17	41.70	N	93.05	W	938	6,783	3,131	N.A.	N.A.	N.A.	N.A.
Ottumwa Airport	B-17	41.10	N	92.45	W	842	6,269	3,414	-5	92	75	N.A.
Sioux City WSO AP	B-17	42.40	N	96.38	W	1,103	6,893	3,149	-11	90	74	602
Waterloo WSO AP	B-19	42.55	N	92.40	W	868	7,406	2,813	-14	88	73	N.A.
Kansas (KS)												
Atchison	B-13	39.57	N	95.12	W	945	5,184	3,940	N.A.	N.A.	N.A.	N.A.
Chanute FAA Airport	B-13	37.67	N	95.48	W	978	4,650	4,226	N.A.	N.A.	N.A.	N.A.
Dodge City WSO AP	B-13	37.77	N	99.97	W	2,582	5,001	4,090	0	97	70	637
El Dorado	B-13	37.82	N	96.83	W	1,340	4,587	4,317	N.A.	N.A.	N.A.	N.A.
Garden City FAA AP	B-13	37.93	N	100.72	W	2,882	5,216	3,936	-3	97	69	N.A.
Goodland WSO AP	B-17	39.37	N	101.70	W	3,650	5,974	3,018	-3	94	66	625
Great Bend	B-13	38.35	N	98.77	W	1,850	4,679	4,425	N.A.	N.A.	N.A.	N.A.
Hutchinson	B-13	37.93	N	98.03	W	1,570	5,103	4,106	N.A.	N.A.	N.A.	N.A.
Liberal	B-13	37.05	N	100.92	W	2,834	4,706	4,185	N.A.	N.A.	N.A.	N.A.
Manhattan	B-13	39.20	N	96.58	W	1,065	5,043	4,155	N.A.	N.A.	N.A.	N.A.
Parsons	B-13	37.37	N	95.28	W	910	4,606	4,339	N.A.	N.A.	N.A.	N.A.
Russell FAA AP	B-13	38.87	N	98.82	W	1,864	5,338	3,939	-4	96	72	N.A.
Salina FAA AP	B-13	38.80	N	97.63	W	1,257	5,101	4,167	-3	97	73	N.A.
Topeka WSFO AP	B-13	39.07	N	95.63	W	877	5,265	3,880	-2	93	75	608
Wichita WSO AP	B-13	37.65	N	97.43	W	1,321	4,791	4,351	2	97	73	N.A.
Kentucky (KY)												
Ashland	B-14	38.45	N	82.62	W	555	5,225	3,280	N.A.	N.A.	N.A.	N.A.
Bowling Green FAA AP	B-13	36.97	N	86.42	W	547	4,328	4,132	7	91	75	N.A.
Covington WSO AP	B-14	39.07	N	84.67	W	869	5,248	3,488	1	89	73	661
Hopkinsville/Campbell	B-13	36.67	N	87.50	W	571	3,928	4,654	N.A.	N.A.	N.A.	N.A.
Lexington WSO AP	B-13	38.03	N	84.60	W	966	4,783	3,754	4	89	73	618
Louisville WSFO AP	B-13	38.18	N	85.73	W	477	4,514	4,000	6	90	75	636
Madisonville	B-13	37.35	N	87.52	W	440	4,167	4,290	N.A.	N.A.	N.A.	N.A.
Owensboro	B-13	37.77	N	87.15	W	405	4,334	4,222	N.A.	N.A.	N.A.	N.A.
Paducah WSO	B-13	37.07	N	88.77	W	410	4,279	4,317	7	93	76	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Louisiana (LA)												
Alexandria	B-8	31.32	N	92.47	W	87	2,003	6,407	27	94	78	N.A.
Baton Rouge WSO AP	B-6	30.53	N	91.13	W	64	1,669	6,845	27	92	77	677
Bogalusa	B-8	30.78	N	89.87	W	100	1,911	6,457	N.A.	N.A.	N.A.	N.A.
Houma	B-6	29.58	N	90.73	W	15	1,429	6,974	N.A.	N.A.	N.A.	N.A.
Lafayette FAA AP	B-6	30.20	N	91.98	W	38	1,587	6,877	28	93	78	N.A.
Lake Charles WSO AP	B-6	30.12	N	93.22	W	9	1,616	6,813	29	91	78	668
Minden	B-8	32.58	N	93.28	W	185	2,533	5,823	N.A.	N.A.	N.A.	N.A.
Monroe FAA AP	B-8	32.52	N	92.05	W	78	2,407	6,039	22	94	78	N.A.
Natchitoches	B-8	31.77	N	93.08	W	130	2,152	6,273	N.A.	N.A.	N.A.	N.A.
New Orleans WSCMO AP	B-6	29.98	N	90.25	W	4	1,513	6,910	30	92	78	789
Shreveport WSO AP	B-8	32.47	N	93.82	W	254	2,264	6,166	22	95	77	697
Maine (ME)												
Augusta FAA AP	B-19	44.32	N	69.80	W	350	7,550	2,093	-3	84	69	N.A.
Bangor FAA AP	B-19	44.80	N	68.82	W	163	7,930	1,916	-7	84	69	669
Caribou WSO AP	B-22	46.87	N	68.02	W	624	9,651	1,470	-14	82	67	692
Lewiston	B-19	44.10	N	70.22	W	180	7,244	2,261	N.A.	N.A.	N.A.	N.A.
Millinocket	B-20	45.65	N	68.70	W	360	8,902	1,708	N.A.	N.A.	N.A.	N.A.
Portland WSMO AP	B-19	43.65	N	70.32	W	57	7,378	1,943	-3	83	70	665
Waterville Pmp Stn	B-19	44.55	N	69.65	W	90	7,382	2,180	N.A.	N.A.	N.A.	N.A.
Maryland (MD)												
Baltimore WSO AP	B-13	39.18	N	76.67	W	196	4,707	3,709	11	91	74	N.A.
Cumberland	B-14	39.63	N	78.75	W	730	5,036	3,432	N.A.	N.A.	N.A.	N.A.
Hagerstown	B-14	39.65	N	77.73	W	660	5,293	3,341	N.A.	N.A.	N.A.	N.A.
Salisbury	B-13	38.37	N	75.58	W	10	4,027	4,002	13	90	76	N.A.
Massachusetts (MA)												
Boston WSO AP	B-17	42.37	N	71.03	W	20	5,641	2,897	7	87	71	713
Clinton	B-17	42.40	N	71.68	W	398	6,698	2,457	N.A.	N.A.	N.A.	N.A.
Framingham	B-17	42.28	N	71.42	W	170	6,262	2,695	N.A.	N.A.	N.A.	N.A.
Lawrence	B-17	42.70	N	71.17	W	57	6,322	2,648	N.A.	N.A.	N.A.	N.A.
Lowell	B-17	42.65	N	71.37	W	110	6,339	2,715	N.A.	N.A.	N.A.	N.A.
New Bedford	B-17	41.63	N	70.93	W	120	5,426	2,973	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
										Dry-Bulb	Wet-Bulb	
									99.6%	1.0%	1.0%	55<Tdb<69
Springfield	B-17	42.10	N	72.58	W	190	5,754	3,037	N.A.	N.A.	N.A.	N.A.
Taunton	B-17	41.90	N	71.07	W	20	6,346	2,461	N.A.	N.A.	N.A.	N.A.
Worcester WSO AP	B-17	42.27	N	71.87	W	986	6,979	2,203	0	83	69	N.A.
Michigan (MI)												
Adrian	B-17	41.92	N	84.02	W	760	6,737	2,586	N.A.	N.A.	N.A.	N.A.
Alpena WSO AP	B-20	45.07	N	83.57	W	689	8,284	1,779	-7	84	69	695
Battle Creek/Kellogg	B-17	42.30	N	85.23	W	942	6,416	3,399	N.A.	N.A.	N.A.	N.A.
Benton Harbor AP	B-17	42.13	N	86.43	W	649	6,303	2,829	N.A.	N.A.	N.A.	N.A.
Detroit City Airport	B-17	42.42	N	83.02	W	625	6,167	3,046	0	87	72	N.A.
Escanaba	B-20	45.75	N	87.03	W	600	8,593	1,664	N.A.	N.A.	N.A.	N.A.
Flint WSO AP	B-17	42.97	N	83.75	W	766	6,979	2,451	-2	86	71	634
Grand Rapids WSO AP	B-17	42.88	N	85.52	W	707	6,973	2,537	0	86	71	622
Holland	B-17	42.80	N	86.12	W	610	6,747	2,536	N.A.	N.A.	N.A.	N.A.
Jackson FAA AP	B-17	42.27	N	84.45	W	1,005	6,791	2,707	-3	86	73	N.A.
Kalamazoo State Hosp	B-17	42.28	N	85.60	W	945	6,230	3,015	N.A.	N.A.	N.A.	N.A.
Lansing WSO AP	B-17	42.77	N	84.60	W	841	7,101	2,449	-3	86	72	N.A.
Marquette	B-20	46.55	N	87.38	W	665	8,356	1,730	-13	82	67	N.A.
Mt Pleasant University	B-19	43.58	N	84.77	W	796	7,436	2,319	N.A.	N.A.	N.A.	N.A.
Muskegon WSO AP	B-17	43.17	N	86.23	W	628	6,924	2,361	3	83	70	N.A.
Pontiac State Hospital	B-17	42.65	N	83.30	W	982	6,653	2,770	N.A.	N.A.	N.A.	N.A.
Port Huron	B-17	42.98	N	82.42	W	590	6,898	2,541	N.A.	N.A.	N.A.	N.A.
Saginaw FAA AP	B-17	43.53	N	84.08	W	660	7,139	2,476	0	87	72	N.A.
Sault Ste Marie WSO	B-22	46.47	N	84.37	W	724	9,316	1,421	-12	80	68	733
Traverse City FAA AP	B-19	44.73	N	85.58	W	623	7,749	2,127	-3	86	70	679
Ypsilanti East Mich U	B-17	42.25	N	83.62	W	779	6,466	2,878	N.A.	N.A.	N.A.	N.A.
Minnesota (MN)												
Albert Lea	B-19	43.62	N	93.42	W	1,230	8,146	2,608	N.A.	N.A.	N.A.	N.A.
Alexandria FAA AP	B-19	45.87	N	95.38	W	1,416	8,999	2,316	-20	86	70	N.A.
Bemidji Airport	B-22	47.50	N	94.93	W	1,377	10,200	1,781	N.A.	N.A.	N.A.	N.A.
Brainerd	B-21	46.37	N	94.20	W	1,180	9,437	1,958	-24	85	68	N.A.
Duluth WSO AP	B-22	46.83	N	92.18	W	1,428	9,818	1,536	-21	81	67	650

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
										Dry-Bulb	Wet-Bulb	
									99.6%	1.0%	1.0%	55<Tdb<69
Faribault	B-19	44.30	N	93.27	W	940	8,279	2,498	N.A.	N.A.	N.A.	N.A.
International Falls WSO AP	B-22	48.57	N	93.38	W	1,179	10,487	1,630	-29	83	67	656
Mankato	B-19	44.15	N	94.02	W	836	8,005	2,691	N.A.	N.A.	N.A.	N.A.
Minneapolis-St Paul WSO AP	B-19	44.88	N	93.22	W	834	7,981	2,680	-16	88	71	566
Rochester WSO AP	B-19	43.92	N	92.50	W	1,297	8,250	2,376	-17	85	71	652
St Cloud WSO AP	B-19	45.55	N	94.07	W	1,037	8,928	2,149	-20	88	71	N.A.
Virginia	B-22	47.50	N	92.55	W	1,435	10,024	1,583	N.A.	N.A.	N.A.	N.A.
Willmar State Hospital	B-19	45.13	N	95.02	W	1,128	8,637	2,465	N.A.	N.A.	N.A.	N.A.
Winona	B-19	44.05	N	91.63	W	652	7,694	2,695	N.A.	N.A.	N.A.	N.A.
Mississippi (MS)												
Biloxi/Keesler AFB	B-6	30.42	N	88.92	W	26	1,486	6,946	31	91	78	N.A.
Clarksdale	B-11	34.20	N	90.57	W	173	3,188	5,357	N.A.	N.A.	N.A.	N.A.
Columbus AFB	B-10	33.65	N	88.45	W	220	2,769	5,565	20	94	78	N.A.
Greenville	B-10	33.38	N	91.02	W	132	2,778	5,661	N.A.	N.A.	N.A.	N.A.
Greenwood FAA AP	B-8	33.50	N	90.08	W	155	2,698	5,760	20	94	78	N.A.
Hattiesburg	B-8	31.32	N	89.30	W	161	2,180	6,085	N.A.	N.A.	N.A.	N.A.
Jackson WSFO AP	B-8	32.32	N	90.08	W	330	2,467	5,900	21	93	76	640
Laurel	B-8	31.68	N	89.12	W	225	2,327	5,893	N.A.	N.A.	N.A.	N.A.
McComb FAA AP	B-8	31.23	N	90.47	W	413	2,115	6,025	23	92	76	N.A.
Meridian WSO AP	B-8	32.33	N	88.75	W	294	2,444	5,804	21	94	76	719
Natchez	B-8	31.55	N	91.38	W	195	1,903	6,378	N.A.	N.A.	N.A.	N.A.
Tupelo WSO AP	B-11	34.27	N	88.73	W	361	3,079	5,224	18	94	76	N.A.
Vicksburg Military Pk	B-8	32.35	N	90.85	W	255	2,196	6,059	N.A.	N.A.	N.A.	N.A.
Missouri (MO)												
Cape Girardeau FAA AP	B-13	37.23	N	89.57	W	337	4,386	4,359	6	94	77	N.A.
Columbia WSO AP	B-13	38.82	N	92.22	W	887	5,212	3,752	-1	92	75	633
Farmington	B-13	37.70	N	90.38	W	935	5,041	3,653	N.A.	N.A.	N.A.	N.A.
Hannibal	B-16	39.72	N	91.37	W	712	5,628	3,685	N.A.	N.A.	N.A.	N.A.
Jefferson City Wtr Plt	B-13	38.58	N	92.15	W	670	5,302	3,705	N.A.	N.A.	N.A.	N.A.
Joplin FAA AP	B-13	37.17	N	94.50	W	980	4,303	4,417	3	94	75	N.A.
Kansas City WSO AP	B-13	39.32	N	94.72	W	973	5,393	3,852	-1	93	75	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
										Dry-Bulb	Wet-Bulb	
									99.6%	1.0%	1.0%	55<Tdb<69
Kirksville Radio KIRX	B-17	40.22	N	92.58	W	970	5,867	3,494	N.A.	N.A.	N.A.	N.A.
Mexico	B-16	39.18	N	91.88	W	775	5,590	3,664	N.A.	N.A.	N.A.	N.A.
Moberly Radio KWIX	B-13	39.40	N	92.43	W	840	5,204	3,948	N.A.	N.A.	N.A.	N.A.
Poplar Bluff R S	B-13	36.77	N	90.42	W	380	4,328	4,368	8	92	76	N.A.
Rolla	B-13	38.13	N	91.77	W	1,148	4,748	4,186	N.A.	N.A.	N.A.	N.A.
Rolla Univ of MO	B-13	37.95	N	91.77	W	1,180	4,959	3,986	N.A.	N.A.	N.A.	N.A.
St Joseph	B-16	39.77	N	94.92	W	811	5,590	3,783	N.A.	N.A.	N.A.	N.A.
St Louis WSCMO AP	B-13	38.75	N	90.37	W	535	4,758	4,283	2	93	75	N.A.
Montana (MT)												
Billings WSO AP	B-17	45.80	N	108.53	W	3,567	7,164	2,466	-13	90	62	617
Bozeman	B-22	45.82	N	110.88	W	5,950	9,908	672	-20	87	60	N.A.
Butte FAA AP	B-22	45.95	N	112.50	W	5,540	9,517	1,152	-22	84	56	N.A.
Cut Bank FAA AP	B-20	48.60	N	112.37	W	3,838	8,904	1,475	-21	84	59	672
Glasgow WSO AP	B-19	48.22	N	106.62	W	2,284	8,745	2,244	-22	90	63	570
Glendive	B-19	47.10	N	104.72	W	2,076	8,178	2,619	N.A.	N.A.	N.A.	N.A.
Great Falls WSCMO AP	B-19	47.48	N	111.37	W	3,663	7,741	1,993	-19	88	60	641
Havre WSO AP	B-19	48.55	N	109.77	W	2,584	8,447	2,132	-25	90	62	N.A.
Helena WSO AP	B-19	46.60	N	112.00	W	3,893	8,031	1,922	-18	87	59	651
Kalispell WSO AP	B-20	48.30	N	114.27	W	2,965	8,378	1,345	-12	86	61	N.A.
Lewistown FAA AP	B-20	47.07	N	109.45	W	4,132	8,479	1,580	-18	86	60	673
Livingston FAA AP	B-19	45.70	N	110.45	W	4,653	7,220	1,900	N.A.	N.A.	N.A.	N.A.
Miles City FAA AP	B-19	46.43	N	105.87	W	2,628	7,796	2,680	-19	93	65	565
Missoula WSO AP	B-20	46.92	N	114.08	W	3,190	7,792	1,679	-9	88	61	658
Nebraska (NE)												
Chadron FAA AP	B-17	42.83	N	03.08	W	3,312	7,020	2,692	N.A.	N.A.	N.A.	N.A.
Columbus	B-17	41.47	N	97.33	W	1,450	6,543	3,345	N.A.	N.A.	N.A.	N.A.
Fremont	B-17	41.43	N	96.48	W	1,180	6,140	3,421	N.A.	N.A.	N.A.	N.A.
Grand Island WSO AP	B-17	40.97	N	98.32	W	1,841	6,421	3,243	-8	93	72	611
Hastings	B-17	40.58	N	98.35	W	1,925	6,506	3,217	N.A.	N.A.	N.A.	N.A.
Kearney	B-17	40.73	N	99.02	W	2,130	6,548	3,090	N.A.	N.A.	N.A.	N.A.
Lincoln WSO AP	B-17	40.85	N	96.75	W	1,190	6,278	3,455	-7	94	74	N.A.
Mc Cook	B-17	40.22	N	100.58	W	2,580	6,115	3,236	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
										Dry-Bulb	Wet-Bulb	
									99.6%	1.0%	1.0%	55<Tdb<69
Norfolk WSO AP	B-17	41.98	N	97.43	W	1,551	6,873	3,072	-11	92	72	N.A.
North Platte WSO AP	B-17	41.13	N	100.68	W	2,775	6,859	2,737	-10	92	69	592
Omaha (Eppley Field)	B-17	41.30	N	95.90	W	980	6,300	3,398	-7	92	75	N.A.
Scottsbluff WSO AP	B-17	41.87	N	103.60	W	3,945	6,729	2,680	-11	92	64	620
Sidney	B-17	41.23	N	103.00	W	4,320	6,966	2,409	-8	92	63	N.A.
Nevada (NV)												
Carson City	B-17	39.15	N	119.77	W	4,651	5,691	2,312	N.A.	N.A.	N.A.	N.A.
Elko FAA AP	B-17	40.83	N	115.78	W	5,075	7,077	2,144	-5	92	59	569
Ely WSO AP	B-20	39.28	N	114.85	W	6,262	7,621	1,717	-6	87	56	683
Las Vegas WSO AP	B-8	36.08	N	115.17	W	2,162	2,407	6,745	27	106	66	719
Lovelock FAA AP	B-17	40.07	N	118.55	W	3,900	5,869	2,886	N.A.	N.A.	N.A.	606
Reno WSFO AP	B-17	39.50	N	119.78	W	4,404	5,674	2,504	8	92	60	752
Tonopah AP	B-17	38.07	N	117.08	W	5,426	5,733	2,840	7	92	57	660
Winnemucca WSO AP	B-17	40.90	N	117.80	W	4,297	6,315	2,379	1	94	60	608
New Hampshire (NH)												
Berlin	B-20	44.45	N	71.18	W	930	8,645	1,718	N.A.	N.A.	N.A.	N.A.
Concord WSO AP	B-19	43.20	N	71.50	W	346	7,554	2,087	-8	87	70	683
Keene	B-17	42.92	N	72.27	W	480	6,948	2,398	N.A.	N.A.	N.A.	N.A.
Portsmouth/Pease AFB	B-17	43.08	N	70.82	W	102	6,572	2,418	4	85	70	N.A.
New Jersey (NJ)												
Atlantic City WSO AP	B-14	39.45	N	74.57	W	138	5,169	3,198	8	88	73	N.A.
Long Branch Oakhurst	B-14	40.27	N	74.00	W	30	5,253	3,057	N.A.	N.A.	N.A.	N.A.
Newark WSO AP	B-13	40.70	N	74.17	W	30	4,888	3,748	10	90	73	644
New Mexico (NM)												
Alamogordo/Holloman	B-11	32.85	N	106.10	W	4,094	3,232	4,726	20	96	63	N.A.
Albuquerque WSFO AP	B-13	35.05	N	106.62	W	5,326	4,425	3,908	13	93	60	703
Artesia	B-11	32.77	N	104.38	W	3,320	3,527	4,583	N.A.	N.A.	N.A.	N.A.
Carlsbad FAA AP	B-10	32.33	N	104.27	W	3,232	2,812	5,512	19	98	66	N.A.
Clovis/Cannon AFB	B-13	34.38	N	103.32	W	4,295	3,983	4,178	10	93	64	N.A.
Farmington	B-17	36.73	N	108.23	W	5,502	5,464	3,307	8	92	60	N.A.
Gallup FAA AP	B-17	35.52	N	108.78	W	6,468	6,244	2,355	-1	87	56	N.A.
Grants Airport	B-17	35.17	N	107.90	W	6,520	5,907	2,481	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude	Longitude	Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	 Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Hobbs	B-11	32.70 N	103.13 W	3,615	2,851	5,160	N.A.	N.A.	N.A.	N.A.
Raton Filter Plant	B-17	36.92 N	104.43 W	6,932	6,103	2,187	N.A.	N.A.	N.A.	N.A.
Roswell FAA AP	B-11	33.30 N	104.53 W	3,669	3,267	4,962	14	96	65	677
Socorro	B-13	34.08 N	106.88 W	4,585	4,074	3,845	N.A.	N.A.	N.A.	N.A.
Tucumcari	B-13	35.20 N	103.68 W	4,086	3,912	4,196	9	95	65	710
New York (NY)										
Albany WSFO AP	B-17	42.75 N	73.80 W	275	6,894	2,525	-7	86	70	605
Auburn	B-17	42.92 N	76.53 W	770	6,782	2,531	N.A.	N.A.	N.A.	N.A.
Batavia	B-17	42.98 N	78.18 W	890	6,657	2,536	N.A.	N.A.	N.A.	N.A.
Binghamton WSO AP	B-19	42.22 N	75.98 W	1,600	7,273	2,193	-2	82	69	662
Buffalo WSCMO AP	B-17	42.93 N	78.73 W	705	6,747	2,468	2	84	69	697
Cortland	B-17	42.60 N	76.18 W	1,129	7,168	2,225	N.A.	N.A.	N.A.	N.A.
Elmira/Chemung Co	B-17	42.17 N	76.90 W	951	6,845	2,420	-2	87	71	N.A.
Geneva Research Farm	B-17	42.88 N	77.03 W	718	6,939	2,364	N.A.	N.A.	N.A.	N.A.
Glens Falls FAA AP	B-19	43.35 N	73.62 W	321	7,635	2,182	-10	85	71	N.A.
Gloversville	B-19	43.05 N	74.35 W	812	7,664	2,118	N.A.	N.A.	N.A.	N.A.
Ithaca Cornell Univ	B-19	42.45 N	76.45 W	960	7,207	2,117	N.A.	N.A.	N.A.	N.A.
Lockport	B-17	43.18 N	78.65 W	520	6,703	2,482	N.A.	N.A.	N.A.	N.A.
Massena FAA AP	B-19	44.93 N	74.85 W	214	8,255	2,046	-15	84	71	627
N Y Central Pk WSO City	B-13	40.78 N	73.97 W	132	4,805	3,634	N.A.	N.A.	N.A.	N.A.
N Y Kennedy WSO AP	B-14	40.65 N	73.78 W	16	5,027	3,342	11	88	72	N.A.
N Y La Guardia WSO AP	B-14	40.77 N	73.90 W	11	4,910	3,547	13	89	73	790
Oswego East	B-17	43.47 N	76.50 W	350	6,733	2,431	N.A.	N.A.	N.A.	N.A.
Plattsburgh AFB	B-19	44.65 N	73.47 W	165	7,837	2,175	-9	83	69	N.A.
Poughkeepsie FAA AP	B-17	41.63 N	73.88 W	155	6,391	2,663	2	88	72	N.A.
Rochester WSO AP	B-17	43.12 N	77.67 W	547	6,734	2,406	1	86	71	608
Rome/Griffiss AFB	B-19	43.23 N	75.40 W	505	7,244	2,344	-5	86	70	N.A.
Schenectady	B-17	42.83 N	73.92 W	220	6,881	2,500	N.A.	N.A.	N.A.	N.A.
Syracuse WSO AP	B-17	43.12 N	76.12 W	421	6,834	2,399	-3	85	71	730
Utica	B-17	43.10 N	75.28 W	500	7,066	2,354	N.A.	N.A.	N.A.	N.A.
Watertown	B-19	43.97 N	75.87 W	497	7,540	2,294	-12	83	70	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
									99.6%	Dry-Bulb 1.0%	Wet-Bulb 1.0%	55<Tdb<69
North Carolina (NC)												
Asheville WSO AP	B-14	35.43	N	82.55	W	2,140	4,308	3,365	11	85	71	915
Charlotte WSO AP	B-11	35.22	N	80.93	W	700	3,341	4,704	18	91	74	777
Durham	B-13	36.03	N	78.97	W	406	3,867	4,159	N.A.	N.A.	N.A.	N.A.
Elizabeth City FAA AP	B-11	36.27	N	76.18	W	10	3,139	4,765	N.A.	N.A.	N.A.	N.A.
Fayetteville/Pope AFB	B-11	35.17	N	79.02	W	217	2,917	5,308	22	94	76	N.A.
Goldsboro	B-11	35.33	N	77.97	W	109	3,040	5,018	22	94	76	N.A.
Greensboro WSO AP	B-13	36.08	N	79.95	W	886	3,865	4,144	15	90	74	718
Greenville	B-11	35.62	N	77.38	W	30	3,129	4,824	N.A.	N.A.	N.A.	N.A.
Henderson	B-13	36.37	N	78.42	W	480	4,038	4,002	N.A.	N.A.	N.A.	N.A.
Hickory FAA AP	B-13	35.73	N	81.38	W	1,143	3,728	4,199	18	91	72	N.A.
Jacksonville/New River	B-8	34.70	N	77.43	W	26	2,456	5,678	23	92	78	N.A.
Lumberton	B-11	34.70	N	79.07	W	130	3,212	4,723	N.A.	N.A.	N.A.	N.A.
New Bern FAA AP	B-11	35.07	N	77.05	W	18	2,742	5,262	22	92	78	N.A.
Raleigh-Durham WSFO AP	B-11	35.87	N	78.78	W	376	3,457	4,499	16	90	75	740
Rocky Mount	B-11	35.90	N	77.72	W	110	3,321	4,586	N.A.	N.A.	N.A.	N.A.
Wilmington WSO AP	B-8	34.27	N	77.90	W	72	2,470	5,557	23	91	78	N.A.
North Dakota (ND)												
Bismarck WSFO AP	B-19	46.77	N	100.77	W	1,647	8,968	2,144	-21	90	67	556
Devils Lake KDLR	B-21	48.12	N	98.87	W	1,464	9,950	1,973	-23	87	67	N.A.
Dickinson FAA AP	B-19	46.78	N	102.80	W	2,581	8,657	2,152	N.A.	N.A.	N.A.	N.A.
Fargo WSO AP	B-21	46.90	N	96.80	W	900	9,254	2,289	-22	88	70	546
Grand Forks FAA AP	B-21	47.95	N	97.17	W	847	9,733	2,084	-20	88	69	N.A.
Jamestown FAA AP	B-21	46.92	N	98.68	W	1,492	9,168	2,262	N.A.	N.A.	N.A.	N.A.
Minot FAA AP	B-21	48.27	N	101.28	W	1,715	9,193	2,135	-20	88	66	581
Ohio (OH)												
Akron-Canton WSO AP	B-17	40.92	N	81.43	W	1,208	6,160	2,779	0	85	71	680
Ashtabula	B-17	41.85	N	80.80	W	690	6,429	2,604	N.A.	N.A.	N.A.	N.A.
Bowling Green	B-17	41.38	N	83.62	W	675	6,482	2,876	N.A.	N.A.	N.A.	N.A.
Cambridge	B-17	40.02	N	81.58	W	800	5,488	3,118	N.A.	N.A.	N.A.	N.A.
Cincinnati-Abbe WSO	B-13	39.15	N	84.52	W	760	4,988	3,733	5	90	75	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
									99.6%	Dry-Bulb 1.0%	Wet-Bulb 1.0%	55<Tdb<69
Cleveland WSFO AP	B-17	41.42	N	81.87	W	770	6,201	2,755	1	86	72	N.A.
Columbus WSO AP	B-17	40.00	N	82.88	W	812	5,708	3,119	1	88	73	708
Dayton WSCMO AP	B-17	39.90	N	84.20	W	995	5,708	3,249	-1	88	73	611
Defiance	B-17	41.28	N	84.38	W	700	6,628	2,810	N.A.	N.A.	N.A.	N.A.
Findlay FAA AP	B-17	41.02	N	83.67	W	797	6,302	2,907	-2	87	72	N.A.
Fremont	B-17	41.33	N	83.12	W	600	6,439	2,823	N.A.	N.A.	N.A.	N.A.
Lancaster	B-17	39.73	N	82.63	W	860	5,988	2,935	N.A.	N.A.	N.A.	N.A.
Lima Sewage Plant	B-17	40.72	N	84.13	W	850	6,253	3,050	N.A.	N.A.	N.A.	N.A.
Mansfield WSO AP	B-17	40.82	N	82.52	W	1,295	6,258	2,818	-1	85	72	N.A.
Marion	B-17	40.62	N	83.13	W	965	6,407	2,836	N.A.	N.A.	N.A.	N.A.
Newark Water Works	B-17	40.08	N	82.42	W	835	5,657	3,107	N.A.	N.A.	N.A.	N.A.
Norwalk	B-17	41.27	N	82.62	W	670	6,434	2,715	N.A.	N.A.	N.A.	N.A.
Portsmouth	B-14	38.75	N	82.88	W	540	4,913	3,581	N.A.	N.A.	N.A.	N.A.
Sandusky	B-17	41.45	N	82.72	W	584	6,131	2,986	N.A.	N.A.	N.A.	N.A.
Springfield New Wtr Wk	B-17	39.97	N	83.82	W	930	6,254	2,790	N.A.	N.A.	N.A.	N.A.
Steubenville	B-17	40.38	N	80.63	W	992	5,700	3,054	N.A.	N.A.	N.A.	N.A.
Toledo Express WSO AP	B-17	41.58	N	83.80	W	669	6,579	2,720	-2	87	72	652
Warren	B-17	41.20	N	80.82	W	900	6,402	2,546	N.A.	N.A.	N.A.	N.A.
Wooster Exp Station	B-17	40.78	N	81.92	W	1,020	6,379	2,570	N.A.	N.A.	N.A.	N.A.
Youngstown WSO AP	B-17	41.25	N	80.67	W	1,178	6,544	2,536	-1	85	70	679
Zanesville FAA AP	B-17	39.95	N	81.90	W	881	5,714	3,013	2	88	73	N.A.
Oklahoma (OK)												
Ada	B-11	34.78	N	96.68	W	1,015	3,182	5,317	N.A.	N.A.	N.A.	N.A.
Altus AFB	B-10	34.65	N	99.27	W	1,378	3,151	5,708	13	100	73	N.A.
Ardmore	B-10	34.20	N	97.15	W	860	2,702	5,978	N.A.	N.A.	N.A.	N.A.
Bartlesville	B-13	36.75	N	96.00	W	715	3,777	4,976	N.A.	N.A.	N.A.	N.A.
Chickasha Exp Station	B-11	35.05	N	97.92	W	1,085	3,366	5,298	N.A.	N.A.	N.A.	N.A.
Enid	B-13	36.42	N	97.87	W	1,245	3,788	5,119	5	98	74	N.A.
Lawton	B-11	34.62	N	98.45	W	1,150	3,457	5,268	12	97	73	N.A.
McAlester FAA AP	B-11	34.88	N	95.78	W	760	3,354	5,233	10	96	76	N.A.
Muskogee	B-11	35.77	N	95.33	W	583	3,413	5,185	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	 Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Norman	B-11	35.18	N	97.45	W	1,109	3,295	5,272	N.A.	N.A.	N.A.	N.A.
Oklahoma City WSFO AP	B-13	35.40	N	97.60	W	1,280	3,659	4,972	9	96	74	733
Ponca City FAA AP	B-13	36.73	N	97.10	W	999	4,226	4,791	N.A.	N.A.	N.A.	N.A.
Seminole	B-10	35.23	N	96.67	W	865	3,097	5,552	N.A.	N.A.	N.A.	N.A.
Stillwater	B-13	36.12	N	97.10	W	895	4,028	4,718	N.A.	N.A.	N.A.	N.A.
Tulsa WSO AP	B-13	36.18	N	95.90	W	668	3,691	5,150	9	97	76	591
Woodward	B-13	36.45	N	99.38	W	1,900	3,900	4,884	N.A.	N.A.	N.A.	N.A.
Oregon (OR)												
Astoria WSO AP	B-15	46.15	N	123.88	W	8	5,158	1,437	25	72	62	1236
Baker FAA AP	B-18	44.83	N	117.82	W	3,368	7,155	1,741	N.A.	N.A.	N.A.	N.A.
Bend	B-18	44.07	N	121.28	W	3,660	6,926	1,405	N.A.	N.A.	N.A.	N.A.
Corvallis State Univ	B-14	44.63	N	123.20	W	225	4,923	2,051	N.A.	N.A.	N.A.	N.A.
Eugene WSO AP	B-14	44.12	N	123.22	W	364	4,546	2,354	21	87	65	N.A.
Grants Pass	B-14	42.42	N	123.33	W	960	4,219	2,986	N.A.	N.A.	N.A.	N.A.
Klamath Falls	B-17	42.20	N	121.78	W	4,098	6,634	1,954	4	87	62	N.A.
Medford WSO AP	B-14	42.38	N	122.88	W	1,300	4,611	2,989	21	95	66	749
Pendleton WSO AP	B-14	45.68	N	118.85	W	1,492	5,294	2,787	3	93	63	N.A.
Portland WSFO AP	B-14	45.60	N	122.60	W	21	4,522	2,517	22	86	66	1060
Roseburg KQEN	B-14	43.20	N	123.35	W	465	4,312	2,607	N.A.	N.A.	N.A.	N.A.
Salem WSO AP	B-14	44.92	N	123.02	W	195	4,927	2,100	20	87	66	916
Pennsylvania (PA)												
Allentown WSO AP	B-17	40.65	N	75.43	W	388	5,785	3,028	5	88	72	710
Altoona FAA AP	B-17	40.30	N	78.32	W	1,476	6,140	2,719	5	86	70	N.A.
Chambersburg	B-17	39.93	N	77.63	W	640	5,574	3,060	N.A.	N.A.	N.A.	N.A.
Erie WSO AP	B-17	42.08	N	80.18	W	732	6,279	2,652	2	83	70	716
Harrisburg FAA AP	B-14	40.22	N	76.85	W	338	5,347	3,358	9	89	73	648
Johnstown	B-17	40.33	N	78.92	W	1,214	5,649	3,028	N.A.	N.A.	N.A.	N.A.
Lancaster	B-17	40.05	N	76.28	W	270	5,584	3,079	N.A.	N.A.	N.A.	N.A.
Meadville	B-17	41.63	N	80.17	W	1,065	6,934	2,209	N.A.	N.A.	N.A.	N.A.
New Castle	B-17	41.02	N	80.37	W	825	6,542	2,502	N.A.	N.A.	N.A.	N.A.
Philadelphia WSCMO AP	B-13	39.88	N	75.23	W	10	4,954	3,623	11	89	74	646

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Pittsburgh WSCMO2 AP	B-17	40.50	N	80.22	W	1,150	5,968	2,836	2	86	70	700
Reading	B-17	40.37	N	75.93	W	270	5,796	3,021	N.A.	N.A.	N.A.	N.A.
State College	B-17	40.80	N	77.87	W	1,170	6,364	2,629	N.A.	N.A.	N.A.	N.A.
Uniontown	B-17	39.92	N	79.72	W	956	5,684	2,913	N.A.	N.A.	N.A.	N.A.
Warren	B-17	41.85	N	79.15	W	1,210	6,890	2,334	N.A.	N.A.	N.A.	N.A.
West Chester	B-14	39.97	N	75.63	W	450	5,283	3,288	N.A.	N.A.	N.A.	N.A.
Williamsport WSO AP	B-17	41.25	N	76.92	W	524	6,087	2,796	2	87	71	N.A.
York Pump Station 22	B-14	39.92	N	76.75	W	390	5,256	3,274	N.A.	N.A.	N.A.	N.A.
Rhode Island (RI)												
Newport	B-17	41.52	N	71.32	W	20	5,659	2,548	N.A.	N.A.	N.A.	N.A.
Providence WSO AP	B-17	41.73	N	71.43	W	51	5,884	2,743	5	86	71	684
South Carolina (SC)												
Anderson	B-11	34.53	N	82.67	W	800	2,965	4,900	N.A.	N.A.	N.A.	N.A.
Charleston WSO AP	B-8	32.90	N	80.03	W	41	2,013	6,188	N.A.	N.A.	N.A.	N.A.
Charleston WSO City	B-8	32.78	N	79.93	W	10	1,866	6,303	25	92	77	N.A.
Columbia WSFO AP	B-8	33.95	N	81.12	W	213	2,649	5,508	21	94	75	705
Florence FAA AP	B-8	34.18	N	79.72	W	146	2,585	5,597	23	94	76	N.A.
Georgetown	B-8	33.35	N	79.25	W	10	2,081	5,947	N.A.	N.A.	N.A.	N.A.
Greenville-Spartanburg WSO AP	B-11	34.90	N	82.22	W	973	3,272	4,625	19	91	74	851
Greenwood	B-11	34.17	N	82.20	W	615	3,288	4,673	N.A.	N.A.	N.A.	N.A.
Orangeburg	B-8	33.50	N	80.87	W	160	2,534	5,477	N.A.	N.A.	N.A.	N.A.
Spartanburg	B-11	34.98	N	81.88	W	840	2,887	5,046	N.A.	N.A.	N.A.	N.A.
Sumter/Shaw AFB	B-8	33.97	N	80.48	W	240	2,506	5,453	24	93	75	N.A.
South Dakota (SD)												
Aberdeen WSO AP	B-19	45.45	N	98.43	W	1,296	8,446	2,497	N.A.	N.A.	N.A.	N.A.
Brookings	B-19	44.32	N	96.77	W	1,642	8,653	2,228	N.A.	N.A.	N.A.	N.A.
Huron WSO AP	B-19	44.38	N	98.22	W	1,282	7,923	2,709	-17	91	71	545
Mitchell	B-19	43.72	N	98.00	W	1,274	7,558	2,925	N.A.	N.A.	N.A.	N.A.
Pierre FAA AP	B-19	44.38	N	100.28	W	1,726	7,411	2,938	-14	95	69	557
Rapid City WSO AP	B-19	44.05	N	103.07	W	3,162	7,301	2,412	-11	91	65	572
Sioux Falls WSFO AP	B-19	43.57	N	96.73	W	1,418	7,809	2,735	-16	90	72	599

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Watertown FAA AP	B-19	44.92	N	97.15	W	1,746	8,375	2,499	N.A.	N.A.	N.A.	N.A.
Yankton	B-19	42.88	N	97.35	W	1,180	7,304	2,935	N.A.	N.A.	N.A.	N.A.
Tennessee (TN)												
Athens	B-13	35.43	N	84.58	W	940	4,054	4,040	N.A.	N.A.	N.A.	N.A.
Bristol WSO AP	B-13	36.48	N	82.40	W	1,525	4,406	3,621	9	87	72	N.A.
Chattanooga WSO AP	B-11	35.03	N	85.20	W	692	3,587	4,609	15	92	75	684
Clarksville Sew Plt	B-13	36.55	N	87.37	W	382	4,159	4,241	N.A.	N.A.	N.A.	N.A.
Columbia	B-13	35.63	N	87.08	W	650	4,206	4,047	N.A.	N.A.	N.A.	N.A.
Dyersburg FAA AP	B-11	36.02	N	89.40	W	337	3,536	5,010	N.A.	N.A.	N.A.	N.A.
Greeneville Exp Stn	B-13	36.10	N	82.85	W	1,320	4,392	3,710	N.A.	N.A.	N.A.	N.A.
Jackson FAA AP	B-11	35.60	N	88.92	W	433	3,540	4,915	12	93	76	N.A.
Knoxville WSO AP	B-13	35.80	N	84.00	W	949	3,937	4,164	13	90	74	703
Memphis FAA-AP	B-10	35.05	N	90.00	W	265	3,082	5,467	16	94	77	851
Murfreesboro	B-13	35.92	N	86.37	W	550	3,992	4,270	N.A.	N.A.	N.A.	N.A.
Nashville WSO AP	B-13	36.12	N	86.68	W	580	3,729	4,689	10	92	75	749
Tullahoma	B-13	35.35	N	86.20	W	1,048	3,630	4,422	N.A.	N.A.	N.A.	N.A.
Texas (TX)												
Abilene WSO AP	B-8	32.42	N	99.68	W	1,784	2,584	6,050	16	97	71	648
Alice	B-5	27.73	N	98.07	W	201	1,062	8,121	N.A.	N.A.	N.A.	N.A.
Amarillo WSO AP	B-13	35.23	N	101.70	W	3,590	4,258	4,128	6	94	66	680
Austin WSO AP	B-6	30.30	N	97.70	W	597	1,688	7,171	25	96	74	664
Bay City Waterworks	B-5	28.98	N	95.98	W	52	1,370	7,211	N.A.	N.A.	N.A.	N.A.
Beaumont Research Ctr	B-6	30.07	N	94.28	W	27	1,677	6,703	29	92	79	N.A.
Beeville	B-5	28.45	N	97.70	W	255	1,372	7,393	28	98	77	N.A.
Big Spring	B-10	32.25	N	101.45	W	2,500	2,772	5,621	N.A.	N.A.	N.A.	N.A.
Brownsville WSO AP	B-3	25.90	N	97.43	W	19	635	8,777	36	94	77	422
Brownwood	B-8	31.72	N	99.00	W	1,385	2,199	6,479	N.A.	N.A.	N.A.	N.A.
Corpus Christi WSO AP	B-5	27.77	N	97.50	W	44	1,016	8,023	32	94	78	543
Corsicana	B-8	32.08	N	96.47	W	425	2,396	6,133	N.A.	N.A.	N.A.	N.A.
Dallas FAA AP	B-8	32.85	N	96.85	W	440	2,259	6,587	17	98	74	N.A.
Del Rio/Laughlin AFB	B-5	29.37	N	100.78	W	1,079	1,565	7,207	28	98	73	732

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Denton	B-8	33.20	N	97.10	W	630	2,665	5,816	N.A.	N.A.	N.A.	N.A.
Eagle Pass	B-5	28.70	N	100.48	W	805	1,441	7,682	N.A.	N.A.	N.A.	N.A.
El Paso WSO AP	B-10	31.80	N	106.40	W	3,918	2,708	5,488	21	98	64	735
Ft Worth/Meacham	B-8	32.82	N	97.35	W	692	2,304	6,557	19	98	74	N.A.
Galveston WSO City	B-5	29.30	N	94.80	W	7	1,263	7,378	N.A.	N.A.	N.A.	N.A.
Greenville	B-10	33.20	N	96.22	W	610	2,953	5,527	N.A.	N.A.	N.A.	N.A.
Harlingen	B-3	26.20	N	97.67	W	38	813	8,405	N.A.	N.A.	N.A.	N.A.
Houston/Hobby	B-5	29.65	N	95.28	W	50	1,371	7,357	29	93	77	N.A.
Houston/Bush Int. Airport	B-6	29.97	N	95.35	W	96	1,599	6,876	27	94	77	N.A.
Huntsville	B-8	30.72	N	95.55	W	494	1,862	6,697	N.A.	N.A.	N.A.	N.A.
Killeen/Robert-Gray	B-8	31.07	N	97.83	W	1,014	2,127	6,477	20	96	73	N.A.
Lamesa	B-11	32.70	N	101.93	W	2,965	3,159	5,107	N.A.	N.A.	N.A.	N.A.
Laredo	B-5	27.57	N	99.50	W	430	1,025	8,495	32	101	74	598
Longview	B-8	32.47	N	94.73	W	330	2,433	5,920	N.A.	N.A.	N.A.	N.A.
Lubbock WSFO AP	B-11	33.65	N	101.82	W	3,254	3,431	4,833	11	95	67	743
Lufkin FAA AP	B-8	31.23	N	94.75	W	281	1,951	6,527	23	95	77	681
McAllen	B-3	26.20	N	98.22	W	122	778	8,597	34	98	76	N.A.
Midland/Odessa WSO AP	B-10	31.95	N	102.18	W	2,857	2,751	5,588	17	97	67	729
Mineral Wells FAA AP	B-8	32.78	N	98.07	W	934	2,625	6,015	N.A.	N.A.	N.A.	N.A.
Palestine	B-8	31.78	N	95.60	W	465	2,005	6,454	N.A.	N.A.	N.A.	N.A.
Pampa No 2	B-13	35.53	N	100.98	W	3,250	4,358	4,131	N.A.	N.A.	N.A.	N.A.
Pecos	B-8	31.42	N	103.50	W	2,610	2,505	5,992	N.A.	N.A.	N.A.	N.A.
Plainview	B-13	34.18	N	101.70	W	3,370	3,717	4,462	N.A.	N.A.	N.A.	N.A.
Port Arthur WSO AP	B-6	29.95	N	94.02	W	16	1,499	6,994	N.A.	N.A.	N.A.	697
San Angelo WSO AP	B-8	31.37	N	100.50	W	1,903	2,414	6,070	20	97	70	619
San Antonio WSFO	B-6	29.53	N	98.47	W	794	1,644	7,142	26	96	73	N.A.
Sherman	B-10	33.63	N	96.62	W	720	2,890	5,682	N.A.	N.A.	N.A.	721
Snyder	B-11	32.72	N	100.92	W	2,335	3,185	5,178	N.A.	N.A.	N.A.	N.A.
Temple	B-8	31.08	N	97.37	W	700	2,153	6,487	N.A.	N.A.	N.A.	N.A.
Tyler	B-8	32.35	N	95.40	W	545	2,194	6,562	N.A.	N.A.	N.A.	N.A.
Vernon	B-10	34.08	N	99.30	W	1,202	3,186	5,605	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Victoria WSO AP	B-5	28.85	N	96.92	W	104	1,296	7,507	29	94	76	N.A.
Waco WSO AP	B-8	31.62	N	97.22	W	500	2,179	6,668	22	99	75	622
Wichita Falls WSO AP	B-10	33.97	N	98.48	W	994	3,042	5,717	N.A.	N.A.	N.A.	723
Utah (UT)												
Cedar City FAA AP	B-17	37.70	N	113.10	W	5,610	5,962	2,770	2	91	59	629
Logan Utah State Univ	B-17	41.75	N	111.80	W	4,790	6,854	2,541	N.A.	N.A.	N.A.	N.A.
Moab	B-13	38.60	N	109.60	W	3,965	4,494	4,356	N.A.	N.A.	N.A.	N.A.
Ogden Sugar Factory	B-17	41.23	N	112.03	W	4,280	5,950	3,053	N.A.	N.A.	N.A.	N.A.
Richfield Radio KSVC	B-17	38.77	N	112.08	W	5,270	6,367	2,300	N.A.	N.A.	N.A.	N.A.
Saint George	B-10	37.10	N	113.57	W	2,760	3,215	5,424	N.A.	N.A.	N.A.	N.A.
Salt Lake City NWSFO	B-17	40.78	N	111.95	W	4,222	5,765	3,276	6	94	62	586
Vernal Airport	B-19	40.45	N	109.52	W	5,260	7,562	2,334	N.A.	N.A.	N.A.	N.A.
Vermont (VT)												
Burlington WSO AP	B-19	44.47	N	73.15	W	332	7,771	2,228	-11	84	69	637
Rutland	B-17	43.60	N	72.97	W	620	7,066	2,345	N.A.	N.A.	N.A.	N.A.
Virginia (VA)												
Charlottesville	B-13	38.03	N	78.52	W	870	4,224	3,902	N.A.	N.A.	N.A.	N.A.
Danville-Bridge St	B-13	36.58	N	79.38	W	410	3,944	4,236	N.A.	N.A.	N.A.	N.A.
Fredericksburg Natl Pk	B-13	38.32	N	77.45	W	90	4,554	3,754	N.A.	N.A.	N.A.	N.A.
Lynchburg WSO AP	B-13	37.33	N	79.20	W	916	4,340	3,728	12	90	74	N.A.
Norfolk WSO AP	B-11	36.90	N	76.20	W	22	3,495	4,478	20	91	76	685
Richmond WSO AP	B-13	37.50	N	77.33	W	164	3,963	4,223	14	92	75	716
Roanoke WSO AP	B-13	37.32	N	79.97	W	1,149	4,360	3,715	12	89	72	713
Staunton Sewage Plant	B-14	38.15	N	79.03	W	1,385	5,273	3,004	N.A.	N.A.	N.A.	N.A.
Winchester	B-14	39.18	N	78.12	W	680	5,269	3,215	N.A.	N.A.	N.A.	N.A.
Washington (WA)												
Aberdeen	B-15	46.97	N	123.82	W	10	5,285	1,488	N.A.	N.A.	N.A.	N.A.
Bellingham FAA AP	B-18	48.80	N	122.53	W	149	5,609	1,508	15	76	64	N.A.
Bremerton	B-14	47.57	N	122.67	W	162	5,119	1,839	N.A.	N.A.	N.A.	N.A.
Ellensburg	B-17	46.97	N	120.55	W	1,480	6,770	1,999	N.A.	N.A.	N.A.	N.A.
Everett	B-15	47.98	N	122.18	W	60	5,311	1,660	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		No. Hrs. 8 a.m.-4 p.m.
										Dry-Bulb	Wet-Bulb	
									99.6%	1.0%	1.0%	55<Tdb<69
Kennewick	B-14	46.22	N	119.10	W	390	4,895	3,195	N.A.	N.A.	N.A.	N.A.
Longview	B-14	46.15	N	122.92	W	12	5,094	1,858	N.A.	N.A.	N.A.	N.A.
Olympia WSO AP	B-18	46.97	N	122.90	W	192	5,655	1,558	18	83	65	985
Port Angeles	B-18	48.12	N	123.40	W	40	5,695	1,257	N.A.	N.A.	N.A.	N.A.
Seattle EMSU WSO	B-14	47.65	N	122.30	W	20	4,611	2,120	N.A.	N.A.	N.A.	N.A.
Seattle-Tacoma WSCMO AP	B-14	47.45	N	122.30	W	450	4,908	2,021	23	81	64	982
Spokane WSO AP	B-17	47.63	N	117.53	W	2,356	6,842	2,032	N.A.	N.A.	N.A.	640
Tacoma/McChord AFB	B-14	47.15	N	122.48	W	322	5,155	1,820	18	82	63	N.A.
Walla Walla FAA AP	B-14	46.10	N	118.28	W	1,166	4,958	3,161	4	95	65	N.A.
Wenatchee	B-17	47.42	N	120.32	W	640	5,579	2,956	3	92	65	N.A.
Yakima WSO AP	B-17	46.57	N	120.53	W	1,064	5,967	2,348	4	92	64	703
West Virginia (WV)												
Beckley WSO AP	B-17	37.78	N	81.12	W	2,504	5,558	2,690	N.A.	N.A.	N.A.	N.A.
Bluefield FAA AP	B-14	37.30	N	81.22	W	2,870	5,230	2,907	5	83	69	N.A.
Charleston WSFO AP	B-13	38.37	N	81.60	W	1,015	4,646	3,655	6	88	73	704
Clarksburg	B-17	39.27	N	80.35	W	945	5,512	3,014	N.A.	N.A.	N.A.	N.A.
Elkins WSO AP	B-17	38.88	N	79.85	W	1,992	6,120	2,360	-2	83	70	N.A.
Huntington WSO AP	B-13	38.37	N	82.55	W	827	4,665	3,615	6	89	73	N.A.
Martinsburg FAA AP	B-14	39.40	N	77.98	W	531	5,192	3,368	8	91	73	N.A.
Morgantown FAA AP	B-14	39.65	N	79.92	W	1,240	5,363	3,155	4	87	71	N.A.
Parkersburg	B-14	39.27	N	81.57	W	615	5,094	3,507	4	88	72	N.A.
Wisconsin (WI)												
Appleton	B-19	44.25	N	88.37	W	750	7,693	2,513	N.A.	N.A.	N.A.	N.A.
Ashland Exp Farm	B-19	46.57	N	90.97	W	650	8,960	1,811	N.A.	N.A.	N.A.	N.A.
Beloit	B-17	42.50	N	89.03	W	780	7,161	2,737	N.A.	N.A.	N.A.	N.A.
Eau Claire FAA AP	B-19	44.87	N	91.48	W	888	8,330	2,407	-18	87	71	661
Fond du Lac	B-19	43.80	N	88.45	W	760	7,541	2,573	N.A.	N.A.	N.A.	N.A.
Green Bay WSO AP	B-19	44.48	N	88.13	W	682	8,089	2,177	-13	85	72	651
La Crosse FAA AP	B-19	43.87	N	91.25	W	651	7,491	2,790	-14	88	73	644
Madison WSO AP	B-19	43.13	N	89.33	W	858	7,673	2,389	-11	87	72	658
Manitowoc	B-19	44.10	N	87.68	W	660	7,597	2,193	N.A.	N.A.	N.A.	N.A.

TABLE D-1 (Continued)
U.S. Climatic Data

State City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
Marinette	B-19	45.10	N	87.63	W	605	8,059	2,272	N.A.	N.A.	N.A.	N.A.
Milwaukee WSO AP	B-19	42.95	N	87.90	W	672	7,324	2,388	-7	86	72	618
Racine	B-17	42.70	N	87.77	W	595	7,167	2,459	N.A.	N.A.	N.A.	N.A.
Sheboygan	B-17	43.75	N	87.72	W	648	7,087	2,390	N.A.	N.A.	N.A.	N.A.
Stevens Point	B-19	44.50	N	89.57	W	1,079	8,009	2,325	N.A.	N.A.	N.A.	N.A.
Waukesha	B-17	43.02	N	88.23	W	860	7,117	2,658	N.A.	N.A.	N.A.	N.A.
Wausau FAA AP	B-19	44.92	N	89.62	W	1,196	8,427	2,182	-15	85	70	N.A.
Wyoming (WY)												
Casper WSO AP	B-19	42.92	N	106.47	W	5,338	7,682	2,082	-13	89	58	535
Cheyenne WSFO AP	B-19	41.15	N	104.82	W	6,120	7,326	1,886	-7	85	57	608
Cody	B-19	44.52	N	109.07	W	5,050	7,431	2,057	-14	87	58	N.A.
Evanston	B-20	41.27	N	110.95	W	6,810	8,846	1,285	N.A.	N.A.	N.A.	N.A.
Lander WSO AP	B-19	42.82	N	108.73	W	5,370	7,889	2,184	-14	87	58	N.A.
Laramie FAA AP	B-22	41.32	N	105.68	W	7,266	9,008	1,237	N.A.	N.A.	N.A.	N.A.
Newcastle	B-19	43.85	N	104.22	W	4,410	7,267	2,518	N.A.	N.A.	N.A.	N.A.
Rawlins FAA AP	B-20	41.80	N	107.20	W	6,736	8,475	1,605	N.A.	N.A.	N.A.	N.A.
Rock Springs FAA AP	B-20	41.60	N	109.07	W	6,741	8,365	1,734	-9	84	54	552
Sheridan WSO AP	B-19	44.77	N	106.97	W	3,964	7,804	2,023	-14	90	61	574
Torrington Exp Farm	B-17	42.08	N	104.22	W	4,098	6,879	2,429	N.A.	N.A.	N.A.	N.A.
U.S. Territories												
Puerto Rico												
San Juan/Isla Verde WSFO		B-1	18.43	N	66.00	W	10	0	11,406	69	90	78

TABLE D-2
Canadian Climatic Data

Province City	Table	Latitude	Longitude	Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature Dry-Bulb	Cooling Design Temperature Wet-Bulb
							99.6%	1.0%	1.0%
Alberta (AB)									
Calgary International A	B-22	51.12 N	114.02 W	3,533	9,885	1,167	-22	80	59
Edmonton International A	B-23	53.30 N	113.58 W	2,345	11,023	1,069	-28.1	78	62
Grande Prairie A	B-23	55.18 N	118.88 W	2,185	11,240	1,031	-32	78	60
Jasper	B-22	52.88 N	118.07 W	3,480	10,244	848	N.A.	N.A.	N.A.
Lethbridge A	B-20	49.63 N	112.80 W	3,047	8,783	1,730	-22	84	61
Medicine Hat A	B-19	50.02 N	110.72 W	2,352	8,988	1,981	-24	87	62
Red Deer A	B-22	52.18 N	113.90 W	2,969	10,765	1,095	-27	79	61
British Columbia (BC)									
Dawson Creek A	B-23	55.73 N	120.18 W	2,148	11,435	890	N.A.	N.A.	N.A.
Ft Nelson A	B-24	58.83 N	122.58 W	1,253	12,941	1,013	-33	78	60
Kamloops	B-17	50.67 N	120.33 W	1,243	6,779	2,335	-8	88	63
Nanaimo A	B-18	49.05 N	123.87 W	98	6,054	1,469	N.A.	N.A.	N.A.
New Westminster BC Pen	B-18	49.22 N	122.90 W	59	5,520	1,691	N.A.	N.A.	N.A.
Penticton A	B-17	49.47 N	119.60 W	1,128	6,500	2,002	5	87	64
Prince George	B-22	53.88 N	122.67 W	2,267	9,495	906	-25	78	59
Prince Rupert A	B-20	54.30 N	130.43 W	111	7,650	572	7	63	57
Vancouver International A	B-18	49.18 N	123.17 W	9	5,682	1,536	18	74	64
Victoria Gonzales Hts	B-18	48.42 N	123.32 W	229	5,494	1,286	23	75	62
Manitoba (MB)									
Brandon CDA	B-23	49.87 N	99.98 W	1,190	10,969	1,661	-29	84	66
Churchill A	B-25	58.73 N	94.07 W	91	16,719	275	-36	72	60
Dauphin A	B-23	51.10 N	100.05 W	1,000	11,242	1,520	-28	84	66
Flin Flon	B-23	54.77 N	101.85 W	1,099	12,307	1,352	N.A.	N.A.	N.A.
Portage La Prairie A	B-21	49.90 N	98.27 W	885	10,594	1,807	-25	85	67
The Pas A	B-23	53.97 N	101.10 W	889	12,490	1,231	-32	79	64
Winnipeg International A	B-23	49.90 N	97.23 W	784	10,858	1,784	-27	84	67
New Brunswick (NB)									
Chatham A	B-22	47.02 N	65.45 W	111	9,028	1,531	-12	83	67
Fredericton A	B-20	45.87 N	66.53 W	55	8,666	1,631	-12	83	68

TABLE D-2 (Continued)
Canadian Climatic Data

Province City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature Dry-Bulb	Cooling Design Temperature Wet-Bulb
									99.6%	1.0%	1.0%
Moncton A	B-20	46.12	N	64.68	W	232	8,731	1,427	-10	80	67
Saint John A	B-20	45.33	N	65.88	W	337	8,776	1,179	-9	75	64
Newfoundland (NF)											
Corner Brook	B-20	48.95	N	57.95	W	16	8,756	1,075	N.A.	N.A.	N.A.
Gander International A	B-22	48.95	N	54.57	W	495	9,354	956	-4	76	63
Goose A	B-23	53.32	N	60.42	W	150	12,017	758	-23	77	61
St John's A	B-20	47.62	N	52.73	W	439	8,888	848	3	73	64
Stephenville A	B-20	48.53	N	58.55	W	26	8,869	952	-2	71	64
Northwest Territories (NW)											
Ft Smith A	B-24	60.02	N	111.95	W	666	14,192	932	-34	78	61
Inuvik A	B-25	68.30	N	133.48	W	193	18,409	489	-43	75	59
Resolute A	B-26	74.72	N	94.98	W	219	22,864	0	-42	48	43
Yellowknife A	B-24	62.47	N	114.45	W	672	15,555	851	-39	74	59
Nova Scotia (NS)											
Halifax International A	B-20	44.88	N	63.52	W	416	8,133	1,464	-2	78	66
Kentville CDA	B-20	45.07	N	64.48	W	160	7,683	1,665	N.A.	N.A.	N.A.
Sydney A	B-20	46.17	N	60.05	W	183	8,364	1,287	-1	78	67
Truro	B-20	45.37	N	63.27	W	131	8,596	1,295	-9	77	67
Yarmouth A	B-20	43.83	N	66.08	W	141	7,515	1,180	7	71	64
Ontario (ON)											
Belleville	B-19	44.15	N	77.40	W	249	7,556	2,252	N.A.	N.A.	N.A.
Cornwall	B-19	45.02	N	74.75	W	209	8,062	2,187	N.A.	N.A.	N.A.
Hamilton RBG	B-17	43.28	N	79.88	W	334	6,872	2,450	N.A.	N.A.	N.A.
Kapuskasing A	B-23	49.42	N	82.47	W	744	11,742	1,108	-30	80	65
Kenora A	B-23	49.78	N	94.37	W	1,335	10,884	1,626	-27	81	65
Kingston A	B-19	44.22	N	76.60	W	305	7,826	1,960	N.A.	N.A.	N.A.
London A	B-19	43.03	N	81.15	W	912	7,565	2,126	-3	83	70
North Bay A	B-22	46.35	N	79.43	W	1,174	9,794	1,509	-18	78	66
Oshawa WPCP	B-19	43.87	N	78.83	W	275	7,253	2,106	N.A.	N.A.	N.A.
Ottawa International A	B-19	45.32	N	75.67	W	380	8,571	2,045	-13	83	69

TABLE D-2 (Continued)
Canadian Climatic Data

Province City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature	
										Dry-Bulb	Wet-Bulb
									99.6%	1.0%	1.0%
Owen Sound MOE	B-19	44.58	N	80.93	W	587	7,730	1,896	N.A.	N.A.	N.A.
Peterborough	B-19	44.28	N	78.32	W	636	8,037	1,975	N.A.	N.A.	N.A.
St Catharines	B-17	43.20	N	79.25	W	298	6,700	2,564	N.A.	N.A.	N.A.
Sudbury A	B-22	46.62	N	80.80	W	1,141	9,990	1,557	-19	81	66
Thunder Bay A	B-22	48.37	N	89.32	W	652	10,562	1,198	-22	80	66
Timmins A	B-23	48.57	N	81.37	W	967	11,374	1,225	-28	81	65
Toronto Downsview A	B-19	43.75	N	79.48	W	649	7,306	2,370	-4	84	70
Windsor A	B-17	42.27	N	82.97	W	623	6,619	2,679	2	86	71
Prince Edward Island (PE)											
Charlottetown A	B-20	46.28	N	63.13	W	157	8,598	1,400	-6	77	67
Summerside A	B-20	46.43	N	63.83	W	78	8,411	1,536	-5	77	66
Quebec (PQ)											
Bagotville A	B-22	48.33	N	71.00	W	521	10,603	1,300	-23	80	65
Drummondville	B-19	45.88	N	72.48	W	269	8,601	2,024	N.A.	N.A.	N.A.
Granby	B-19	45.38	N	72.70	W	551	8,367	1,984	N.A.	N.A.	N.A.
Montreal Dorval International A	B-19	45.47	N	73.75	W	101	8,285	2,146	-12	83	70
Quebec A	B-22	46.80	N	71.38	W	229	9,449	1,571	-16	80	68
Rimouski	B-22	48.45	N	68.52	W	118	9,665	1,215	N.A.	N.A.	N.A.
Sept-Iles A	B-23	50.22	N	66.27	W	180	11,287	690	-20	69	59
Shawinigan	B-22	46.57	N	72.75	W	400	9,246	1,720	N.A.	N.A.	N.A.
Sherbrooke A	B-22	45.43	N	71.68	W	780	9,464	1,372	-20	80	68
St Jean de Cherbourg	B-23	48.88	N	67.12	W	1,151	11,277	801	N.A.	N.A.	N.A.
St Jerome	B-22	45.80	N	74.05	W	557	9,171	1,771	N.A.	N.A.	N.A.
Thetford Mines	B-22	46.10	N	71.35	W	1,250	9,687	1,425	N.A.	N.A.	N.A.
Trois Rivieres	B-22	46.37	N	72.60	W	173	9,124	1,766	N.A.	N.A.	N.A.
Val d'Or A	B-23	48.07	N	77.78	W	1,105	11,256	1,193	-27	80	65
Valleyfield	B-19	45.28	N	74.10	W	150	8,083	2,268	N.A.	N.A.	N.A.
Saskatchewan (SK)											
Estevan A	B-22	49.22	N	102.97	W	1,876	10,092	1,793	-25	86	65
Moose Jaw A	B-21	50.33	N	105.55	W	1,893	9,989	1,812	-27	87	64

TABLE D-2 (Continued)
Canadian Climatic Data

Province City	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%
North Battleford A	B-23	52.77	N	108.25	W	1,797	11,127	1,473	-31	82	63
Prince Albert A	B-23	53.22	N	105.68	W	1,404	12,009	1,252	-34	81	64
Regina A	B-22	50.43	N	104.67	W	1,893	10,773	1,620	-29	85	64
Saskatoon A	B-23	52.17	N	106.68	W	1,643	11,118	1,537	-31	84	63
Swift Current A	B-22	50.28	N	107.68	W	2,683	10,128	1,541	-25	84	62
Yorkton A	B-23	51.27	N	102.47	W	1,633	11,431	1,476	-30	82	64
Yukon Territory (YT)											
Whitehorse A	B-24	60.72	N	135.07	W	2,306	12,797	611	-34	73	55

TABLE D-3
International Climatic Data

Country City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%
Argentina												
Buenos Aires/Ezeiza		B-9	34.82	S	58.53	W	66	2,211	4,693	31	90	72
Cordoba		B-9	31.32	S	64.22	W	1,555	1,816	5,182	31	91	72
Tucuman/Pozo		B-6	26.85	S	65.10	W	1,444	1,146	6,622	N.A.	N.A.	N.A.
Australia												
Adelaide	SA	B-9	34.95	S	138.53	E	20	2,082	4,381	39	92	64
Alice Springs	NT	B-5	23.80	S	133.90	E	1,782	1,142	7,777	34	102	64
Brisbane	QL	B-4	27.43	S	153.08	E	7	545	7,009	44	86	72
Darwin Airport	NT	B-1	12.43	S	130.87	E	95	0	11,736	64	92	76
Perth/Guildford	WA	B-7	31.92	S	115.97	E	56	1,507	5,353	41	95	66
Sydney/K Smith	NSW	B-7	33.95	S	151.18	E	20	1,351	5,259	42	85	67
Azores												
Lajes	Terceira	B-7	38.75	N	27.08	W	180	1,279	4,892	46	78	71
Bahamas												
Nassau		B-2	25.05	N	77.47	W	10	29	9,775	57	90	78

TABLE D-3 (Continued)
International Climatic Data

Country City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature Dry-Bulb	Cooling Design Temperature Wet-Bulb
										99.6%	1.0%	1.0%
Belgium												
Brussels Airport		B-17	50.90	N	4.47	E	128	5,460	1,862	15	79	66
Bermuda												
St Georges/Kindley		B-3	32.37	N	64.68	W	20	170	8,365	N.A.	N.A.	N.A.
Bolivia												
La Paz/El Alto		B-18	16.50	S	68.18	W	13,287	7,189	237	25	62	44
Brazil												
Belem		B-1	1.43	S	48.48	W	79	0	11,552	72	90	78
Brasilia		B-3	15.77	S	47.93	W	3,809	58	7,943	48	88	65
Fortaleza		B-1	3.72	S	38.55	W	62	1	11,748	72	90	78
Porto Alegre		B-6	30.08	S	51.18	W	23	902	7,076	40	92	75
Recife/Curado		B-1	8.13	S	34.92	W	36	2	10,951	70	91	78
Rio de Janeiro		B-2	22.90	S	43.17	W	16	14	9,688	59	99	77
Salvador/Ondina		B-2	13.00	S	38.52	W	167	0	10,785	68	88	78
Sao Paulo		B-3	23.50	S	46.62	W	2,608	447	7,219	48	88	69
Bulgaria												
Sofia		B-17	42.82	N	23.38	E	1,952	5,629	2,508	10	85	65
Chile												
Concepcion		B-12	36.77	S	73.05	W	39	3,559	2,283	35	74	62
Punta Arenas/Chabunco		B-20	53.03	S	70.85	W	108	7,807	395	23	61	53
Santiago/Pedahuel		B-12	33.38	S	70.88	W	1,575	2,820	3,471	29	88	65
China												
Shanghai/Hongqiao		B-11	31.17	N	121.43	E	16	3,182	5,124	26	92	81
Cuba												
Guantanamo Bay NAS	Ote.	B-1	19.90	N	75.15	W	75	0	11,719	67	93	78
Cyprus												
Akrotiri		B-6	34.58	N	32.98	E	75	1,287	6,147	40	89	72
Larnaca		B-6	34.88	N	33.63	E	7	1,452	6,028	37	91	72
Paphos		B-6	34.75	N	32.40	E	30	1,279	5,924	39	86	76

TABLE D-3 (Continued)
International Climatic Data

Country City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature	
											Dry-Bulb	Wet-Bulb
										99.6%	1.0%	1.0%
Czech Republic (Former Czechoslovakia)												
Prague/Libus		B-17	50.00	N	14.45	E	1,001	6,376	1,853	3	80	64
Dominican Republic												
Santo Domingo		B-1	18.47	N	69.88	W	43	0	10,862	N.A.	N.A.	N.A.
Egypt												
Cairo		B-3	30.13	N	31.40	E	243	834	7,993	45	97	69
Luxor		B-2	25.67	N	32.70	E	289	581	9,849	40	108	71
Finland												
Helsinki/Seutula		B-22	60.32	N	24.97	E	167	9,051	1,138	-11	75	61
France												
Lyon/Satolas		B-14	45.73	N	5.08	E	814	4,930	2,609	17	86	69
Marseille		B-11	43.45	N	5.22	E	26	3,194	3,933	25	87	70
Nantes		B-14	47.17	N	1.60	W	89	4,286	2,480	23	83	68
Nice		B-9	43.65	N	7.20	E	33	2,641	3,983	35	83	73
Paris/Le Bourget		B-14	48.97	N	2.45	E	217	5,046	2,211	18	82	68
Strasbourg		B-17	48.55	N	7.63	E	502	5,533	2,193	12	84	68
Germany												
Berlin/Schoenfeld		B-17	52.38	N	13.52	E	154	6,331	1,820	11	82	65
Hamburg		B-18	53.63	N	9.98	E	52	6,319	1,569	11	79	64
Hannover		B-18	52.47	N	9.70	E	180	6,093	1,730	9	80	65
Mannheim		B-17	49.53	N	8.50	E	318	5,428	2,262	N.A.	N.A.	N.A.
Greece												
Souda	Crete	B-6	35.55	N	24.12	E	417	1,767	5,472	39	90	67
Thessalonika/Mikra		B-11	40.52	N	22.97	E	26	3,389	4,115	25	90	69
Greenland												
Narssarssuaq		B-23	61.18	N	45.42	W	79	11,521	292	-18	62	49
Hungary												
Budapest/Lorinc		B-17	47.43	N	19.18	E	459	5,534	2,647	8	86	68
Iceland												
Reykjavik		B-22	64.13	N	21.93	W	200	9,286	293	14	58	52

TABLE D-3 (Continued)
International Climatic Data

Country City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature Dry-Bulb	Cooling Design Temperature Wet-Bulb
										99.6%	1.0%	1.0%
India												
Ahmedabad		B-1	23.07	N	72.63	E	180	31	11,648	52	106	74
Bangalore		B-2	12.97	N	77.58	E	3,018	2	9,409	59	92	67
Bombay/Santa Cruz		B-1	19.12	N	72.85	E	26	2	11,372	62	93	74
Calcutta/Dum Dum		B-1	22.65	N	88.45	E	16	26	11,064	54	97	79
Madras		B-1	13.00	N	80.18	E	52	0	12,403	68	99	77
Nagpur Sonegaon		B-1	21.10	N	79.05	E	1,014	18	11,274	53	108	71
New Delhi/Safdarjung		B-2	28.58	N	77.20	E	702	480	10,060	44	105	72
Indonesia												
Djakarta/Halimperda	Java	B-1	6.25	S	106.90	E	98	0	11,477	N.A.	N.A.	N.A.
Kupang Penfui	Sunda Island	B-1	10.17	S	123.67	E	354	2	11,686	N.A.	N.A.	N.A.
Makassar	Celebes	B-1	5.07	S	119.55	E	56	3	11,481	N.A.	N.A.	N.A.
Medan	Sumatra	B-1	3.57	N	98.68	E	85	0	11,491	N.A.	N.A.	N.A.
Palembang	Sumatra	B-1	2.90	S	104.70	E	33	0	11,565	N.A.	N.A.	N.A.
Surabaja Perak	Java	B-1	7.22	S	112.72	E	10	0	12,088	N.A.	N.A.	N.A.
Ireland												
Dublin Airport		B-18	53.43	N	6.25	W	279	5,507	1,276	29	69	61
Shannon Airport		B-15	52.68	N	8.92	W	66	5,106	1,455	28	71	63
Israel												
Jerusalem		B-9	31.78	N	35.22	E	2,654	2,423	4,609	33	86	64
Tel Aviv Port		B-6	32.10	N	34.78	E	33	955	6,851	44	86	74
Italy												
Milano/Linate		B-14	45.43	N	9.28	E	351	4,507	3,335	21	87	72
Napoli/Capodichino		B-9	40.88	N	14.30	E	236	2,658	4,301	32	89	73
Roma/Fiumicino		B-9	41.80	N	12.23	E	7	2,684	4,173	30	86	74
Jamaica												
Kingston/Manley		B-1	17.93	N	76.78	W	46	0	11,860	71	98	78
Montego Bay/Sangster		B-1	18.50	N	77.92	W	3	1	10,915	70	90	79
Japan												
Fukaura		B-17	40.65	N	139.93	E	223	5,522	2,933	30	91	78
Sapporo		B-17	43.05	N	141.33	E	56	6,753	2,518	12	81	71
Tokyo		B-11	35.68	N	139.77	E	118	2,986	4,749	31	88	77

TABLE D-3 (Continued)
International Climatic Data

Country City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature 99.6%	Cooling Design Temperature Dry-Bulb 1.0%	Cooling Design Temperature Wet-Bulb 1.0%
Jordan												
Amman		B-8	31.98	N	35.98	E	2,516	2,337	5,427	33	92	65
Kenya												
Nairobi Airport		B-4	1.32	S	36.93	E	5,328	273	6,177	49	83	60
Korea												
Pyonggang		B-17	38.40	N	127.30	E	1,217	6,735	2,840	3	85	74
Seoul		B-13	37.57	N	126.97	E	282	5,007	3,956	N.A.	N.A.	N.A.
Malaysia												
Kuala Lumpur		B-1	3.13	N	101.55	E	56	0	11,530	71	93	78
Penang/Bayan Lepas		B-1	5.30	N	100.27	E	10	0	N	N.A.	N.A.	N.A.
Mexico												
Mexico City	Distrito Federal	B-4	19.40	N	99.20	W	5,213	701	6,121	39	82	57
Guadalajara	Jalisco	B-1	20.67	N	103.38	W	30	10	11,122	N.A.	N.A.	N.A.
Monterrey	Nuevo Laredo	B-4	25.87	N	100.20	W	6,368	745	5,542	N.A.	N.A.	N.A.
Tampico	Tamaulipas	B-2	22.22	N	97.85	W	551	0	10,760	50	90	80
Veracruz	Veracruz	B-9	19.15	N	96.12	W	7,156	2,198	3,850	57	92	80
Merida	Yucatan	B-5	20.98	N	89.65	W	72	1,191	10,439	57	98	76
Netherlands												
Amsterdam/Schiphol		B-18	52.30	N	4.77	E	-13	5,691	1,619	17	77	65
New Zealand												
Auckland Airport		B-9	37.02	S	174.80	E	23	2,242	3,650	35	76	66
Christchurch		B-14	43.48	S	172.55	E	118	4,359	2,115	28	79	61
Wellington		B-12	41.28	S	174.77	E	420	3,597	2,258	35	71	63
Norway												
Bergen/Florida		B-18	60.38	N	5.33	E	128	6,882	1,014	16	68	57
Oslo/Fornebu		B-20	59.90	N	10.62	E	52	8,020	1,331	0	77	62
Pakistan												
Karachi Airport		B-5	24.90	N	67.13	E	75	1,155	11,049	N.A.	N.A.	N.A.
Papua New Guinea												
Port Moresby		B-1	9.43	S	147.22	E	92	2	11,272	N.A.	N.A.	N.A.

TABLE D-3 (Continued)
International Climatic Data

Country City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature Dry-Bulb	Cooling Design Temperature Wet-Bulb
										99.6%	1.0%	1.0%
Paraguay												
Asuncion/Stroessner		B-2	25.27	S	57.63	W	331	469	9,005	41	95	75
Peru												
Lima-Callao/Chavez		B-4	12.00	S	77.12	W	43	260	6,745	57	84	74
San Juan de Marcona		B-4	15.35	S	75.15	W	197	306	6,765	N.A.	N.A.	N.A.
Talara		B-3	4.57	S	81.25	W	282	4	8,973	60	88	75
Philippines												
Manila Airport	Luzon	B-1	14.52	N	121.00	E	75	0	11,449	69	93	80
Poland												
Krakow/Balice		B-17	50.08	N	19.80	E	778	6,924	2,007	-1	81	67
Romania												
Bucuresti/Bancasa		B-17	44.50	N	26.13	E	308	5,461	2,948	8	88	70
Russia (Former Soviet Union)												
Kaliningrad	East Prussia	B-18	54.70	N	20.62	E	89	7,115	1,589	-3	77	64
Krasnoiarsk		B-23	56.00	N	92.88	E	636	11,278	1,351	-29	80	63
Moscow Observatory		B-20	55.75	N	37.57	E	512	8,596	1,708	-10	79	65
Petropavlovsk		B-22	53.02	N	158.72	E	23	10,107	530	5	66	58
Rostov-Na-Donu		B-17	47.25	N	39.82	E	259	6,360	3,015	2	86	68
Vladivostok		B-20	43.12	N	131.90	E	453	8,915	1,728	-8	75	67
Volgograd		B-19	48.68	N	44.35	E	476	7,558	2,840	-6	88	65
Saudi Arabia												
Dhahran		B-1	26.27	N	50.17	E	72	381	10,936	N.A.	N.A.	N.A.
Riyadh		B-2	24.70	N	46.73	E	2,005	536	10,725	41	110	64
Senegal												
Dakar/Yoff		B-2	14.73	N	17.50	W	89	6	9,750	61	88	77
Singapore												
Singapore/Changi		B-1	1.37	N	103.98	E	49	0	11,995	73	90	79
South Africa												
Cape Town/D F Malan		B-7	33.97	S	18.60	E	151	1,685	4,454	38	83	67

TABLE D-3 (Continued)
International Climatic Data

Country City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature	
											Dry-Bulb	Wet-Bulb
										99.6%	1.0%	1.0%
Johannesburg		B-9	26.13	S	28.23	E	5,558	1,919	4,252	34	82	60
Pretoria		B-6	25.73	S	28.18	E	4,364	1,151	5,828	39	88	63
Spain												
Barcelona		B-9	41.28	N	2.07	E	13	2,638	3,965	32	84	74
Madrid		B-13	40.47	N	3.57	W	1,909	3,669	3,702	24	94	68
Valencia/Manises		B-9	39.50	N	0.47	W	203	1,942	5,045	34	88	72
Sweden												
Stockholm/Arlanda		B-20	59.65	N	17.95	E	200	8,123	1,297	-2	77	61
Switzerland												
Zurich		B-17	47.38	N	8.57	E	1,867	6,015	1,995	13	80	65
Syria												
Damascus Airport		B-11	33.42	N	36.52	E	2,001	2,771	5,293	25	98	64
Taiwan												
Tainan		B-2	22.95	N	120.20	E	52	150	9,729	51	91	81
Taipei		B-3	25.03	N	121.52	E	26	438	8,896	48	93	80
Tanzania												
Dar es Salaam		B-2	6.88	S	39.20	E	180	4	10,755	N.A.	N.A.	N.A.
Thailand												
Bangkok		B-1	13.73	N	100.57	E	52	0	12,430	65	97	79
Tunisia												
Tunis/El Aouina		B-6	36.83	N	10.23	E	16	1,657	5,769	41	94	73
Turkey												
Adana		B-8	37.00	N	35.42	E	217	1,847	6,098	32	94	71
Ankara/Etimesgut		B-14	39.95	N	32.68	E	2,644	5,162	3,077	2	86	63
Istanbul/Yesilkoy		B-11	40.97	N	28.82	E	121	3,534	3,777	26	84	69
United Kingdom												
Birmingham	England	B-18	52.45	N	1.73	W	325	5,866	1,355	21	75	62
Edinburgh	Scotland	B-18	55.95	N	3.35	W	135	6,347	1,001	21	69	60
Glasgow Apt	Scotland	B-18	55.87	N	4.43	W	23	6,287	1,041	21	71	61
London/Heathrow	England	B-14	51.48	N	0.45	W	79	5,015	1,894	25	78	64

TABLE D-3 (Continued)
International Climatic Data

Country / City	Province or Region	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature	
											Dry-Bulb	Wet-Bulb
										99.6%	1.0%	1.0%
Uruguay												
Montevideo/Carrasco		B-9	34.83	S	56.03	W	108	2,124	4,602	35	86	71
Venezuela												
Caracas/Maiquetia		B-1	10.60	N	66.98	W	236	9	11,501	70	91	83
Vietnam												
Hanoi/Gialam		B-2	21.02	N	105.80	E	26	330	9,868	N.A.	N.A.	N.A.
Saigon (Ho Chi Minh)		B-1	10.82	N	106.67	E	62	0	12,057	68	94	77

(This is an informative appendix and is not part of this standard.)

INFORMATIVE APPENDIX E

INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of Standard 90.1-2001 and to acknowledge source documents when appropriate. Some documents are also included in Section 12 – Normative References because there are other citations of that document within the standard that are normative.

Address/Contact Information

AABC

Associated Air Balance Council
1518 K Street Northwest, Suite 503
Washington, DC 20005
aabchg@aol.com

BLAST

American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
http://www.ashrae.org

DOE-2 Data

U.S. Department of Commerce
Technology Administration
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
http://www.ntis.gov

MICA

Midwest Insulation Contractors Association
16712 Elm Circle
Omaha, NE 68130
http://www.micainsulation.org

NEBB

National Environmental Balancing Bureau
8575 Grovemont Circle
Gaithersburg, MD 20877
http://www.nebb.org

SMACNA

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

TMY Data

National Climatic Data Center
National Environmental Satellite, Data, and Information Service
National Oceanic and Atmospheric Administration
Climate Services Branch
Federal Building
Room 468
151 Patton Avenue
Asheville, NC 28801-5001
info@ncdc.noaa.gov
Free download at http://doe2.com/Download/Weather/TMY

WYEC Data

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASHRAE Customer Service
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
orders@ashrae.org
Free download at http://doe2.com/Download/Weather/WYEC

CWEC Data

Canadian Climatic Service
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
Canada M3H 5T4
climate.services@ec.gc.ca

Subsection No.	Reference	Title/Source
6.2.2	2001 ASHRAE Handbook—Fundamentals	-
6.2.4.1.1	MICA Insulation Standards - 1999	National commercial and industrial insulation standards
6.2.4.2.1	SMACNA Duct Construction Standards - 1995	HVAC duct construction standards, metal and flexible
6.2.4.2.2	SMACNA Duct Leakage Test Procedures - 1985	***HVAC Air Duct Leakage Test Manual***
6.2.5.3.1	NEBB Procedural Standards - 1999	Procedural standards for building systems commissioning
6.2.5.3.1	AABC 2002	Associated Air Balance Council Test and Balance procedures
6.2.5.3.1	ASHRAE Standard 111 - 1988	***Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems***
6.2.5.2	ASHRAE Guideline 4 - 1993	***Preparation of Operating and Maintenance Documentation for Building Systems***
6.2.5.4	ASHRAE Guideline 1 - 1996	***The HVAC Commissioning Process***
7.2.1 and 7.3.1	1999 ASHRAE Handbook—HVAC Applications	Chapter 48, Service Water Heating
11.2.1	DOE-2	National Technical Information Service
11.2.1	BLAST	University of Illinois
11.2.2	WYEC2 Data	Weather Year for Energy Calculations 2
11.2.2	TMY Data	Typical Meteorological Year
11.2.2	CWEC Data	Canadian Weather for Energy Calculations

(This is an informative appendix and is not part of this standard.)

Appendix F

Addenda Description Information

ANSI/ASHRAE/IESNA Standard 90.1-2001 incorporates ANSI/ASHRAE/IESNA Standard 90.1-1999 and Addenda a, b, d, e, f, g, j, k, m, n, o, q, r, s, t, u, v, w, y, z, aa, ab, ac, ad, af, ag, ah, ai, ak, al, am, an, ao, and ap. Table F-1 lists each addendum and describes the way in which the text is affected by the change. Table F-2 lists the ASHRAE and ANSI approval dates.

TABLE F-1
Addenda to ANSI/ASHRAE/IESNA Standard 90.1-1999; Changes Identified

Addenda to 90.1-1999	Sections Affected	Description of Changes[a]
90.1a	5. Building Envelope	Clarification to 5.2.1.2, Substantial Contact.
90.1b	5. Building Envelope	Editorial clarification on how the exception in 5.3.1.1, Roof Insulation, is applied.
90.1d	5. Building Envelope	Intended to clarify what F-factors should be used for trade-offs in the calculation procedures for slab-on-grade insulation in 5.3.1.5, Slab-on-Grade Floor Insulation. Appendix A, A6.
90.1e	A9 Determination of Alternative U-Factors, C-Factors, and F-Factors	This change makes clear that the calculation procedures in A9 can also be used for determining heat capacity of assemblies not covered in Tables A6 and A7.
90.1f	Normative Appendix B, Building Envelope Criteria	Change to Appendix B changes the unheated slab-on-grade floor criteria for residential spaces.
90.1g	Normative Appendix B, Building Envelope Criteria	Change to Appendix B changes the heated slab-on-grade floor values in Tables 19 through 26.
90.1j	6. Heating, Ventilating, and Air Conditioning	Changes to 6.2.1, Mechanical Equipment Efficiency, and corresponding Tables 6.2.1C, H, I and J.
90.1k	6. Heating, Ventilating, and Air Conditioning	Exceptions to 6.2.3.1.1, General, have been reworded for clarity and consistency.
90.1m	6. Heating, Ventilating, and Air Conditioning	Change to 6.2.3.2.4, Shutoff Damper Controls, adds a climatic limitation and rewords the low leakage requirement to clarify; it applies only to motorized dampers in the closed position.
90.1n	6. Heating, Ventilating, and Air Conditioning	Change to the Exceptions to 6.2.3.2.4, Shutoff Damper Controls, relates to gravity dampers and makes the statement consistent with the requirements of 6.1.3 (n), Simplified Approach Option for HVAC Systems.
90.1o	6. Heating, Ventilating, and Air Conditioning	Change to 6.2.3.2.5, Zone Isolation, clarifies how zones may be grouped and removes the detailed performance requirements.
90.1q	6. Heating, Ventilation, and Air Conditioning	This change removes 6.2.3.5, Enclosed Parking Garage Ventilation, in its entirety.
90.1r	6. Heating, Ventilation, and Air Conditioning	This is a change to the Exception to 6.3.1 (b) with regard to economizers.
90.1s	6. Heating, Ventilation, and Air Conditioning	This exception to 6.3.1.4, Economizer Heating System Impact, was added to ensure that code officials would allow economizer operation where reheat was allowed.
90.1t	6. Heating, Ventilation, and Air Conditioning	Change to 6.2.5.3.1, General, and 6.2.5.3.2, Air System Balancing, relates to system balancing and removes the exception to 6.2.5.3.1.
90.1u	6. Heating, Ventilation, and Air Conditioning	This change to Table 6.2.1B, Electrically Operated Unitary and Applied Heat Pumps-Minimum Efficiency Requirements, adds the heat pump minimum efficiency ratings using the ISO procedures that are equivalent to the current requirements.
90.1v	9. Lighting	In 9.2.1.1, Automatic Lighting Shutoff, the term "occupant intervention" is vague and needed clarification.
90.1w	9. Lighting	This change to 9.3.1.2, Space-by-Space Method of Calculating Interior Lighting Power Allowance, clarifies the intended use of this additional interior lighting allowance.

TABLE F-1
Addenda to ANSI/ASHRAE/IESNA Standard 90.1-1999; Changes Identified

90.1y	9. Lighting	This addendum clarifies the definition of "General Low Bay" and "General High Bay" under the heading of Industrial Buildings, Table 9.3.1.2, Lighting Power Densities Using the Space-by-Space Method.
90.1z	9. Lighting	This change to 9.3.2, Exterior Building Lighting Power, and Table 9.3.2, Lighting Power Limits for Building Exteriors, clarifies the language and intent of exterior building lighting power.
90.1aa	8. Power	Change to 8.2.1.1, Feeders, and 8.2.1.2, Branch Circuits, specifies that connection load is not always the sizing method used in electrical design.
90.1ab	9. Lighting	Change to 9.3, Prescriptive Path, and Table 9.3.1.2, Space-by-Space Method of Calculating Interior Lighting Power Allowance, clarifies that the additional power allowances apply to any lighted area that meets the criteria.
90.1ac	7. Service Water Heating	Change to 7.2.1, Sizing of Systems, provides additional wording to the designer for more flexibility in determining the load of the system.
90.1ad	6. Heating, Ventilating, and Air Conditioning	Numerous changes, including Tables 6.2.1A, 6.2.1B, 6.2.4.2B, and 6.1.3; 6.2.3.1, 6.2.4.1, 6.2.5.1 and 6.2.5.2.
90.1af	4. Administration and Enforcement	Changes to 4.1.2.2, strengthens the standard, and eliminates the possibility of loopholes.
90.1ag	5. Building Envelope	Changes to 5.2.2.1, 5.2.2.2, A8, Tables A-17, A-17 and A-19. Revises U-factor requirements for glazed wall systems in vertical fenestration to require compliance with NFRC certification programs.
90.1ah	9. Lighting	Change to 9.3.1.1 to allow building area lighting power allowance method to be used for all buildings.
90.1ai	9. Lighting	Change to 9.3.1.1, adding footnote to Table 9.3.1.1 to indicate specific building types apply.
90.1ak	Appendix B	Tables B-1 to B-26 (SI only), revises all U-factors in SI edition to be consistent with the IP edition.
90.1al	3 & 6. Definitions, Abbreviations, and Acronyms & Heating, Ventilating, and Air Conditioning	In 3, modifies the definition of pump system energy demand. Also, change to 6.3.2.1, "mechanical refrigeration" to "mechanical cooling", and 6.2.5.3, deleted certain requirements for system balancing.
90.1am	4. Administration and Enforcement	Changes to subsections of 4.1 and exceptions, rewritten version of Section 4 makes clear the different treatments given to additions and alterations to existing buildings.
90.1an	11. Energy Cost Budget Method	Change to 11.4.2, coordinates subsection 11.4.2 with 4.1.2.1 and 4.1.2.2.
90.1ao	5. Building Envelope	Editorial changes to the entire section. No changes to the requirements. The revision simply restructures to make it easier to read and use.
90.1ap	11. Energy Cost Budget Method	Wording change to 11.4.3(e) and (f), this clarifies the rules for air and water economizers for budget building design.

[a] These descriptions may not be complete and are provided for information only.

TABLE F-2
Addenda to ANSI/ASHRAE/IESNA Standard 90.1-1999, Approval Dates

Addenda to 90.1-1999	ASHRAE Standards Committee Approval Date	ASHRAE Board of Directors Approval Date	ANSI Approval Date
90.1a	January 27, 2001	February 01, 2001	May 22, 2001
90.1b	April 1, 2001	June 24, 2001	September 17, 2001
90.1d	January 27, 2001	February 01, 2001	May 22, 2001
90.1e	January 27, 2001	February 01, 2001	May 22, 2001
90.1f	April 1, 2001	June 24, 2001	October 11, 2001
90.1g	January 27, 2001	February 01, 2001	May 22, 2001
90.1j	January 27, 2001	February 01, 2001	May 22, 2001
90.1k	January 27, 2001	February 01, 2001	May 22, 2001
90.1m	April 1, 2001	June 24, 2001	N/A - Superseded
90.1n	January 27, 2001	February 01, 2001	May 22, 2001
90.1o	April 1, 2001	June 24, 2001	October 22, 2001
90.1q	June 23, 2001	June 28, 2001	October 22, 2001
90.1r	April 1, 2001	June 24, 2001	September 17, 2001
90.1s	January 27, 2001	February 01, 2001	May 22, 2001
90.1t	January 27, 2001	February 01, 2001	May 22, 2001
90.1u	January 27, 2001	February 01, 2001	May 22, 2001
90.1v	April 1, 2001	June 24, 2001	September 17, 2001
90.1w	January 27, 2001	February 01, 2001	May 22, 2001
90.1y	January 27, 2001	February 01, 2001	May 22, 2001
90.1z	January 27, 2001	February 01, 2001	May 22, 2001
90.1aa	January 27, 2001	February 01, 2001	May 22, 2001
90.1ab	January 27, 2001	February 01, 2001	May 22, 2001
90.1ac	January 27, 2001	February 01, 2001	May 22, 2001
90.1ad	June 23, 2001	June 28, 2001	September 17, 2001
90.1af	June 27, 2001	June 28, 2001	September 17, 2001
90.1ag	April 1, 2001	June 24, 2001	September 17, 2001
90.1ah	June 27, 2001	June 28, 2001	September 17, 2001
90.1ai	April 1, 2001	June 24, 2001	September 17, 2001
90.1ak	April 1, 2001	June 24, 2001	September 17, 2001
90.1al	April 1, 2001	June 24, 2001	September 17, 2001
90.1am	June 27, 2001	June 28, 2001	October 11, 2001
90.1an	April 1, 2001	June 24, 2001	September 17, 2001
90.1ao	April 1, 2001	June 24, 2001	September 17, 2001
90.1ap	April 1, 2001	June 24, 2001	September 17, 2001

NOTICE

INSTRUCTIONS FOR SUBMITTING A PROPOSED CHANGE TO THIS STANDARD UNDER CONTINUOUS MAINTENANCE

This standard is maintained under continuous maintenance procedures by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. SSPC consideration will be given to proposed changes according to the following schedule:

Deadline for receipt of proposed changes	SSPC will consider proposed changes at next
February 20	ASHRAE Annual Meeting (normally June)

Proposed changes must be submitted to the Manager of Standards (MOS) in the latest published format available from the MOS. However, the MOS may accept proposed changes in an earlier published format, if the MOS concludes that the differences are immaterial to the proposed changes. If the MOS concludes that the current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

Specific changes in text or values are required and must be substantiated. The Manager of Standards will return to the submitter any change proposals that do not meet these requirements. Supplemental background documents to support changes submitted may be included.

FORM FOR SUBMITTAL OF PROPOSED CHANGE TO ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

(Please type)

1. Submitter: ____
   (name-type)

   Affiliation: ____

   Address: ______________________________ City: _________________ State: _______ Zip: ________

   Telephone: ____________________ __ Fax: _________________ E-Mail: _______________________

I hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) the non-exclusive royalty rights, including non-exclusive royalty rights in copyright, in my proposals and I understand that I acquire no rights in publication of this standard in which my proposal in this or other similar analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Author's Signature: ____ Date: _______________

NOTE: Use a separate form for each comment, completing each section (including Sections 1 and 2) to facilitate processing.

2. Number and Year of Standard:

3. Clause (i.e., Section), Subclause or Paragraph Number, and Page Number:

4. I Propose To: [ ] Change to read as shown [ ] Delete and substitute as shown
   (check one) [ ] Add new text as shown [ ] Delete without substitution

---

(Indicate the proposed change by showing a strikeout line through material to be deleted and underlining material to be added. After showing the text to be changed, insert a horizontal line and state the purpose, reason, and substantiation for the proposed change. Use additional pages if necessary.)

5. Proposed Change:

6. Purpose, Reason, and Substantiation Statements:
   (Be brief; provide abstracts of lengthy substantiation; full text should be enclosed for reference on request by project committee members.)

[ ] Check if additional pages are attached. Number of additional pages: ______

NOTE: Use separate form for each comment. Submittals (MS Word 7 preferred) may be attached to e-mail (preferable), submitted on diskettes, or submitted in paper form by mail or fax to ASHRAE, Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
E-mail: change.proposal@ashrae.org. Fax: 404-321-5478

ELECTRONIC PREPARATION/SUBMISSION OF FORM FOR PROPOSING CHANGES

An electronic version of each change, which must comply with the instructions in the Notice and the Form, is the preferred form of submittal to ASHRAE Headquarters at the address shown below. The electronic format facilitates both paper-based and computer-based processing. Submittal in paper form is acceptable. The following instructions apply to change proposals submitted in electronic form.

Use the appropriate file format for your word processor and save the file in either Microsoft Word 7 (preferred) or higher or WordPerfect 5.1 for DOS format. Please save each change proposal file with a different name (example, prop001.doc, prop002.doc, etc., for Word files-prop001.wpm, prop002.wpm, etc., for WordPerfect files). If supplemental background documents to support changes submitted are included, it is preferred that they also be in electronic form as wordprocessed or scanned documents.

Electronic change proposals may be submitted either as files (MS Word 6 preferred) attached to an e-mail (uuencode preferred) or on 3.5" floppy disk. ASHRAE will accept the following as equivalent tot he signature required on the change submittal form to convey non-exclusive copyright:

Files attached to e-mail:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg), or e-mail address.
Files on disk:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg), listing of the submitter's e-mail address on the change submittal form, or a letter with submitter's signature accompanying the disk or sent by facsimile (single letter may cover all of proponent's proposed changes).

Submit e-mail or disks containing change proposal files to:
Manager of Standards
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
E-mail: change.proposal@ashrae.org
(Alternatively, mail paper versions to ASHRAE address or Fax: 404-321-5478.)

The form and instructions for electronic submittal may be obtained from the Standards section of ASHRAE's Home Page, http://www.ashrae.org, or by contacting a Standards Secretary, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. Phone: 404-636-8400. Fax: 404-321-5478.
Email: standards.section@ashrae.org.

POLICY STATEMENT DEFINING ASHRAEíS CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its membersí activities on both the indoor and outdoor environment. ASHRAEís members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAEís short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its ***Handbook***, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the systemís intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAEís primary concern for environmental impact will be at the site where equipment within ASHRAEís scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

86245
PC 12/03
Errata noted in lists dated 5/8/03 and 11/10/03 have been corrected.

ANSI/ASHRAE/IESNA Addendum *a* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Addendum *a* was approved by the ASHRAE Standards Committee January 25, 2003; by the ASHRAE Board of Directors January 30, 2003; and by the American National Standards Institute April 3, 2003.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAEís Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

When addenda or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE web site at http://xp20.ashrae.org/standards/addenda.htm or http://xp20.ashrae.org/standards/intpstd.htm.

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1

Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
David Duly
Douglas S. Erickson*
Thomas A. Farkas
Charles R. Foster, III*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*

Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
Samantha Hollomon
William G. Holy*
Graham C. Hunter, II*
J. Delaine Jones*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*

Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Robert D. Ross*
Donald L. Sampler*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

Requirements for transformers were deleted from a prior draft of the standard, and Section 4.4.7 was inadvertently not deleted at the same time transformer requirements were deleted. Without the transformer requirements in Section 8, or any sort of indication as to how transformers were to be labeled, the requirement for labeling transformers with their "energy-efficiency level" in Section 4.4.7 became meaningless or confusing.

Addendum 90.1*a* (I-P and SI Editions)

Delete Section 4.4.7 in its entirety:

~~4.4.7 **Transformers.** The energy-efficiency level shall be identified on a permanent nameplate installed on the *transformer* by the manufacturer.~~

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *b* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee June 22, 2002; by the ASHRAE Board of Directors June 27, 2002; and by the American National Standards Institute July 30, 2002.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

When addenda or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE Home Page at *www.ashrae.org/STANDARDS/ addenda.htm* or *www.ashrae.org/STANDARDS/intpstd.htm*.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Larry G. Spielvogel, *Chair**
Don L. Beaty, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Albert R. Barfield*
Albert W. Black, III*
Valerie Block*
Ernest A. Conrad
Charles Cottrell*
Roy Crane*
Joseph J. Deringer*
David Duly
Douglas S. Erickson*
Charles R. Foster, III*
Alan Fraser*
James A. Garrigus*
Jason Glazer*
Ashok Gupta
Randall T. Higa*
Billy G. Hinton*
John F. Hogan*
Samantha Hollomon*

William Holy*
Graham C. Hunter*
J. Delaine Jones*
Hyman M. Kaplan*
Gersil N. Kay*
Steven D. Kennedy*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim Ranfone*
Eric E. Richman*

Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
Donald L. Sampler*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Donald F. Steiner*
Joseph K. Ting*
T. Ming Tran*
Cedric S. Trueman*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Jerry W. White, Jr.*
Robin Wilson*
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*
Michael W. Woodford

**Denotes members of voting status when the document was approved for publication*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(This foreword is provided for information only and is not part of the addendum.)

FOREWORD

The existing language gives an unfair advantage to competing products when one of the products has a certification program in existence and the other does not. For example, there are small cooling towers that compete with air-cooled equipment. The cooling towers have an optional certification program, but no program exists for competing air-cooled equipment. The current language would force the added burden of certification onto all cooling towers, whereas no added burden would be placed on air-cooled equipment. The proposed language addresses this issue for cooling towers by requiring them to meet the same requirements as air-cooled equipment. Additionally, the current language was adjusted to avoid conflict with Department of Energy certification requirements for equipment covered by the Federal Energy Policy Act (EPACT) of 1992.

Notice: *ASHRAE now has a list server for Standing Standards Project Committee 90.1 (SSPC 90.1). Interested parties can now subscribe and unsubscribe to the list server and be automatically notified via e-mail when activities and information related to the Standard and the User's Manual is available. To sign up for the list server please vist Standards List Servers on the Standards and Codes section of the ASHRAE website at http://www.ashrae.org/STANDARDS/listservers.htm.*

Addendum 90.1b (I-P and SI editions)

6.2.1 Mechanical Equipment Efficiency. Equipment shown in Tables 6.2.1A through 6.2.1G shall have a minimum performance at the specified rating conditions when tested in accordance with the specified test procedure. Omission of minimum performance requirements for equipment not listed in Tables 6.2.1A through 6.2.1G does not preclude use of such equipment. Equipment not listed in Tables 6.2.1A through 6.2.1G has no minimum performance requirements. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements, unless otherwise exempted by footnotes in the table. However, equipment covered under the Federal Energy Policy Act (EPACT) of 1992 shall have no minimum efficiency requirements for operation at minimum capacity or other than standard rating conditions. Equipment used to provide water heating functions as part of a combination system shall satisfy all stated requirements for the appropriate space heating or cooling category.

Equipment covered under the Federal Energy Policy Act of 1992 (EPACT) shall comply with U.S. Department of Energy certification requirements. For other equipment, i~~I~~f a certification program exists for a product covered in Tables 6.2.1A through 6.2.1~~G~~F, and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be either listed in the certification program or, alternatively, the ratings shall be verified by an independent laboratory test report. If no certification program exists for a product covered in Tables 6.2.1A through 6.2.1~~G~~F, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Products covered in Table 6.2.1G shall have efficiency ratings supported by data furnished by the manufacturer. Where components such as indoor or outdoor coils from different manufacturers are used, the system designer shall specify component efficiencies whose combined efficiency meets the minimum equipment efficiency requirements in 6.2.1.

Note: The reference to STD 201 in Table 6.2.1G needs to be removed, since it is the standard used in the optional certification program administered by CTI. The table should still make reference to ATC-105 as it is the actual test procedure to which cooling towers are tested.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *c* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee June 22, 2002; by the ASHRAE Board of Directors June 27, 2002; and by the American National Standards Institute July 30, 2002.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

When addenda or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE Home Page at *www.ashrae.org/STANDARDS/ addenda.htm* or *www.ashrae.org/STANDARDS/intpstd.htm*.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Larry G. Spielvogel, *Chair**
Don L. Beaty, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Albert R. Barfield*
Albert W. Black, III*
Valerie Block*
Ernest A. Conrad
Charles Cottrell*
Roy Crane*
Joseph J. Deringer*
David Duly
Douglas S. Erickson*
Charles R. Foster, III*
Alan Fraser*
James A. Garrigus*
Jason Glazer*
Ashok Gupta
Randall T. Higa*
Billy G. Hinton*
John F. Hogan*
Samantha Hollomon*

William Holy*
Graham C. Hunter*
J. Delaine Jones*
Hyman M. Kaplan*
Gersil N. Kay*
Steven D. Kennedy*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim Ranfone*
Eric E. Richman*

Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
Donald L. Sampler*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Donald F. Steiner*
Joseph K. Ting*
T. Ming Tran*
Cedric S. Trueman*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Jerry W. White, Jr.*
Robin Wilson*
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*
Michael W. Woodford

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2001-2002

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(This foreword is provided for information only and is not part of the addendum.)

FOREWORD

There are several issues that were considered in issuing this addendum:

This restriction on pressure-sensitive tape exists in Standard 90.1-1989 and is included in the ASHRAE handbook section on duct sealing. However, both of these predate the development of new UL Standard 181A (Closure Systems for Use with Rigid Air Ducts and Air Connectors) and UL Standard 181B (Closure Systems for Use with Flexible Air Ducts and Air Connectors) regarding the application of pressure-sensitive tapes. Given these UL standards, the use of pressure-sensitive tape is allowed.

The committee has requested that UL extend its standards to include sheet metal ducts. Support from the related industries is urged so testing in these areas can be expedited.

***Notice:** ASHRAE now has a list server for Standing Standards Project Committee 90.1 (SSPC 90.1). Interested parties can now subscribe and unsubscribe to the list server and be automatically notified via e-mail when activities and information related to the Standard and the User's Manual is available. To sign up for the list server please vist Standards List Servers on the Standards and Codes section of the ASHRAE website at http://www.ashrae.org/STANDARDS/listservers.htm.*

Addendum 90.1*c* (I-P and SI editions)

Modify Table 6.2.4.3B as follows:

TABLE 6.2.4.3B
Duct Seal Levels

Seal Level	Sealing Requirements[a]
A	All transverse joints, longitudinal seams, and duct wall penetrations. Pressure-sensitive tape shall not be used as the primary sealant <u>unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification</u>.
B	All transverse joints and longitudinal seams. Pressure-sensitive tape shall not be used as the primary sealant <u>unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification</u>.
C	Transverse joints only.

[a] Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod, or wire. Spiral lock seams in round and flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps, and other branch connections, access door frames and jambs, duct connections to equipment, etc.

Add UL-181A and UL-181B to Section 12, Normative References.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *d* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee June 22, 2002; by the ASHRAE Board of Directors June 27, 2002; and by the American National Standards Institute July 30, 2002.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

When addenda or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE Home Page at *www.ashrae.org/STANDARDS/ addenda.htm* or *www.ashrae.org/STANDARDS/intpstd.htm*.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Larry G. Spielvogel, *Chair**
Don L. Beaty, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Albert R. Barfield*
Albert W. Black, III*
Valerie Block*
Ernest A. Conrad
Charles Cottrell*
Roy Crane*
Joseph J. Deringer*
David Duly
Douglas S. Erickson*
Charles R. Foster, III*
Alan Fraser*
James A. Garrigus*
Jason Glazer*
Ashok Gupta
Randall T. Higa*
Billy G. Hinton*
John F. Hogan*
Samantha Hollomon*
William Holy*
Graham C. Hunter*
J. Delaine Jones*
Hyman M. Kaplan*
Gersil N. Kay*
Steven D. Kennedy*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim Ranfone*
Eric E. Richman*
Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
Donald L. Sampler*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Donald F. Steiner*
Joseph K. Ting*
T. Ming Tran*
Cedric S. Trueman*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Jerry W. White, Jr.*
Robin Wilson*
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*
Michael W. Woodford

**Denotes members of voting status when the document was approved for publication*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(This foreword is provided for information only and is not part of the addendum.)

FOREWORD

This proposal sets minimum efficiency standards for single-package vertical units (SPVU), which consist of a separate encased or unencased combination of cooling and optional heating components, factory assembled as a single package, and intended for exterior mounting at an outside wall. They include air-conditioners (SPVAC) and heat pumps (SPVHP).

Until recently, SPVUs were classified as residential products and were covered under NAECA. However, on October 5, 2000, the Department of Energy (DOE) concluded that SPVUs were commercial products covered by EPACT. Meanwhile, SPVU manufacturers have completed the development of ARI Standard 390-2001, which rates the performance of SPVUs in terms of energy efficiency ratio (EER) instead of seasonal energy efficiency ratio (SEER) to maintain consistency with EPACT-covered products. In addition, SPVU manufacturers have been working through ARI to develop an equipment certification program. The program is expected to start in January 2002.

***Notice:** ASHRAE now has a list server for Standing Standards Project Committee 90.1 (SSPC 90.1). Interested parties can now subscribe and unsubscribe to the list server and be automatically notified via e-mail when activities and information related to the Standard and the User's Manual is available. To sign up for the list server please vist Standards List Servers on the Standards and Codes section of the ASHRAE website at http://www.ashrae.org/STANDARDS/listservers.htm.*

Addendum 90.1d (I-P and SI editions)

(a) Add to Table 6.2.1D the following products (below the PTHP Equipment Type)

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Efficiency as of 01/01/2002	Test Procedure
SPVAC (Cooling Mode)	All Capacities	95°F db/ 75°F wb Outdoor Air		8.6 EER	ARI 390
SPVHP (Cooling Mode)	All Capacities	95°F db/ 75°F wb Outdoor Air		8.6 EER	
SPVHP (Heating Mode)	All Capacities	47°F db/ 43°F wb Outdoor Air		2.7 COP	

(b) Modify caption of Table 6.2.1D to read as follows:

TABLE 6.2.1D

Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, <u>Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps</u>, Room Air Conditioners, and Room Air Conditioner Heat Pumps-Minimum Efficiency Requirements

(c) Add the following reference to Section 12, Normative References (under Air Conditioning and Refrigeration Institute):

Reference	Title
ARI 390-2001	Single Package Vertical Air-Conditioners and Heat Pumps

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *e* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on January 24, 2004; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on March 31, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard

ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Samanthan H. LaFleur*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Michael L. Rosenberg
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

Certain agencies, such as the U.S. Green Building Council, have referenced Section 11, Energy Cost Budget Method, of Standard 90.1 as the benchmark for a performance rating of building designs. These agencies require the use of the Energy Cost Budget (ECB) Method in order to gain credits for certification of a building design.

The ECB Subcommittee and interested parties identified some serious problems with using Section 11 as a benchmark for above-standard design, which is something that a growing number of users are now doing. At the same time, there was a consensus among the participants in the discussion that Section 11 was appropriate, as written, for determining minimum compliance with 90.1.

There is a fundamental tension between these two uses of Section 11: for above-standard ratings and for minimum code compliance. An effective rating procedure needs to recognize the contribution of a broad range of features that can be used to make buildings more energy efficient. In contrast, an alternate path for minimum compliance cannot penalize the use of features that are permitted under the standard or reward the use of features that are outside of its scope and still represent an equivalent path. A number of users of the U.S. Green Buildings Council's LEED rating system, which is based in part on Section 11, have recognized this as a problem and brought it to the attention of members of the ECB Subcommittee.

To meet the needs of the users of Standard 90.1 as a code-compliance tool and as a benchmark for above-standard design, the ECB Subcommittee decided to develop an appendix chapter expressly for use in above-standard ratings. This appendix would be an informative one because it is not to be included as part of the minimum requirements to comply with code. The attempt is to provide a generic method, one that can be referenced by any rating agency. The result, Informative Appendix G (Performance Rating Method), parallels Section 11, on which it is based, but contains some significant differences. The rating method generates a performance benchmark that, while generally equivalent in stringency with Standard 90.1, is more stable because it is based on programmatic requirements of the project rather than on its design. Because the benchmark is more stable, a wider array of measures receive credit, and exemplary buildings will show higher ratings than under Section 11, which will bring the applicable components of the standard in line with the requirements of the various rating agencies. In addition to these changes, we identified a number of ways to clarify and streamline the use of performance methods. We hope to move some of these improvements into Section 11 in the future.

Addendum *e* to 90.1-2001 (I-P and SI editions)

Add the following new definitions to Section 3.2:

baseline building design: a computer representation of a hypothetical design based on the proposed building project. This representation is used as the basis for calculating the *baseline building performance* for rating above-standard design.

baseline building performance: the annual energy cost for a building design intended for use as a baseline for rating above-standard design.

rating authority: the organization or agency that adopts or sanctions use of this rating methodology.

regulated loads: building energy load components that are regulated by this standard. HVAC, lighting, and service water heating are regulated loads; receptacle and most process loads are not.

performance rating method: a calculation procedure that generates an index of merit for the performance of building designs that substantially exceeds the energy efficiency levels required by this standard.

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

Revise the following definition in Section 3.2:

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

Add the following new informative appendix:

(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.)

INFORMATIVE APPENDIX G PERFORMANCE RATING METHOD

G1 GENERAL

G1.1 Performance Rating Method Scope. This building performance rating method is a modification of the Energy Cost Budget (ECB) Method in Section 11 and is intended for use in rating the energy efficiency of building designs that exceed the requirements of this standard. This section does NOT offer an alternative compliance path for minimum standard compliance; that is the intent of Section 11, Energy Cost Budget Method. Rather, it is provided for those wishing to use the methodology developed for this standard to quantify performance that substantially exceeds the requirements of Standard 90.1. It may be useful for evaluating the performance of all proposed designs, including alterations and additions to existing buildings, except designs with no mechanical systems.

G1.2 Performance Rating

This performance rating method requires conformance with the following provisions:

(a) All requirements of 5.2, 6.2, 7.2, 8.2, 9.2, and 10.2 are met. These sections contain the mandatory provisions of the standard, and are prerequisites for this rating method.

(b) 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.

G1.3 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 meet the prescriptive requirements of Sections 5.3, 6.3, 7.3, and 9.3.

G1.4 Documentation Requirements. Simulated performance shall be documented, and documentation shall be submitted to the *rating authority*. 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 rating is based. This list shall document all energy features that differ between the models used in the *baseline building performance* and *proposed building performance* calculations.

(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: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for both the *proposed design* and *baseline building design*.

(d) An explanation of any error messages noted in the *simulation program* output.

G2 SIMULATION GENERAL REQUIREMENTS

G2.1 *Simulation Program*. The *simulation program* shall be a computer-based program for the analysis of energy consumption in buildings (a program such as, but not limited to, DOE-2, BLAST, or EnergyPlus). The *simulation program* shall include calculation methodologies for the building components being modeled. For components that cannot be modeled by the simulation program, the exceptional calculation methods requirements in Section G5 may be used.

G2.1.1 The *simulation program* shall be approved by the *rating authority* and shall, at a minimum, have the ability to explicitly model all of the following:

(a) 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) *baseline building design* characteristics specified in G4.

G2.1.2 The *simulation program* shall have the ability to either (1) directly determine the *proposed building performance* and *baseline building performance* or (2) produce hourly reports of energy use by an energy source suitable for determining the *proposed building performance* and *baseline building performance* using a separate calculation engine.

G2.1.3 The *simulation program* shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with generally accepted engineering standards and handbooks (for example, *ASHRAE Handbook—Fundamentals*) for both the *proposed design* and *baseline building design*.

G2.2 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 represents the climate at the construction site. The selected weather data shall be approved by the *rating authority.*

G2.3 Energy Rates. Annual energy costs shall be determined using either actual rates for purchased energy or state average energy prices published by DOE's Energy Information Administration (EIA) for commercial building customers, but rates from different sources may not be mixed in the same project.

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

Exception to G2.3: 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 back-up energy source or on the use of electricity if no back-up energy source has been specified.

G2.4 Performance Calculations. The *proposed building performance* and *baseline building performance* shall be calculated using the following:

(a) the same *simulation program,*

(b) the same weather data, and

(c) the same energy rates.

G3 CALCULATION OF THE *PROPOSED BUILDING PERFORMANCE*

G3.1 Proposed Design Model. 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.

G3.2 Space Use Classification. Usage shall be specified using the building type or space type lighting classifications in accordance with 9.3.1.1 or 9.3.1.2. 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.

G3.3 Buildings with Incomplete Energy System Designs. When the *performance rating* method is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the *proposed design* exactly as they are defined in the *baseline building design.* Where the space classification for a space is not known, the space shall be categorized as an office space.

G3.4 Requirement for Both Heating and Cooling. 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 setpoints and schedules shall be the same for *proposed* and *baseline building designs*.

G3.5 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 6.2.1 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.*

G3.6 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 to G3.6: 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. 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 E903, ASTM E1175, or ASTM E1918, and the emittance values shall be based on testing in accordance with ASTM C835, ASTM C1371, or ASTM E408. 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.

G3.7 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.

G3.8 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 9.2.4 and 9.2.5.
(c) Where lighting neither exists nor is specified, lighting power shall be determined in accordance with the building area method for the appropriate building type.
(d) Lighting system power shall include all lighting system components shown or provided for on the plans (including lamps and ballasts and task and furniture-mounted fixtures).

Exception to G3.8 (d): 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, but exclude these loads when calculating the *baseline building performance* and *proposed building performance*.

(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 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 *rating authority*.
(g) For automatic lighting controls in addition to those required for minimum code compliance under 9.2, credit may be taken for automatically controlled systems by reducing the connected lighting power by the applicable percentages listed in Table G3.8. 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 *rating authority*.

G3.9 Receptacle 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 *rating authority*. These loads shall be included in simulations of the building and shall be included when calculating the *baseline building performance* and *proposed building performance*.

G3.10 Further Modeling Limitations and Exceptions

G3.10.1 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.

G3.10.2 Alterations and Additions. It is acceptable to demonstrate compliance using building models that exclude parts of the existing building provided that all of the following conditions are met:

(a) Work to be performed in excluded parts of the building shall meet the requirements of Sections 5 through 10.
(b) Excluded parts of the building are served by *HVAC systems* that are entirely separate from those serving parts of the building that are included in the building model.
(c) Design space temperature and HVAC system operating setpoints 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.

G3.11 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 *rating authority*. Schedules shall be identical for the *proposed design* and *baseline building design*.

TABLE G3.8
Power Adjustment Percentages for Automatic Lighting Controls

Automatic Control Devices(s)	Non 24 h & <=5,000 ft^2 (460 m^2)	All Other
(1) Programmable timing control	10%	0%
(2) Occupancy sensor	15%	10%
(3) Occupancy sensor and programmable timing control	15%	10%

Notes: The 5,000 ft^2 (460 m^2) condition pertains to the total conditioned floor area of the building.

Exception to G3.11: Schedules may be allowed to differ between *proposed design* and *baseline building design* when necessary to model nonstandard efficiency measures, provided that the revised schedules have the approval of the *rating authority.* Measures that may warrant use of different schedules include, but are not limited to, lighting controls, natural ventilation, demand control ventilation, and measures that reduce service water heating loads.

G3.11.1 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.

Exception to G3.11.1: Where no heating and/or cooling system is to be installed and a heating or cooling system is being simulated only to meet the requirements described in Section G3.4, 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.

G3.12 Thermal Blocks

G3.12.1 *HVAC Zones* Designed. Where *HVAC zones* are defined on HVAC design drawings, each HVAC zone shall be modeled as a separate *thermal block*.

Exception to G3.12.1: 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*.

G3.12.2 *HVAC Zones* Not Designed. Where the *HVAC zones* and systems have not yet been designed, *thermal blocks* shall be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following guidelines:

(a) separate *thermal blocks* shall be assumed for interior and perimeter spaces. Interior spaces shall be those located greater than 15 ft (5 m) from an exterior wall. Perimeter spaces shall be those located within 15 ft (5 m) of an exterior wall.

(b) separate *thermal blocks* shall be assumed for spaces adjacent to glazed exterior walls; a separate zone shall be provided for each orientation, except that orientations that differ by less than 45 degrees may be considered to be the same orientation. Each zone shall include all floor area that is 15 ft (5 m) or less from a glazed perimeter wall, except that floor area within 15 ft (5 m) of glazed perimeter walls having more than one orientation shall be divided proportionately between zones.

(c) separate *thermal blocks* shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.

(d) separate *thermal blocks* shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

G3.12.3 *Thermal Blocks* in 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.

G4 CALCULATION OF THE *BASELINE BUILDING PERFORMANCE*

G4.1 *Baseline Building* Envelope. The *baseline building design* shall be modeled with the same number of floors and identical conditioned floor area as the *proposed design*. 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, light-weight assembly types and shall match the appropriate assembly maximum U-factors in Tables B-1 through B-26:
- 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 to 4.1.2.2.1.

(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 B-1 through B-26 for the applicable vertical glazing percentage for U_{fixed}. Fenestration solar heat gain coefficient (SHGC) shall match the appropriate requirements in Tables B-1 through B-26 using the value for $SHGC_{all}$ for the applicable vertical glazing percentage. All vertical glazing shall be modeled as fixed and shall be assumed to be flush with the exterior wall, and no shading projections shall be modeled. Manual window shading devices such as blinds or shades shall not be modeled. The fenestration areas for envelope alterations shall reflect the limitations on area, U-factor, and SHGC as described in 4.1.2.2.1.

(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. 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 B-1 through B-26.

(e) *Roof Albedo*. All 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.

G4.2 *Baseline* HVAC Systems. The HVAC system(s) in the *baseline building design* shall be of the type and description specified in G4.2.1, shall meet the general HVAC system requirements specified in G4.2.2, and shall meet any system-specific requirements in G4.2.3 that are applicable to the *baseline* HVAC system type(s).

G4.2.1 *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 G4.2.1A, and shall conform with the system descriptions in Table G4.2.1B.

TABLE G4.2.1A
Baseline HVAC System Types

Heating Source	Residential	Nonresidential & Three Floors or Less & <75,000 ft^2 (7,000 m^2)	Nonresidential & Four or Five Floors & <75,000 ft^2 (7,000 m^2) or Five Floors or Less & 75,000 ft^2 (7,000 m^2) to 150,000 ft^2 (14,000 m^2)	Nonresidential & More than Five Floors or >150,000 ft^2 (14,000 m^2)
Fossil Fuel, Fossil/Electric Hybrid & Purchased Heat	Sys. 1—PTAC	Sys. 3—PSZ-AC	Sys. 5—Packaged VAV w/ Reheat	Sys. 7—VAV w/Reheat
Electric and Other	Sys. 2—PTHP	Sys. 4—PSZ-HP	Sys. 6—Packaged VAV w/ PFP Boxes	Sys. 8—VAV w/PFP Boxes

Notes:
1. Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.
2. Where no heating system is to be provided or no heating energy source is specified, use the “Electric and Other” heating source classification.
3. 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.

TABLE G4.2.1B
Baseline System Descriptions

	System 1 – PTAC	System 3 – PSZ – AC	System 5 – Packaged VAV w/ Reheat	System 7 – VAV w/Reheat
System Type	Packaged terminal air conditioner	Packaged rooftop air conditioner	Packaged rooftop variable air volume with reheat	Variable air volume with reheat
Fan Control	Constant Volume	Constant Volume	VAV	VAV
Cooling Type	Direct Expansion	Direct Expansion	Direct Expansion	Chilled Water
Heating Type	Hot Water Fossil Fuel Boiler	Fossil Fuel Furnace	Hot Water Fossil Fuel Boiler	Hot Water Fossil Fuel Boiler

	System 2 – PTHP	System 4 – PSZ – HP	System 6 – Packaged VAV w/ PFP Boxes	System 8 – VAV w/ PFP Boxes
System Type	Packaged terminal heat pump	Packaged rooftop heat pump	Packaged rooftop variable air volume with reheat	Variable air volume with reheat
Fan Control	Constant Volume	Constant Volume	VAV	VAV
Cooling Type	Direct Expansion	Direct Expansion	Direct Expansion	Chilled Water
Heating Type	Electric Heat Pump	Electric Heat Pump	Electric Resistance	Electric Resistance

Exceptions to G4.2.1:

(a) Use additional system type(s) for nonpredominant conditions (i.e., residential/nonresidential or heating source) if those conditions apply to more than 20,000 ft^2 (1900 m^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 10 Btu/h·ft^2 (31.2 W/m^2) or more from the average of other spaces served by the system or schedules that differ by more than 40 equivalent full-load hours per week from other spaces served by the system are considered to differ significantly. Examples where this exception may be applicable include, but are not limited to, computer server rooms, natatoriums, and continually occupied security areas.

(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.

G4.2.1.1 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*.

G4.2.2 General *Baseline* HVAC System Requirements. HVAC Systems in the *baseline building design* shall conform with the general provisions in this section.

G4.2.2.1 Equipment Efficiencies. All HVAC equipment in the *baseline building design* shall be modeled at the minimum efficiency levels—both part load and full load—in accordance with Section 6.2. 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.

G4.2.2.2 Equipment Capacities. The equipment capacities for the *baseline building design* shall be based on sizing runs for each orientation (per Section G4.1a) 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 *rating authority* provided that sufficient justification is given indicating that the accuracy of the simulation is not significantly compromised by these unmet loads.

G4.2.2.2.1 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.

G4.2.2.3 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*.

G4.2.2.4 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.

G4.2.2.5 Ventilation. Minimum outdoor air ventilation rates shall be the same for the *proposed* and *baseline building designs.*

Exception to G4.2.2.5: When modeling demand-control ventilation in the *proposed design* when its use is not required by 6.2.3.8.

G4.2.2.6 Economizers. Outside air economizers shall not be included in *baseline* HVAC Systems 1 and 2. Outside air economizers shall be included in *baseline* HVAC System 3 and 4 as specified in Table G4.2.2.6A based on building-conditioned floor area, whether the zone served is an interior or perimeter zone, and climate. Outside air economizers shall be included in *baseline* HVAC Systems 5 through 8 based on climate as specified in Table G4.2.2.6B. Any zone having more than half of its floor area more than 15 ft (5 m) from a glazed exterior wall is considered an interior zone for purposes of applying Tables G4.2.2.6A and G4.2.2.6B.

Exceptions to G4.2.2.6: Economizers shall not be included for systems meeting one or more of the exceptions listed below.

(a) Systems that include gas phase air cleaning to meet the requirements of 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 G4.2.2.6A (I-P)
Minimum Building-Conditioned Floor Areas at which Economizers are Included for Baseline Systems 3 and 4

No. of Hours Between 8 a.m. and 4 p.m. with 55°F < T_{db} < 69°F	Minimum Building-Conditioned Floor Area (ft²) at which Economizers are Included					
	1% Cooling Design Wet-Bulb Temperature					
	T_{wb} < 69°F		69°F ≤ T_{wb} ≤ 73°F		T_{wb} > 73°F	
Type of Zone	Interior	Perimeter	Interior	Perimeter	Interior	Perimeter
0-199	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
200-599	15,000	N.R.	N.R.	N.R.	N.R.	N.R.
600-799	10,000	25,000	15,000	N.R.	N.R.	N.R.
800-999	10,000	25,000	15,000	N.R.	15,000	N.R.
1000-1199	10,000	25,000	10,000	25,000	15,000	N.R.
>1199	10,000	25,000	10,000	25,000	10,000	25,000
High-Limit Dry-Bulb Shutoff	75°F		70°F		65°F	

T_{db} = 1% cooling design dry-bulb temperature.
T_{wb} = 1% cooling design wet-bulb temperature.
N.R. means that there is no conditioned building floor area for which economizers are included for the type of zone and climate.

TABLE G4.2.2.6A (SI)
Minimum Building-Conditioned Floor Areas at which Economizers are Included for Baseline Systems 3 and 4

No. of Hours Between 8 a.m. and 4 p.m. with 13°C < T_{db} < 21°C	Minimum Building-Conditioned Floor Area (m²) at which Economizers are Included					
	1% Cooling Design Wet-Bulb Temperature					
	T_{wb} < 21°C		21°F ≤ T_{wb} ≤ 23°C		T_{wb} > 23°C	
Type of Zone	Interior	Perimeter	Interior	Perimeter	Interior	Perimeter
0-199	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
200-599	1,400	N.R.	N.R.	N.R.	N.R.	N.R.
600-799	900	2,300	1,400	N.R.	N.R.	N.R.
800-999	900	2,300	1,400	N.R.	1,400	N.R.
1000-1199	900	2,300	900	2,300	1,400	N.R
>1199	900	2,300	900	2,300	900	2,300
High-Limit Dry-Bulb Shutoff	24°C		21°C		18°C	

T_{db} = 1% cooling design dry-bulb temperature.
T_{wb} = 1% cooling design wet-bulb temperature.
N.R. means that there is no conditioned building floor area for which economizers are included for the type of zone and climate.

TABLE G4.2.2.6B (I-P)
Climate Conditions Under which Economizers are Included for Baseline Systems 5 through 8

No. of Hours Between 8 a.m. and 4 p.m. with 55°F < T_{db} < 69°F	1% Cooling Design Wet-Bulb Temperature		
	T_{wb} < 69°F	69°F ≤ T_{wb} ≤ 73°F	T_{wb} > 73°F
0-199	N.R.	N.R.	N.R.
200-599	Economizer Included	N.R.	N.R.
600-799	Economizer Included	Economizer Included	N.R.
>800	Economizer Included	Economizer Included	Economizer Included
High-Limit Dry-Bulb Shutoff	75°F	70°F	65°F

T_{db} = 1% cooling design dry-bulb temperature.
T_{wb} = 1% cooling design wet-bulb temperature.
N.R. means that economizers are not included for these climates.

TABLE G4.2.2.6B (SI)
Climate Conditions Under which Economizers are Included for Baseline Systems 5 through 8

No. of Hours Between 8 a.m. and 4 p.m. with 13°C < T_{db} < 21°C	1% Cooling Design Wet-Bulb Temperature		
	T_{wb} < 21°C	21°C ≤ T_{wb} ≤ 23°C	T_{wb} > 23°C
0-199	N.R.	N.R.	N.R.
200-599	Economizer Included	N.R.	N.R.
600-799	Economizer Included	Economizer Included	N.R.
>800	Economizer Included	Economizer Included	Economizer Included
High-Limit Dry-Bulb Shutoff	24°C	21°C	18°C

T_{db} = 1% cooling design dry-bulb temperature.
T_{wb} = 1% cooling design wet-bulb temperature.
N.R. means that economizers are not included for these climates.

TABLE G4.2.2.9
Baseline Fan Brake Horsepower

Supply Air Volume	*Baseline* Fan Motor Brake Horsepower	
	Constant Volume Systems 1 – 4	Variable Volume Systems 5 – 6
< 20,000 cfm (9400 L/s)	17.25 + (cfm – 20000) × 0.0008625	24 + (cfm – 20000) × 0.0012
>= 20,000 cfm (9400 L/s)	17.25 + (cfm – 20000) × 0.000825	24 + (cfm – 20000) × 0.001125

G4.2.2.7 Economizer High-Limit Shutoff. The high-limit shutoff shall be a dry-bulb switch with setpoint temperatures in accordance with the values listed at the bottom of Tables G4.2.2.6A and G4.2.2.6B.

G4.2.2.8 Design Airflow Rates. System design supply airflow rates for the *baseline building design* shall be based on a supply-air-to-room-air temperature difference of 20°F (11°C). If return or relief fans are specified in the *proposed design*, the *baseline building design* shall also be modeled with fans serving the same functions and sized for the *baseline* system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.

G4.2.2.9 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:

$$P_{fan} = 746 / (1 - \exp[-0.2437839 \times \ln(\text{bhp}) - 1.685541]) \times \text{bhp}$$

where

P_{fan} = electric power to fan motor (watts)

bhp = brake horsepower of *baseline* fan motor from Table G4.2.2.9

where

cfm = design supply flow rate.

Exception to 4.2.2.9. If systems in the *proposed design* require air filtering systems with pressure drops in excess of 1 in.w.c. when filters are clean, the allowable fan system power in the *baseline design* system serving the same space may be increased using the following pressure credit:

$$\text{Pressure Credit (Watts)} = CFM_{filter} * (Sp_{filter} - 1)/4.984$$

where

CFM_{filter} = supply air volume of the proposed system with air filtration system in excess on 1 in.w.c.

Sp_{filter} = air pressure drop of the filtering system in w.g. when the filters are clean.

G4.2.2.10 Exhaust Air Energy Recovery. Individual fan systems that have both a design supply air capacity of 5000 cfm (2400 L/s) or greater and have a minimum outside air supply of 70% or greater of the design supply air quantity shall have an energy recovery system with at least 50% recovery effectiveness. Fifty percent energy recovery effectiveness shall mean a change in the enthalpy of the outdoor air supply equal to 50% of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the heat-recovery system to permit air economizer operation, where applicable.

Exceptions to G4.2.2.10: 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 60°F (16°C).

(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) Commercial kitchen hoods (grease) classified as Type 1 by NFPA 96. This exception shall only be used if exhaust air energy recovery is not used in the *proposed design*.

(d) Heating systems in climates with less than 3600 HDD65 (2000 HDD18).

(e) Cooling systems in climates with a 1% cooling design wet-bulb temperature less than 64°F (18°C).

(f) Where the largest exhaust source is less than 75% of the design outdoor airflow. This exception shall be used only if exhaust air energy recovery is not used in the *proposed design*.

(g) Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil. This exception shall be used only if exhaust air energy recovery and series-style energy recovery coils are not modeled in the *proposed design*.

G4.2.3 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.

G4.2.3.1 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 outside air temperature is less than 40°F (4°C).

G4.2.3.2 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 G4.2.1.1. The *baseline building design* boiler plant shall be modeled as having a single boiler if the *baseline building design* plant serves a conditioned floor area of 15,000 ft^2 (1,400 m^2) or less and as having two equally sized boilers for plants serving more than 15,000 ft^2 (1,400 m^2). Boilers shall be staged as required by the load.

G4.2.3.3 Hot Water Supply Temperature (Systems 1, 5, and 7). Hot water design supply temperature shall be modeled as 180°F (82°C), and design return temperature as 130°F (54°C).

G4.2.3.4 Hot Water Supply Temperature Reset (Systems 1, 5, and 7). Hot water supply temperature shall be reset based on outside dry-bulb temperature using the following schedule: 180°F @ 20°F (82°C @ –7°C) and below, 150°F @ 50°F (66°C @ 10°C) and above, and ramped linearly between 180°F (82°C) and 150°F (66°C) at temperatures between 20°F (–7°C) and 50°F (10°C).

G4.2.3.5 Hot Water Pumps (Systems 1, 5, and 7). The *baseline building design* hot water pump power shall be 19 W/gpm (301 kW/1000 L/s). The pumping system shall be modeled as primary-only with continuous variable flow. Hot water systems serving 120,000 ft^2 (11,148 m^2) or more shall be modeled with variable-speed drives, and systems serving less than 120,000 ft^2 (11,148 m^2) shall be modeled as riding the pump curve.

G4.2.3.6 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.

G4.2.3.7 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 G4.2.3.7 as a function of building conditioned floor area.

G4.2.3.8 Chilled Water Design Supply Temperature (Systems 7 and 8). Chilled water design supply temperature shall be modeled at 44°F (6.7°C), and return water temperature at 56°F (13°C).

G4.2.3.9 Chilled Water Supply Temperature Reset (Systems 7 and 8). Chilled water supply temperature shall be reset based on outside dry-bulb temperature using the following schedule: 44°F @ 80°F (7°C @ 27°C) and above, 54°F @ 60°F (12°C @ 16°C) and below, and ramped linearly between 44°F (7°C) and 54°F (12°C) at temperatures between 80°F (27°C) and 60°F (16°C).

G4.2.3.10 Chilled Water Pumps (Systems 7 and 8). The *baseline building design* pump power shall be 22 W/gpm (349 kW/1000 L/s). Chilled water systems serving 120,000 ft^2 (11,148 m^2) 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 120,000 ft^2 (11,148 m^2) shall be modeled as a primary/secondary system with secondary pump riding the pump curve.

G4.2.3.11 Heat Rejection (Systems 7 and 8). The heat rejection device shall be an axial fan cooling tower with two-speed fans. Condenser water design supply temperature shall be 85°F (29°C) or 10°F (5.6°C) approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F (5.6°C). The tower shall be controlled to maintain a 70°F (21°C) leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The *baseline building design* condenser water pump power shall be 19 W/gpm (301 kW/1000 L/s). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

TABLE G4.2.3.7
Type and Number of Chillers

Building-Conditioned Floor Area	Number and Type of Chiller(s)
≤120,000 ft^2 (≤11,148 m^2)	1 screw chiller
>120,000 ft^2, <240,000 ft^2 (>11,148 m^2, <22,296 m^2)	2 screw chillers sized equally
≥240,000 ft^2 (≥22,296 m^2)	2 centrifugal chillers minimum with chillers added so that no chiller is larger than 800 tons (2813 kW), all sized equally

TABLE G4.2.3.15
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).

G4.2.3.12 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 10°F (5.6°C) temperature difference under minimum load conditions. Design airflow rates shall be sized for the reset supply air temperature; i.e., a 10°F (5.6°C) temperature difference.

G4.2.3.13 VAV Minimum Flow Setpoints (System 5 and 7). Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft^2 (2.15 L/s·m^2) of floor area served.

G4.2.3.14 Fan Power (System 6 and 8). Fans in parallel VAV fan-powered boxes shall be sized for 50% of the peak design flow rate and shall be modeled with 0.35 W/cfm (0.74 W per L/s) fan power. Minimum volume setpoints for fan-powered boxes shall be equal to 30% of peak design flow rate or the rate required to meet the minimum outside air ventilation requirement, whichever is larger. The supply air temperature setpoint shall be constant at the design condition.

G4.2.3.15 VAV Fan Part-Load Performance (Systems 5 through 8). VAV systems 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 G4.2.3.15.

G4.3 *Baseline* Service Hot Water Systems. 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 equipment shall match the minimum efficiency requirements in Section 7.2. 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 Section 7.2 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 meeting the minimum efficiency requirements applicable to each system individually.

G4.3.1 Heat Recovery for Service Water Heating. For large, 24-hour per day facilities that meet the prescriptive criteria for use of condenser heat recovery systems described in Section 6.3.6.2, a system meeting the requirements of that section shall be included in the *baseline building design* regardless of the exceptions to 6.3.6.2.

Exception to G4.3.1: If a condenser heat recovery system meeting the requirements described in Section 6.3.6.2 cannot be modeled, the requirement for including such a system in the actual building shall be met as a prescriptive requirement in accordance with 6.3.6.2, and no heat-recovery system shall be included in the *proposed* or *baseline building designs*.

G4.4 *Baseline* Lighting Systems. 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 9.3. No automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in the *baseline building design* because the lighting schedules used are understood to reflect the mandatory control requirements in this standard.

G4.5 Other *Baseline* Systems. Other systems, such as motors covered by Section 10, and miscellaneous loads shall be modeled as identical to those in the *proposed design*. Where there are specific efficiency requirements in Section 10, these systems or components shall be modeled as having the lowest efficiency allowed by those requirements.

G5 EXCEPTIONAL CALCULATION METHODS

Where no *simulation program* is available that adequately models a design, material, or device, the *rating authority* 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.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *g* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 28, 2003; by the ASHRAE Board of Directors on July 3, 2003; and by the American National Standards Institute on August 6, 2003.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
Samantha H. LaFleur
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2002-2003

Thomas E. Watson, *Chair*
Van D. Baxter, *Vice-Chair*
Charles G. Arnold
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Brian P. Dougherty
Hakim Elmahdy
Arthur D. Hallstrom
Matt R. Hargan
Richard D. Hermans
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
William J. Landman
Merle F. McBride
Ross D. Montgomery
Cyrus H. Nasseri
Davor Novosel
Dennis A. Stanke
Michael H. Tavares
Steven T. Taylor
David R. Tree
Terry E. Townsend, *CO*
Maureen Grasso, *ExO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This revision of Table 9.3.1.1 and replacement of Table 9.3.1.2 represent a complete update of the LPD values in the tables based on a comprehensive review of the inputs to the space and building models used to derive these values. The review included recent research data on fluorescent fixture light loss factors and space type characteristics of new commercial construction, as well as revised lighting level recommendations as published in the IESNA Lighting Handbook, *9th edition. The review covered all model inputs and applied current knowledge of lighting principles, design applications, and efficient equipment availability.*

- ***Light level inputs.*** *Each of the 124 individual space models was reviewed and both task lighting and general lighting levels compared with the new IESNA 9th edition recommendations. Changes were made where appropriate.*
- ***Applied lighting technologies.*** *Each of the 124 individual space models incorporates up to three specific lighting technologies represented by generic luminaire (fixture) types. Changes were made to more appropriate technologies where current design practice warranted.*
- ***Lighting technology application formula.*** *The formula was revised to directly weight the technologies by lumen output of each technology, providing a more accurate assessment of power needs for all technology types.*
- ***Lighting technology efficiencies and light loss factors.*** *The lamp efficacy for each of the 35 generic luminaire/fixture types and the associated lamp lumen depreciation factors were reevaluated based upon current, commonly available technologies. A recent study (Luminaire Dirt Depreciation Study, July 2000, NALMCO No. CX824574-01-0) was used to update these values for most fluorescent luminaire types. The luminaire dirt depreciation value for all remaining types was reviewed against the latest* IESNA Lighting Handbook.
- ***Luminaire/fixture data.*** *The generic luminaire type performance characteristics (efficiency, etc.) are based on the actual tested characteristics of over 240 specific luminaire products. These were reviewed and generally found to be still valid. New luminaire data were incorporated where applicable.*
- ***Whole building LPD development data.*** *The proposed whole building values are derived by applying the 124 space models to detailed interior space type data on a set of 246 buildings (increased from 95).*

ADDENDUM *g* to 90.1-2001 (I-P and SI EDITIONS)

1. Revise Table 9.3.1.1 as shown to incorporate revised whole building LPD values and split the previous hospital/health care category into two separate categories. The revised LPD values reflect current light source efficiency data, recent research work on light loss factors, and the latest IESNA light level recommendations.

I-P TABLES:

TABLE 9.3.1.1
Lighting Power Densities Using the Building Area Method

Building Area Type[a]	Lighting Power Density (W/ft²)
Automotive Facility	~~1.5~~0.9
Convention Center	~~1.4~~1.2
Court House	~~1.4~~1.2
Dining: Bar Lounge/Leisure	~~1.5~~1.3
Dining: Cafeteria/Fast Food	~~1.8~~1.4
Dining: Family	~~1.9~~1.6
Dormitory	~~1.5~~1.0
Exercise Center	~~1.4~~1.0
Gymnasium	~~1.7~~1.1
Healthcare-Clinic	1.0
Hospital~~/Healthcare~~	~~1.6~~1.2
Hotel	~~1.7~~1.0
Library	~~1.5~~1.3
Manufacturing Facility	~~2.2~~1.3
Motel	~~2.0~~1.0
Motion Picture Theatre	~~1.6~~1.2
Multi-Family	~~1.0~~0.7
Museum	~~1.6~~1.1
Office	~~1.3~~1.0
Parking Garage	0.3
Penitentiary	~~1.2~~1.0
Performing Arts Theatre	~~1.5~~1.6
Police/Fire Station	~~1.3~~1.0
Post Office	~~1.6~~1.1
Religious Building	~~2.2~~1.3
Retail	~~1.9~~1.5
School/University	~~1.5~~1.2
Sports Arena	~~1.5~~1.1
Town Hall	~~1.4~~1.1
Transportation	~~1.2~~1.0
Warehouse	~~1.2~~0.8
Workshop	~~1.7~~1.4

a In cases where both general building area type and a specific building area type are listed, the specific building area type shall apply.

2. ***Replace Table 9.3.1.2 with the following new table to incorporate revised space-by-space LPD values and provide a table format that includes the same space categories as the previous table but in a clearer, easier-to-use format. These revised LPD values reflect current light source efficiency data, recent research on light loss factors, and the latest IESNA light level recommendations.***

TABLE 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method

Space-by-Space Method Lighting Power Density (LPD)			
Common Space Types[a]	**LPD (W/ft^2)**	**Building Specific Space Types (Continued)**	**LPD (W/ft^2)**
Office-enclosed	1.1	Fire Stations	
Office-open plan	1.1	Fire Station Engine room	0.8
Conference/ Meeting/ Multipurpose	1.3	Sleeping Quarters	0.3
Classroom/ Lecture/ Training	1.4	Post Office - Sorting Area	1.2
For Penitentiary	1.3	Convention Center - Exhibit Space	1.3
Lobby	1.3	Library	
For Hotel	1.1	Card File & Cataloguing	1.1
For Performing Arts Theater	3.3	Stacks	1.7
For Motion Picture Theatre	1.1	Reading Area	1.2
Audience/ Seating Area	0.9	Hospital	
For Gymnasium	0.4	Emergency	2.7
For Exercise Center	0.3	Recovery	0.8
For Convention Center	0.7	Nurse station	1.0
For Penitentiary	0.7	Exam/Treatment	1.5
For Religious Buildings	1.7	Pharmacy	1.2
For Sports Arena	0.4	Patient Room	0.7
For Performing Arts Theatre	2.6	Operating Room	2.2
For Motion Picture theatre	1.2	Nursery	0.6
For Transportation	0.5	Medical Supply	1.4
Atrium-first three floors	0.6	Physical Therapy	0.9
Atrium-each additional floor	0.2	Radiology	0.4
Lounge/Recreation	1.2	Laundry-Washing	0.6
For Hospital	0.8	Automotive – Service/Repair	0.7
Dining area	0.9	Manufacturing	
For Penitentiary	1.3	Low Bay (<25 ft Floor to Ceiling Height)	1.2
For Hotel	1.3	High Bay (>25 ft Floor to Ceiling Height)	1.7
For Motel	1.2	Detailed Manufacturing	2.1
For Bar Lounge/Leisure Dining	1.4	Equipment room	1.2
For Family Dining	2.1	Control room	0.5
Food Preparation	1.2	Hotel/ Motel Guest Rooms	1.1
Laboratory	1.4	Dormitory - Living Quarters	1.1
Restrooms	0.9	Museum	
Dressing/Locker/Fitting Room	0.6	General Exhibition	1.0
Corridor/Transition	0.5	Restoration	1.7
For Hospital	1.0	Bank/Office - Banking Activity Area	1.5
For Manufacturing Facility	0.5	Religious Buildings	

a In cases where both a common space type and a building specific space type are listed, the building specific space type shall apply.

TABLE 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method (Continued)

Stairs – active	0.6	Worship-pulpit, choir	2.4
Active Storage	0.8	Fellowship Hall	0.9
For Hospital	0.9	Retail [For accent lighting see 9.3.1.2.1.(c)]	
Inactive storage	0.3	Sales area	2.1
For Museum	0.8	Mall Concourse	1.7
Electrical/ mechanical	1.5	Sports Arena	
Workshop	1.9	Ring Sports Area	2.7
		Court Sports Area	2.3
Building Specific Space Types		Indoor Playing Field Area	1.4
Gymnasium/ Exercise Center		Warehouse	
Playing Area	1.4	Fine Material Storage	1.4
Exercise Area	0.9	Medium/Bulky Material Storage	0.9
Courthouse/ Police Station/ Penitentiary		Parking Garage - Garage Area	0.2
Courtroom	1.9	Transportation	
Confinement Cells	0.9	Airport - Concourse	0.6
Judges Chambers	1.3	Air/Train/Bus - Baggage Area	1.0
		Terminal - Ticket counter	1.5

SI TABLES:

TABLE 9.3.1.1
Lighting Power Densities
Using the Building Area Method

Building Area Type[a]	Lighting Power Density (W/m^2)
Automotive Facility	~~16~~10
Convention Center	~~15~~13
Court House	~~15~~13
Dining: Bar Lounge/Leisure	~~16~~14
Dining: Cafeteria/Fast Food	~~19~~15
Dining: Family	~~20~~17
Dormitory	~~16~~11
Exercise Center	~~15~~11
Gymnasium	~~18~~12
Healthcare-Clinic	11
Hospital/~~Healthcare~~	~~17~~13
Hotel	~~18~~11
Library	~~16~~14
Manufacturing Facility	~~24~~14
Motel	~~22~~11
Motion Picture Theatre	~~17~~13
Multi-Family	~~11~~8
Museum	~~17~~12
Office	~~14~~11
Parking Garage	3
Penitentiary	~~13~~11
Performing Arts Theatre	~~16~~17
Police/Fire Station	~~14~~11
Post Office	~~17~~12
Religious Building	~~24~~14
Retail	~~20~~16
School/University	~~16~~13
Sports Arena	~~16~~12
Town Hall	~~15~~12
Transportation	~~13~~11
Warehouse	~~13~~9
Workshop	~~18~~15

a In cases where both general building area type and a specific building area type are listed, the specific building area type shall apply.

TABLE 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method

Space-by-Space Method Lighting Power Density (LPD)			
Common Space Types[a]	**LPD (W/m^2)**	**Building Specific Space Types (Continued)**	**LPD (W/m^2)**
Office-enclosed	12	Fire Stations	
Office-open plan	12	Fire Station Engine room	9
Conference/ Meeting/ Multipurpose	14	Sleeping Quarters	3
Classroom/ Lecture/ Training	15	Post Office - Sorting Area	13
For Penitentiary	14	Convention Center - Exhibit Space	14
Lobby	14	Library	
For Hotel	12	Card File & Cataloguing	12
For Performing Arts Theater	36	Stacks	18
For Motion Picture Theatre	12	Reading Area	13
Audience/ Seating Area	10	Hospital	
For Gymnasium	4	Emergency	29
For Exercise Center	3	Recovery	9
For Convention Center	8	Nurse station	11
For Penitentiary	8	Exam/Treatment	16
For Religious Buildings	18	Pharmacy	13
For Sports Arena	4	Patient Room	8
For Performing Arts Theatre	28	Operating Room	24
For Motion Picture theatre	13	Nursery	6
For Transportation	5	Medical Supply	15
Atrium-first three floors	6	Physical Therapy	10
Atrium-each additional floor	2	Radiology	4
Lounge/Recreation	13	Laundry-Washing	6
For Hospital	9	Automotive - Service/Repair	8
Dining area	10	Manufacturing	
For Penitentiary	14	Low Bay (<25 ft Floor to Ceiling Height)	13
For Hotel	14	High Bay (>25 ft Floor to Ceiling Height)	18
For Motel	13	Detailed Manufacturing	23
For Bar Lounge/Leisure Dining	15	Equipment room	13
For Family Dining	23	Control room	5
Food Preparation	13	Hotel/ Motel Guest Rooms	12
Laboratory	15	Dormitory - Living Quarters	12
Restrooms	10	Museum	
Dressing/Locker/Fitting Room	6	General Exhibition	11
Corridor/Transition	5	Restoration	18
For Hospital	11	Bank/Office - Banking Activity Area	16
For Manufacturing Facility	5	Religious Buildings	
Stairs – active	6	Worship-pulpit, choir	26
Active Storage	9	Fellowship Hall	10
For Hospital	10	Retail [For accent lighting see 9.3.1.2.1.(c)]	
Inactive storage	3	Sales area	23

a In cases where both a common space type and a building specific space type are listed, the building specific space type shall apply.

TABLE 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method (Continued)

For Museum	9	Mall Concourse	18
Electrical/ mechanical	16	Sports Arena	
Workshop	20	Ring Sports Area	29
		Court Sports Area	25
Building Specific Space Types		Indoor Playing Field Area	15
Gymnasium/ Exercise Center		Warehouse	
Playing Area	15	Fine Material Storage	15
Exercise Area	10	Medium/Bulky Material Storage	10
Courthouse/ Police Station/ Penitentiary		Parking Garage - Garage Area	2
Courtroom	20	Transportation	
Confinement Cells	10	Airport - Concourse	6
Judges Chambers	14	Air/Train/Bus - Baggage Area	11
		Terminal - Ticket counter	16

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *h* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on October 5, 2003; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on February 25, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Samanthan H. LaFleur*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Michael L. Rosenberg
Steven Rosenstock
Robert D. Ross
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This proposed addendum updates the normative references to reflect the latest editions. These changes in references do affect the testing procedures for determining the building material thermal properties (R-values and thermal conductivities) and assembly U-factors of Sections A9.3.1 and A9.3.2 of Normative Appendix A. Alternative test procedure ASTM C1363 replaces the existing ASTM C236 and ASTM C976 for these properties. In addition, where credit is taken for a low-emissivity coating for skylights, the emissivity of the coating shall now be determined in accordance with NFRC 300-2001 instead of NFRC 301-1993.

Addendum *h* to 90.1-2001 (I-P and SI editions)

In Section 12, replace the existing normative references with the following updated versions:

ASTM C177-97	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmittance Properties by Means of the Guarded-Hot-Plate Apparatus
ASTM C518-98	Standard Test Method for Steady-State Thermal Transmittance Properties by Means of the Heat Flow Meter Apparatus
ASTM C1371-98	Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers
NFRC 100:2001	Procedure for Determining Fenestration Product U-Factors, (Second Edition) *Published November 2002*
NFRC 200-2001	Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence, (Second Edition) *Published November 2002*
NFRC 300-2001	Standard Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems, (Second Edition) *Published November 2002*
NFRC 400-2001	Procedure for Determining Fenestration Product Air Leakage, (Second Edition) *Published November 2002*

In Section 12, add the following new normative references:

<u>ASTM C1363-97</u>	<u>Standard Test Method for the Thermal Performance of Building Assemblies by Means of a Hot Box Apparatus</u>
<u>NFRC 101: 2001</u>	<u>Procedure for Determining Thermo-Physical Properties of Materials for Use in NFRC–Approved Software Programs, (First Edition) *Published November 2002*</u>
<u>NFRC 102-2001</u>	<u>Test Procedures for Measuring the Steady-State Thermal Transmittance of Fenestration Systems, (Second Edition) *Published November 2002*</u>
<u>NFRC 201-2001</u>	<u>Interim Standard Test Method for Measuring the Solar Heat Gain Coefficient of Fenestration Systems Using Calorimetry Hot Box Methods, (Second Edition) *Published November 2002*</u>

In Section 12, delete the following normative references:

~~ASTM C976-90~~	~~Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box~~
~~NFRC 301-93~~	~~Standard Test Method for Emittance of Specular Surfaces Using Spectrometric Measurements~~

In Section 5.5.2.2, make the following changes to Exception (c):

Where credit is being taken for a low-emissivity coating, the emissivity of the coating shall be determined in accordance with NFRC ~~301~~<u>300</u>.

In Section A9.3.1, make the following changes to the test procedure references:

a. ASTM C177,

b. ~~ASTM C236~~ ASTM C518, or

c. ~~ASTM C518~~ <u>ASTM C1363</u>

~~d.~~ ~~ASTM C976~~

In Section A9.3.2, make the following changes to the test procedure references:

A9.3.2 Assembly U-Factors. If assembly *U-factors* are determined by testing, ~~one of~~ the ~~following~~ <u>ASTM C1363</u> test procedure~~s~~ shall be used.

~~a.~~ ~~ASTM C236 or~~

~~b.~~ ~~ASTM C976~~

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *i* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 28, 2003; by the ASHRAE Board of Directors on July 3, 2003; and by the American National Standards Institute on August 6, 2003.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
Samantha H. LaFleur
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2002-2003

Thomas E. Watson, *Chair*
Van D. Baxter, *Vice-Chair*
Charles G. Arnold
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Brian P. Dougherty
Hakim Elmahdy
Arthur D. Hallstrom
Matt R. Hargan
Richard D. Hermans
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
William J. Landman
Merle F. McBride
Ross D. Montgomery
Cyrus H. Nasseri
Davor Novosel
Dennis A. Stanke
Michael H. Tavares
Steven T. Taylor
David R. Tree
Terry E. Townsend, *CO*
Maureen Grasso, *ExO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

During the development of Standard 90.1-2001, the project committee explicitly chose not to revise standards for three-phase air-cooled air conditioners and heat pumps less than 65,000 Btu/h (19 kW). This decision was based on the close relationship the design of these products has to single-phase air-cooled air conditioners and heat pumps less than 65,000 Btu/h (19 kW), products whose efficiency is regulated in the USA under the National Appliance Energy Conservation Act (NAECA).

Concurrent with the development of Standard 90.1-2001, the U.S. Department of Energy (DOE) conducted standards rulemaking to develop and set new efficiency standards for these single-phase products. DOE completed its analysis and published a Final Rule on it in the Federal Register *(67 FR100, Page 36368) on May 23, 2002. This rule sets efficiency standards for single-phase air-cooled air conditioners and heat pumps at a seasonal energy efficiency ratio, or SEER, rating of 12.0 (SCOP = 3.52) for both split and single-package systems and a heating seasonal performance factor (HSPF) of 7.4 (SCOP = 2.17) for both single-package and split-system heat pumps.*

In the interest of supporting efficiency improvements to ANSI/ASHRAE/IESNA Standard 90.1, the project committee has adoped a 12 SEER level (SCOP = 3.52) for < 65,000 Btu/h (19 kW) capacity three-phase air-cooled unitary air conditioners and heat pumps, with an additional 7.4 HSPF level (SCOP = 2.17) for such heat pumps.

The DOE final rule for single-phase residential central air conditioners sets a new product class for through-the-wall (TTW) systems. For these products, DOE adopted a 10.9 SEER (SCOP = 3.19) for split air conditioners, a 10.6 SEER (SCOP = 3.11) for packaged air conditioners, a 10.9 SEER (SCOP = 3.19) and 7.1 HSPF (SCOP = 2.08) for split heat pumps, and a 10.6 SEER (SCOP = 3.11) and 7.0 HSPF (SCOP = 2.05) for packaged heat pumps. DOE is limiting the size to TTWs with a cooling capacity up to 30,000 Btu/h (8.8 kW) and is proposing the new class for four years only (for products manufactured until January 23, 2010). After January 23, 2010, the standards for these products will be 12 SEER (SCOP = 3.52) and 7.4 HSPF (SCOP = 2.17). The DOE Final Rule also sets a new product class for small-duct, high-velocity (SDHV) systems.[1] DOE concluded that the NAECA-prescribed minimum efficiency standards of 10 SEER/6.8 HSPF (SCOP 2.93/1/99) should remain applicable to SDHV systems pending further study to establish appropriate higher standard levels. DOE intends to conduct a separate rulemaking for SDHV systems.

The adoption date for the new standards under Standard 90.1 is specified as January 23, 2006, in order to harmonize with the effective date mandated in the DOE Final Rule for single-phase central air conditioner products.

The DOE justification of the recommended efficiency levels can be found in its Technical Support Document, Energy Conservation Standards for Consumer Products: Central Air Conditioners and Heat Pumps, *October 2000* (*posted on DOE's website at* http://www.eere.energy.gov/buildings/appliance_standards/residential/ac_central.html).

[1] A small-duct, high-velocity product is a product that contains a blower and indoor coil combination that is designed for, and produces, at least 1.2 in. (299 Pa) of external static pressure when operated at the certified air volume rate of 220-350 CFM (103.8-165.2 L/s) per rated ton (3.52 kW) of cooling. When applied in the field, small-duct products use high-velocity room outlets (i.e., outlets with velocities generally greater than 1000 fpm [5.1 m/s]) having less than 6.0 in.^{2} (38.7 cm^2) of free area.

ADDENDUM *i* to 90.1-2001 (I-P and SI Editions)

Revise Tables 6.2.1A and 6.2.1B for air conditioners and heat pumps less than 65,000 Btu/h (19 kW) as follows:

I-P Edition:

TABLE 6.2.1A
Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Conditioners, Air Cooled	<65,000 Btu/h[c]	All	Split System	~~10.0 SEER~~ 10.0 SEER (before 1/23/2006) 12.0 SEER (as of 1/23/2006)	ARI 210/240
			Single Package	~~9.7 SEER~~ 9.7 SEER (before 1/23/2006) 12.0 SEER (as of 1/23/2006)	
Through-the-Wall, Air Cooled	≤ 30,000 Btu/h[c]	All	Split System	10.0 SEER (before 1/23/2006) 10.9 SEER (as of 1/23/2006) 12 SEER (as of 1/23/2010)	ARI 210/240
			Single Package	9.7 SEER (before 1/23/2006) 10.6 SEER (as of 1/23/2006) 12.0 SEER (as of 1/23/2010)	
Small-Duct High-Velocity, Air Cooled	< 65,000 Btu/h[c]	All	Split System	10 SEER	ARI 210/240

Remainder of table left unchanged.

TABLE 6.2.1B
Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled (Cooling Mode)	<65,000 Btu/h[c]	All	Split System	~~10.0 SEER~~ 10.0 SEER (before 1/23/2006) 12.0 SEER (as of 1/23/2006)	ARI 210/240
			Single Package	~~9.7 SEER~~ 9.7 SEER (before 1/23/2006) 12.0 SEER (as of 1/23/2006)	
Through-the-Wall (Air Cooled, Cooling Mode)	≤ 30,000 Btu/h[c]	All	Split System	10.0 SEER (before 1/23/2006) 10.9 SEER (as of 1/23/2006) 12 SEER (as of 1/23/2010)	ARI 210/240
			Single Package	9.7 SEER (before 1/23/2006) 10.6 SEER (as of 1/23/2006) 12.0 SEER (as of 1/23/2010)	
Small-Duct High-Velocity (Air Cooled, Cooling Mode)	< 65,000 Btu/h[c]	All	Split System	10 SEER	ARI 210/240
Air Cooled (Heating Mode)	<65,000 Btu/h[c] (cooling capacity)	-	Split System	~~6.8 HSPF~~ 6.8 HSPF (before 1/23/2006) 7.4 HSPF as of 1/23/2006)	ARI 210/240
			Single Package	6.6 HSPF (before 1/23/2006) 7.4 HSPF as of 1/23/2006)	
Through-the-Wall, (Air Cooled, Heating Mode)	≤ 30,000 Btu/h[c] (cooling capacity)	-	Split System	6.8 HSPF (before 1/23/2006) 7.1 HSPF (as of 1/23/2006) 7.4 HSPF as of 1/23/2010)	ARI 210/240
			Single Package	6.6 HSPF (before 1/23/2006) 7.0 HSPF (as of 1/23/2006) 7.4 HSPF (as of 1/23/2010)	
Small-Duct High-Velocity (Air Cooled, Heating Mode)	< 65,000 Btu/h[c] (cooling capacity)	-	Split System	6.8 HSPF	ARI 210/240

Remainder of table left unchanged.

SI Edition:

TABLE 6.2.1A
Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Conditioners, Air Cooled	<19 kW[c]	All	Split System	~~2.93 SCOP~~ 2.93 SCOP (before 1/23/2006) 3.52 SCOP (as of 1/23/2006)	ARI 210/240
			Single Package	~~2.84 SCOP~~ 2.84 SCOP (before 1/23/2006) 3.52 SCOP (as of 1/23/2006)	
Through-the-Wall, Air Cooled	≤ 8.8 kW[c]	All	Split System	2.93 SCOP (before 1/23/2006) 3.19 SCOP (as of 1/23/2006) 3.52 SCOP (as of 1/23/2010)	ARI 210/240
			Single Package	2.84 SCOP (before 1/23/2006) 3.11 SCOP (as of 1/23/2006) 3.52 SCOP (as of 1/23/2010)	
Small-Duct High-Velocity, Air Cooled	< 19 kW[c]	All	Split System	2.93 SCOP	ARI 210/240

Remainder of table left unchanged.

TABLE 6.1.2B
Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled (Cooling Mode)	<19 kW[c]	All	Split System	~~2.93 SCOP$_C$~~ 2.93 SCOP$_C$ (before 1/23/2006) 3.52 SCOP$_C$ (as of 1/23/2006)	ARI 210/240
			Single Package	~~2.84 SCOP$_C$~~ 2.84 SCOP$_C$ (before 1/23/2006) 3.52 SCOP$_C$ (as of 1/23/2006)	
Through-the-Wall (Air Cooled, Cooling Mode)	<8.8 kW[c]	All	Split System	2.93 SCOP$_C$ (before 1/23/2006) 3.19 SCOP$_C$ (as of 1/23/2006) 3.52 SCOP$_C$ (as of 1/23/2010)	ARI 210/240
			Single Package	2.84 SCOP$_C$ (before 1/23/2006) 3.11 SCOP$_C$ (as of 1/23/2006) 3.52 SCOP$_C$ (as of 1/23/2010)	
Small-Duct High-Velocity (Air Cooled, Cooling Mode)	< 19 kW[c]	All	Split System	2.93 SCOP$_C$	ARI 210/240
Air Cooled (Heating Mode)	<19 kW[c] (cooling capacity)	-	Split System	~~1.99 SCOP$_H$~~ 1.99 SCOP$_H$ (before 1/23/2006) 2.17 SCOP$_H$ (as of 1/23/2006)	ARI 210/240
			Single Package	~~1.93 SCOP$_H$~~ 1.93 SCOP$_H$ (before 1/23/2006) 2.17 SCOP$_H$ (as of 1/23/2006)	
Through-the-Wall (Air Cooled, Heating Mode)	≤ 8.8 kW[c] (cooling capacity)	-	Split System	1.99 SCOP$_H$ (before 1/23/2006) 2.08 SCOP$_H$ (as of 1/23/2006) 2.17 SCOP$_H$ as of 1/23/2010)	ARI 210/240
			Single Package	1.93 SCOP$_H$ (before 1/23/2006) 2.05 SCOP$_H$ (as of 1/23/2006) 2.17 SCOP$_H$ (as of 1/23/2010)	
Small-Duct High-Velocity (Air Cooled, Heating Mode)	< 19 kW[c] (cooling capacity)	-	Split System	1.99 SCOP$_H$	ARI 210/240

Remainder of table left unchanged.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *j* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 28, 2003; by the ASHRAE Board of Directors on July 3, 2003; and by the American National Standards Institute on August 6, 2003.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
Samantha H. LaFleur
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2002-2003

Thomas E. Watson, *Chair*
Van D. Baxter, *Vice-Chair*
Charles G. Arnold
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Brian P. Dougherty
Hakim Elmahdy
Arthur D. Hallstrom
Matt R. Hargan
Richard D. Hermans
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
William J. Landman
Merle F. McBride
Ross D. Montgomery
Cyrus H. Nasseri
Davor Novosel
Dennis A. Stanke
Michael H. Tavares
Steven T. Taylor
David R. Tree
Terry E. Townsend, *CO*
Maureen Grasso, *ExO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The revision of Section 9.2.1.2 eliminates two points of potential confusion in understanding the application of the provisions. Item (b) is revised to apply to any installed time-of-day controls instead of only those installed to meet the requirements of this energy standard. This ensures safe use of occupied spaces after normal working hours. Item (c) has been changed to its own provision in order to differentiate between the need for accessibility of manual controls by occupants but not necessarily occupancy sensors or other automatic controls. The revision of exception (n) in Section 9.3.1 makes clear the specific lights that are exempted instead of potentially entire areas.

ADDENDUM *j* to 90.1-2001 (I-P and SI EDITIONS)

Revise Section 9.2.1.2 as follows:

(a) *control* a maximum of 2500 ft^2 (232 m^2) area for a space 10,000 ft^2 (929 m^2) or less and a maximum of 10,000 ft^2 (929 m^2) area for a space greater than 10,000 ft^2 (929 m^2) ~~.~~, and

(b) be capable of overriding any time-of-day scheduled ~~the~~ shut-off *control* ~~required in 9.2.1.1~~ for no more than four hours., ~~and~~

~~(c)~~ Each manual control device shall be readily accessible and located so the occupant can see the controlled lighting.

And revise Section 9.3.1 item "n" as follows:

(n) ~~Athletic playing areas with permanent facilities for~~ Lighting for television broadcasting in sporting activity areas.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *k* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on September 17, 2002; by the ASHRAE Board of Directors on October 14, 2002; and by the American National Standards Institute on December 17, 2002.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAEís Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares

Jerry W. White, *Chair**
Jim Calm, *Vice-Chair**
Don Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Valerie Block*
Donald M. Brundage*
Charles Cottrell*
Roy Crane*
Joseph J. Deringer*
Douglas S. Erickson*
Thomas A. Farkas
Charles R. Foster, III*
Alan Fraser*
James A. Garrigus*
Jason Glazer*
Ashok Gupta
Katherine Hammack*
Randall T. Higa*
Adam W. Hinge*
Billy G. Hinton*
John F. Hogan*
Samantha Hollomon
William Holy*
Graham C. Hunter*
J. Delaine Jones*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim Ranfone*
Eric E. Richman*
Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
Donald L. Sampler*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*
Frederick F. Wajcs, Jr.
Michael W. Woodford

**Denotes members of voting status when the document was approved for publication*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(This foreword is provided for information only and is not part of the draft addendum.)

FOREWORD

The stricken wording prohibited the use of standard pneumatic controllers for either zone thermostatic or supply loop control. The committee has neither undertaken nor been provided with a study on which a DDC requirement could be based.

Addendum 90.1k (I-P and SI editions)

6.2.3.1.1 General. The supply of heating and cooling energy to each *zone* shall be individually controlled by thermostatic controls responding to temperature within the *zone*. ~~All *zone* and loop controllers, shall use control methodology that incorporates the application of control error reduction.~~ For the purposes of Section 6.2.3.1, a dwelling unit shall be permitted to be considered a single *zone*.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *m* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Addendum *m* was approved by the ASHRAE Standards Committee January 25, 2003; by the ASHRAE Board of Directors January 30, 2003; and by the American National Standards Institute April 3, 2003.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAEís Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

When addenda or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE web site at http://xp20.ashrae.org/standards/addenda.htm or http://xp20.ashrae.org/standards/intpstd.htm.

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standard Project Committee 90.1

Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
David Duly
Douglas S. Erickson*
Thomas A. Farkas
Charles R. Foster, III*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
Samantha Hollomon
William G. Holy*
Graham C. Hunter, II*
J. Delaine Jones*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Robert D. Ross*
Donald L. Sampler*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

Until recently, there was no method of test for heat pump pool heaters. In 1998, ASHRAE published Standard 146, which includes methods of test for all types of pool heaters. There is now a trade association of heat pump pool heater manufacturers who have launched a certification program using the services of Intertek Testing Services. Their first directory has been published.

Addendum 90.1*m* (I-P and SI Editions)

Table 7.2.2: Below the line "Pool Heaters, Oil, and Gas," add a new line, "Heat Pump Pool Heaters."

TABLE 7.2.2
Performance Requirements for Water Heating Equipment

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[a]	Test Procedure[b]
Heat Pump Pool Heaters	All		4.0 COP	ASHRAE 146

Remainder of table left unchanged.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *n* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 28, 2003; by the ASHRAE Board of Directors on July 3, 2003; and by the American National Standards Institute on September 25, 2003.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
Samantha H. LaFleur
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2002-2003

Thomas E. Watson, *Chair*
Van D. Baxter, *Vice-Chair*
Charles G. Arnold
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Brian P. Dougherty
Hakim Elmahdy
Arthur D. Hallstrom
Matt R. Hargan
Richard D. Hermans
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
William J. Landman
Merle F. McBride
Ross D. Montgomery
Cyrus H. Nasseri
Davor Novosel
Dennis A. Stanke
Michael H. Tavares
Steven T. Taylor
David R. Tree
Terry E. Townsend, *CO*
Maureen Grasso, *ExO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The addition of detailed explanations of control means clarifies the intent of the supplemental heater control requirements. The additional exemption of NAECA-regulated equipment is justified since the heat pump and controls are tested for the required functionality as part of the heating seasonal performance factor (HSPF) rating.

ADDENDUM 90.1*n* to 90.1-2001 (I-P and SI EDITIONS)

Add the following to Section 6.1.3g:

6.1.3g If a heat pump equipped with auxiliary internal electric resistance heaters is installed, controls shall be provided that prevent supplemental heater operation when the heating load can be met by the heat pump alone during both steady-state operation and setback recovery. Supplemental heater operation is permitted during outdoor coil defrost cycles. Two means of meeting this requirement are (1) a digital or electronic thermostat designed for heat pump use that energizes auxiliary heat only when the heat pump has insufficient capacity to maintain setpoint or to warm up the space at a sufficient rate or (2) a multi-stage space thermostat and an outdoor air thermostat wired to energize auxiliary heat only on the last stage of the space thermostat and when outside air temperature is less than 40°F (4°C). Heat pumps whose minimum efficiency is regulated by NAECA and whose HSPF rating both meets the requirements shown in Table 6.2.1B and includes all usage of internal electric resistance heating are exempted from the control requirements of this part (6.1.3g).

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *o* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on October 5, 2003; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on February 25, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Samanthan H. LaFleur*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Michael L. Rosenberg
Steven Rosenstock
Robert D. Ross
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

Exception d to Section 6.3.1 is being revised to clearly indicate that it applies only to heat recovery systems that are required by Section 6.3.6.2. This change is being made in response to a concern that the current wording of "d" would allow a misinterpretation that by just having condenser heat recovery to preheat hot water without regard to how much energy was being recovered, the requirement for economizers in Section 6.3.1 could be avoided.

Addendum *o* to 90.1-2001 (I-P and SI editions)

Change exception (d) in Section 6.3.1 as follows:

Exceptions to 6.3.1: Economizers are not required for the systems listed below.

(d) Systems that include a condenser heat recovery system ~~complying with~~ required by 6.3.6.2.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *p* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on October 5, 2003; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on February 25, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Samanthan H. LaFleur*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Michael L. Rosenberg
Steven Rosenstock
Robert D. Ross
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The "Energy Cost Budget" section relies on the use of a building energy simulation program to estimate the energy cost difference between the design building model and a budget building model. The building designer can select any building energy simulation program for performing these estimates as long as the program complies with a list of requirements (see Section 11.2.1) describing the minimum capabilities of the software. The current section does not contain any requirements that would indicate the minimum quality of the program being used. This addendum starts to address this omission by requiring that the simulation program be tested with ANSI/ASHRAE Standard 140-2001, Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.

The addendum proposes a new section that requires that building energy simulation programs be tested using Standard 140 and that the test results be made available. The tests contained in Standard 140 focus primarily on the software's ability to simulate the building envelope and how that envelope responds to the climate. This is the most fundamental requirement of a building energy simulation program, and, clearly, if this requirement is not met, it does not matter how well chillers and cooling towers are simulated.

The first tests in Standard 140 model a very simple "shoebox" building. Subsequent tests progressively add new features to this model so that the impact of each new feature can be separately understood. The results of each test include the simulated annual heating load, annual cooling load, peak heating load, and peak cooling load. An informative appendix to Standard 140 contains the results of these tests for eight different programs including DOE-2, BLAST, ESP, and TRNSYS.

No one simulation program provides the correct answers. There is no "right" answer. These programs use many different algorithms and simulation assumptions, and none can perfectly simulate a building's actual energy consumption. The best these programs can do is estimate the energy consumption using various degrees of simplification. The Standard 140 method of test requires the testing of the building energy simulation program by the software developer and for the developer to examine the differences between the performance of its program and the other programs. In this way, errors in the software can be diagnosed.

Requiring the building energy simulation program to be tested using the Standard 140 procedure provides benefits to persons using the energy cost budget method by prompting developers to fix bugs found during the testing.

Addendum *p* to 90.1-2001 (I-P and SI editions)

Add the following subsection to Section 11.2.1:

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

Add the following normative reference to Section 12:

ANSI/ASHRAE Standard 140-2001, *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs*

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *q* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 26, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Hugh F. Crowther
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

[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.]

FOREWORD

This addendum is an extensive revision of the 90.1-2001 Exterior Lighting Requirements. It was prompted by comments and continuous maintenance proposals the committee has received about the deficiencies of the exterior lighting requirements in the currently published standard. The committee's review involved the following activities:

- *Reviewing existing exterior lighting documents, including outdoor lighting research proposal for California outdoor lighting standards, IESNA RP-33, RP-2, RP-20, RP-10 (draft), DG-5, and the 9th edition Handbook.*
- *Establishing a set of categories of exterior lighting applications for new lighting requirement tables.*
- *Developing a set of exterior lighting models and cases to determine appropriate LPD values. These models included current efficient, commonly available equipment. Multiple lighting solution models were created and analyzed for parking areas, walkways, plazas, building entries, canopies, façade lighting, and outdoor sales.*
- *Revising the current supporting requirements text for clarity. This included a revision and update of exemptions and all basic requirements.*

This addendum increases the stringency of the section. Where LPD values existed in the 2001 standard, these values were reduced or maintained based on current design criteria and current lighting equipment efficiency. All of the other exterior lighting in the existing 2001 lighting section was only regulated as a light source efficacy. This addendum enhances this requirement with specific LPD values that provide definite limits for exterior lighting use.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and strikethrough (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum *q* to 90.1-2001 (I-P and SI editions)

Modify Sections 9.2.1.3 and 9.3.2 as follows:

9.2.1.3 Exterior Lighting Control. ~~Lighting for all exterior applications not exempted in 9.1 and 9.3.2 shall be controlled by a photosensor or astronomical time switch that is capable of automatically turning off the exterior lighting when sufficient daylight is available or the lighting is not required.~~ Lighting for all exterior applications not exempted in 9.1 shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours. Lighting not designated for dusk-to-dawn operation shall be controlled by an astronomical time switch. Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. Astronomical time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least 10 h.

Exception to 9.2.1.3: Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.

9.2.6 Exterior Building Grounds Lighting. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under 9.1 or 9.3.2.

9.3.2 Exterior Building Lighting Power. ~~The exterior building façade lighting power shall not exceed 0.25 W/ft^2 of the illuminated area.~~ The total *exterior lighting power allowance* for all ~~other~~ exterior building applications is the sum of the individual lighting power ~~limits~~ densities permitted ~~and specified~~ in Table 9.3.2 for these applications plus an additional unrestricted allowance of 5% of that sum. Trade-offs are allowed only among exterior lighting applications listed in the Table 9.3.2 "Tradable Surfaces" section. Exterior lighting for all applications (except those included in the exceptions to 9.1 and 9.3.2) shall comply with the requirements of 9.2.6.

Exceptions to 9.3.2: Lighting used for the following exterior applications is exempt when equipped with ~~an~~ a ~~independent~~ *control device* independent of the control of the nonexempt lighting:

(a) specialized signal, directional, and marker lighting associated with transportation;

~~(b) lighting used to highlight features of public monuments and registered *historic* landmark structures or *buildings*; and~~

(b) ~~(c) lighting that is integral to~~ advertising signage or directional signage;

(c) lighting that is integral to *equipment* or instrumentation and is installed by its *manufacturer;*

(d) lighting for theatrical purposes, including performance, stage, film, and video production;

(e) lighting for athletic playing areas;

(f) temporary lighting;

(g) lighting for industrial production, material handling, transportation sites, and associated storage areas;

(h) theme elements in theme/amusement parks; and

(i) lighting used to highlight features of public monuments and registered *historic* landmark structures or *buildings.*

Replace the current IP version of Table 9.3.2 with the revised version (shown below the current version):

Current IP version of Table 9.3.2:

TABLE 9.3.2
Lighting Power Limits for Building Exteriors

Applications	**Power Limits**
Building entrance with canopy or freestanding canopy	3 W/ft^2 of canopied area
Building entrance without canopy	33 W/lin ft of door width
Building exit	20 W/lin ft of door width

Revised IP version of Table 9.3.2:

TABLE 9.3.2
Lighting Power Densities for Building Exteriors

Applications	**Lighting Power Densities**
Tradable Surfaces (Lighting Power Densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded.)	
Uncovered Parking Areas	
Parking lots and drives	0.15 W/ft^2
Building Grounds	
Walkways less than 10 feet wide	1.0 watts per linear foot
Walkways 10 feet wide or greater, plaza areas, and special feature areas	0.2 W/ft^2
Stairways	1.0 W/ft^2
Building Entrances and Exits	
Main entries	30 watts per linear foot of door width
Other doors	20 watts per linear foot of door width
Canopies and Overhangs	
Canopies (freestanding and attached and overhangs)	1.25 W/ft^2
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft^2
Street frontage for vehicle sales lots in addition to "open area" allowance	20 watts per linear foot
Non-Tradable Surfaces (Lighting Power Density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	
Building facades	0.2 W/ft^2 for each illuminated wall or surface or 5.0 watts per linear foot for each illuminated wall or surface length
Automated teller machines and night depositories	270 watts per location plus 90 watts per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft^2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles	0.5 W/ft^2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
Drive-up windows at fast food restaurants	400 watts per drive-through
Parking near 24-hour retail entrances	800 watts per main entry

Replace the current SI version of Table 9.3.2 with the revised version (shown below the current version):

Current SI version of Table 9.3.2:

TABLE 9.3.2
Lighting Power Limits for Building Exteriors

Applications	**Power Limits**
Building entrance with canopy or freestanding canopy	32.4 W/m^2 of canopied area
Building entrance without canopy	108.3 W/lin m of door width
Building exit	65.6 W/lin m of door width

Revised SI version of Table 9.3.2:

TABLE 9.3.2
Lighting Power Densities for Building Exteriors

Applications	**Lighting Power Densities**
Tradable Surfaces (Lighting Power Densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded.)	
Uncovered Parking Areas	
Parking lots and drives	1.6 W/m^2
Building Grounds	
Walkways less than 10 feet wide	10.7 watts per linear meter
Walkways 10 feet wide or greater, plaza areas, and special feature areas	2.2 W/m^2
Stairways	10.8 W/m^2
Building Entrances and Exits	
Main entries	98 watts per linear meter of door width
Other doors	66 watts per linear meter of door width
Canopies and Overhangs	
Canopies (freestanding and attached and overhangs)	13.5 W/m^2
Outdoor Sales	
Open areas (including vehicle sales lots)	5.4 W/m^2
Street frontage for vehicle sales lots in addition to “open area” allowance	66 watts per linear meter
Non-Tradable Surfaces (Lighting Power Density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the “Tradable Surfaces” section of this table.)	
Building facades	2.2 W/m^2 for each illuminated wall or surface or 16.4 watts per linear meter for each illuminated wall or surface length
Automated teller machines and night depositories	270 watts per location plus 90 watts per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	13.5 W/m^2 of uncovered area (covered areas are included in the “Canopies and Overhangs” section of “Tradable Surfaces”)
Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles	5.4 W/m^2 of uncovered area (covered areas are included in the “Canopies and Overhangs” section of “Tradable Surfaces”)
Drive-up windows at fast food restaurants	400 watts per drive-through
Parking near 24-hour retail entrances	800 watts per main entry

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *r* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on October 5, 2003; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on February 25, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Samanthan H. LaFleur*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Michael L. Rosenberg
Steven Rosenstock
Robert D. Ross
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The minimum insulation requirements for return ducts in 90.1-2001 apply to all return ducts, whether the return duct is for a cooling only or heating only system or a combined heating and cooling duct system. Showing the return duct requirements only under Table 6.2.4.1.2A (formerly Table 6.2.4.2A) created some potential for confusion since that table is titled, "Cooling and Heating Only Supply Ducts and Return Ducts." This proposed addendum modifies Table 6.2.4.1.2B (formerly Table 6.2.4.2B) to make it clear that the return duct insulation requirements shown in Table 6.2.4.1.2A also apply to return ducts when combined heating and cooling supply ducts are used.

Addendum *r* to 90.1-2001 (I-P and SI editions)

Revise Table 6.2.4.1.2B (formerly Table 6.2.4.2B) in both the I-P and the SI editions of the standard as follows:

1. *Add insulation requirements for return ducts from Table 6.2.4.1.2A (formerly Table 6.2.4.2A) to the bottom of Table 6.2.4.1.2B (formerly Table 6.2.4.2B) (see attached revised Table 6.2.4.1.2B).*
2. *Insert the title for "Supply Ducts" to create balance and consistency with the addition for "Return Ducts" information.*
3. *Change the title of Table 6.2.4.1.2B (formerly Table 6.2.4.2B) to read as follows: "Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Supply Ducts and Return Ducts."*

See the I-P Version of Table 6.2.4.1.2B (formerly Table 6.2.4.2B) on the following page for the specific changes.

I-P Edition:

TABLE 6.2.4.1.2B

Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Supply Ducts and Return Ducts

Climate Zone			Duct Location						
Envelope Criteria Table	HDD65	CDD50	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic w/ Roof Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Supply Ducts									
B-1	0-900	10801+	R-8	R-6	R-8	R-3.5	R-3.5	none	R-3.5
B-2	0-900	9001-10800	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
B-3	0-900	7201-9000	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-4	0-900	0-7200	R-6	R-3.5	R-6	R-3.5	R-1.9	none	R-3.5
B-5	901-1800	7201+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-6	901-1800	5401-7200	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-7	901-1800	0-5400	R-3.5	R-3.5	R-6	R-1.9	R-1.9	none	R-1.9
B-8	1801-2700	5401+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-9	1801-2700	0-5400	R-6	R-3.5	R-6	R-1.9	R-1.9	none	R-1.9
B-10	2701-3600	5401+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-11	2701-3600	3601-5400	R-6	R-6	R-6	R-3.5	R-3.5	none	R-1.9
B-12	2701-3600	0-3600	R-3.5	R-3.5	R-3.5	R-1.9	R-1.9	none	R-1.9
B-13	3601-5400	3601+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-14	3601-5400	1801-3600	R-6	R-3.5	R-6	R-1.9	R-3.5	none	R-1.9
B-15	3601-5400	0-1800	R-3.5	R-3.5	R-3.5	R-1.9	R-1.9	none	R-1.9
B-16	5401-7200	3601+	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
B-17	5401-7200	1801-3600	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-18	5401-7200	0-1800	R-6	R-3.5	R-3.5	R-1.9	R-3.5	none	R-3.5
B-19	7201-9000	1801+	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-20	7201-9000	0-1800	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-21	9001-10800	1801+	R-8	R-6	R-6	R-1.9	R-6	none	R-3.5
B-22	9001-10800	0-1800	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
B-23	10801-12600	all	R-8	R-6	R-6	R-1.9	R-6	none	R-6
B-24	12601-16200	all	R-8	R-8	R-8	R-1.9	R-6	none	R-6
B-25	16201-19800	all	R-10	R-8	R-8	R-3.5	R-6	none	R-6
B-26	19801+	all	R-10	R-10	R-8	R-3.5	R-8	R-3.5	R-6
Return Ducts									
B-1 to B-26	All climates		R-3.5	R-3.5	R-3.5	none	none	none	none

a Insulation R-values, measured in $(h \cdot ft^2 \cdot °F)/Btu$, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 6.2.4.2 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.

SI Edition:

TABLE 6.2.4.1.2B

Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Supply Ducts and Return Ducts

Climate Zone			Duct Location						
Envelope Criteria Table	**HDD65**	**CDD50**	**Exterior**	**Ventilated Attic**	**Unvented Attic Above Insulated Ceiling**	**Unvented Attic w/ Roof Insulation[a]**	**Uncondi-tioned Space[b]**	**Indirectly Condi-tioned Space[c]**	**Buried**
Supply Ducts									
Return Ducts									
B-1 to B-26	All climates		R-0.62	R-0.62	R-0.62	none	none	none	none

a Insulation R-values, measured in (h·ft^2·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 6.2.4.2 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.

All other information in Table 6.2.4.1.2B remains the same.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *s* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on October 5, 2003; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on February 25, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE web site, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Donald L. Beaty*
Albert W. Black, III*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson
Douglas S. Erickson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Graham C. Hunter, II*
Hyman M. Kaplan*
Gersil N. Kay*
Larry Kouma*
Ronald D. Kurtz*
Samanthan H. LaFleur*
Michael D. Lane*
Steven J. Lit*
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Jack F. Roberts*
Michael L. Rosenberg
Steven Rosenstock
Robert D. Ross
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
Frederick F. Wajcs, Jr.
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Dale L. Woodin
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The change in exception (g) to Section 6.3.6.1 is an acknowledged typo in Standard 90.1-2001, noted in the 2001 User's Manual, but not corrected to date as errata. As written, exception (i) to Section 6.3.6.1 exempts only systems that require dehumidification and that use series-style energy recovery coils wrapped around the cooling coil. Since series energy recovery is accomplished by a number of technologies, including, but not limited to, heat recovery coils, run around loops, plates, heat pipes, and wheels, the exception is being revised to apply to systems requiring dehumidification that employ any series energy recovery technology.

Addendum *s* to 90.1-2001 (I-P and SI editions)

Exceptions to 6.3.6.1:

Change exception (g) as follows:

(g) Cooling systems in climates with a ~~2.5%~~ 1% cooling design wet-bulb temperature less than 65°F (18°C).

Change exception (i) as follows:

(i) Systems requiring dehumidification that employ ~~series-style~~ energy recovery ~~coils wrapped around~~ in series with the cooling coil.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *t* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on April 28, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum adds specific exceptions to the requirement for automatic lighting shutoff device in Section 9.2.1.1. Exception c addresses critical maintenance areas and other areas with dangerous equipment or materials, such as elevator machine rooms, mechanical rooms, electrical rooms, industrial processes, and hazardous materials storage. Exception b addresses spaces where patient care is rendered. Hospitals may have three different power sources feeding lighting for equipment areas—normal, life safety, and critical branches—that need to be independently routed, circuited, and switched. Health care clientele have expressed concern over the safety and practicality of introducing an automatic shutoff of lighting in patient care areas.

Addendum *t* to 90.1-2001 (I-P and SI editions)

Change the exception to 9.2.1.1 as follows:

Exceptions to 9.2.1.1: The following shall not require an *automatic control device*.

a. Lighting intended for 24-hour operation. ~~shall not require an *automatic control device*.~~

b. Lighting in spaces where patient care is rendered.

c. Spaces where an automatic shutoff would endanger the safety or security of the room or building occupant(s).

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *u* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 26, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Hugh F. Crowther
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum adds dew-point and dry-bulb temperature as a shutoff control type in Tables 6.3.1.1.3.A and 6.3.1.1.3B and adds the required high-limit values for this type of control.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and strikethrough (for deletions).

Addendum u to 90.1-2001 (I-P and SI editions)

Modify Tables 6.3.1.1.3A and 6.3.1.1.3B (I-P versions) as follows:

TABLE 6.3.1.1.3A
High-Limit Shutoff Control Options for Air Economizers

Climate	Allowed Control Types	Prohibited Control Types
Dry T_{wb} < 69°F or (T_{wb} < 75°F and T_{db} ≥ 100°F[a]	Fixed Dry Bulb Differential Dry Bulb Electronic Enthalpy[b] Differential Enthalpy Dew-Point and Dry-Bulb Temperature	Fixed Enthalpy
Intermediate 69°F ≤ T_{wb} ≤ 73°F T_{db} < 100°F	Fixed Dry Bulb Differential Dry Bulb Fixed Enthalpy Electronic Enthalpy[b] Differential Enthalpy Dew-Point and Dry-Bulb Temperature	
Humid T_{wb} > 73°F	Fixed Dry Bulb Fixed Enthalpy Electronic Enthalpy[b] Differential Enthalpy Dew-Point and Dry- Bulb Temperature	Differential Dry Bulb

a T_{wb} is the 1% *cooling design* wet-bulb temperature. T_{db} is the 1% *cooling design* dry-bulb temperature.

b Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

TABLE 6.3.1.1.3.B
High-Limit Shutoff Control Settings for Air Economizers

Device Type	Climate	Required High Limit (Economizer Off When):	
		Equation	Description
Fixed Dry Bulb	Dry Intermediate Humid	$T_{OA} > 75°F$	Outside air temperature exceeds 75°F
		$T_{OA} > 70°F$	Outside air temperature exceeds 70°F
		$T_{OA} > 65°F$	Outside air temperature exceeds 65°F
Differential Dry Bulb	All	$T_{OA} > T_{RA}$	Outside air temperature exceeds return air temperature
Fixed Enthalpy	All	$h_{OA} > 28$ Btu/lb[a]	Outside air enthalpy exceeds 28 Btu/lb of dry air[a]
Electronic Enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outside air temperature/RH exceeds the "A" setpoint curve[b]
Differential Enthalpy	All	$h_{OA} > h_{RA}$	Outside air enthalpy exceeds return air enthalpy
Dew-Point and Dry-Bulb Temperature	All	$DP_{oa} \geq 55°F$ or $T_{oa} \geq 75°F$	Outside air dry bulb exceeds 75 °F or outside dew point exceeds 55 °F (65g/lb)

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

b Setpoint "A" corresponds to a curve on the psychometric chart that goes through a point at approximately 75°F and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

Modify Tables 6.3.1.1.3A and 6.3.1.1.3B (SI versions) as follows:

TABLE 6.3.1.1.3.A
High-Limit Shutoff Control Options for Air Economizers

Climate	Allowed Control Types	Prohibited Control Types
Dry $T_{wb} < 21°C$ or ($T_{wb} < 24°C$ and $T_{db} \geq 38°C$[a]	Fixed Dry Bulb Differential Dry Bulb Electronic Enthalpy[b] Differential Enthalpy Dew-Point and Dry-Bulb Temperature	Fixed Enthalpy
Intermediate $21°C \leq T_{wb} \leq 23°C$ $T_{db} < 38°C$	Fixed Dry Bulb Differential Dry Bulb Fixed Enthalpy Electronic Enthalpy[b] Differential Enthalpy Dew-Point and Dry-Bulb Temperature	
Humid $T_{wb} > 23°C$	Fixed Dry Bulb Fixed Enthalpy Electronic Enthalpy[b] Differential Enthalpy Dew-Point and Dry-Bulb Temperature	Differential Dry Bulb

a T_{wb} is the 1% *cooling design* wet-bulb temperature. T_{db} is the 1% *cooling design* dry-bulb temperature.

b Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

TABLE 6.3.1.1.3.B
High-Limit Shutoff Control Settings for Air Economizers

Device Type	Climate	Required High Limit (Economizer Off When):	
		Equation	**Description**
Fixed Dry Bulb	Dry Intermediate Humid	$T_{OA} > 24°C$	Outside air temperature exceeds 24°C
		$T_{OA} > 21°C$	Outside air temperature exceeds 21°C
		$T_{OA} > 18°C$	Outside air temperature exceeds 18°C
Differential Dry Bulb	All	$T_{OA} > T_{RA}$	Outside air temperature exceeds return air temperature
Fixed Enthalpy	All	$h_{OA} > 47$ kJ/kg[a]	Outside air enthalpy exceeds 47 kJ/kg of dry air[a]
Electronic Enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outside air temperature/RH exceeds the "A" setpoint curve[b]
Differential Enthalpy	All	$h_{OA} > h_{RA}$	Outside air enthalpy exceeds return air enthalpy
Dew-Point and Dry-Bulb Temperature	All	$DP_{oa} > 13°C$ or $T_{oa} > 24°C$	Outside air dry-bulb temperature exceeds 24 °C or outside dew point exceeds 13 °C

a At altitudes substantially different from sea level, the fixed enthalpy limit value shall be set to the enthalpy value at 24°C and 50% relative humidity. As an example, at approximately 1830 m elevation, the fixed enthalpy limit is approximately 53.5 Btu/lb.

b Setpoint "A" corresponds to a curve on the psychometric chart that goes through a point at approximately 24°C and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *x* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on May 10, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on August 5, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard

ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.

1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum broadens the requirement for off-hour controls for HVAC systems. It requires off-hour controls for systems greater than 15,000 Btu/h (4.4 kW), whereas the current 2001 edition of 90.1-2001 requires such controls for systems greater than 65,000 Btu/h (19 kW). Exceptions still apply for systems intended to operate continuously and for hotel/motel guest rooms. This addendum also adds a requirement for fan motors larger than ¾ hp (0.5 kW) to have automatic shutoff controls, with an exception for fans intended to run continuously.

Addendum *x* to 90.1-2001 (I-P and SI editions)

Revise Sections 6.1.3-i and 6.2.3.2 and add a new Section 6.2.3.3.5 as follows:

6.1.3 Simplified Approach Option for HVAC Systems.

i. *Systems* serving spaces other than hotel/motel guest rooms, and other than those requiring continuous operation, that have both a cooling or heating capacity greater than ~~65,000~~ 15,000 Btu/h (~~19~~ 4.4 kW) and a supply fan motor power greater than ¾ hp (0.5 kW) shall be provided with a timeclock that (1) can start and stop the system under different schedules for seven different day-types per week, (2) is capable of retaining programming and time setting during a loss of power for a period of at least 10 hours, (3) includes an accessible manual override that allows temporary operation of the system for up to two hours, (4) is capable of temperature setback down to 55°F (13°C) during off hours, and (5) is capable of temperature setup to 90°F (32°C) during off hours.

6.2.3.2 Off-Hour Controls. HVAC systems ~~having a design heating or cooling capacity greater than 65,000 Btu/h (19kW) and *fan system power* greater than ¾ hp (0.5 kW) shall have all of the following off-hour controls: Automatic Shutdown (6.2.3.2.1), Setback Controls (6.2.3.2.2), Optimum Start Controls (6.2.3.2.3), Shutoff Damper Controls (6.2.3.2.4), and Zone Isolation (6.2.3.2.5)~~ shall have the off-hour controls required by Sections 6.2.3.2.1 to 6.2.3.2.4.

Exceptions to 6.2.3.2:

a. *HVAC systems* serving hotel/motel guest rooms.

b. *HVAC systems* intended to operate continuously.

c. *HVAC systems* having a design heating capacity and cooling capacity less than 15,000 Btu/h (4.4 kW) that are equipped with readily accessible manual on/off controls.

6.2.3.3.5 Ventilation Fan Controls. Fans with motors greater than ¾ hp (0.5 kW) shall have automatic controls complying with Section 6.2.3.2.1 that are capable of shutting off fans when not required.

Exception to 6.2.3.3.5: *HVAC systems* intended to operate continuously.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *y* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on April 28, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum changes the limitation on VAV fan motor requirements from 30 hp (22 kW) to 15 hp (11 kW). The reduction to 15 hp (11 kW) from 30 hp (22 kW) is justifiable since the cost of variable-frequency drives has decreased significantly in the last several years.

Addendum *y* to 90.1-2001 (I-P and SI editions)

Change Section 6.3.3.2.1 as follows:

6.3.3.2.1 Part-Load Fan Power Limitation. Individual VAV fans with motors ~~30~~ 15 hp (~~22~~ 11 kW) and larger shall meet one of the following:

a. The fan shall be driven by a mechanical or electrical variable-speed drive.

b. The fan shall be a vane-axial fan with variable-pitch blades.

c. The fan shall have other controls and devices that will result in fan motor demand of no more than 30% of design wattage at 50% of design air volume when static pressure setpoint equals one-third of the total design static pressure, based on manufacturer's certified fan data.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *z* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on April 28, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum clarifies the language in the exception to Section 6.2.1. The language is changed to clearly show that applications requiring secondary coolants (e.g., glycol or brine) for freeze protection are excluded from the standard. This exclusion was previously implied by the word "Water" in the labels of "Leaving Chiller Water Temperature, Entering Condenser Water Temperature, and Condensing Water Temperature Rise," but now it is more clearly defined.

Addendum *z* to 90.1-2001 (I-P and SI editions)

Revise the Exception to 6.2.1 as follows:

Exception to 6.2.1: Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550/590 test conditions (and thus cannot be tested to meet the requirements of Table 6.2.1C) of 44°F (6.7°C) leaving chilled water temperature and 85°F (29.4°C) entering condenser water temperature shall have a minimum full-load COP as shown in Tables 6.2.1H, I, and J and a minimum NPLV rating as shown in Tables 6.2.1 K, L, and M. The table values are only applicable over the following full-load design ranges:

Leaving Chiller Water Temperature:	40°F to 48°F (4.4°C to 8.9~~6.7~~°C)
Entering Condenser Water Temperature:	75°F to 85°F (23.9°C to 29.4°C)
Condensing Water Temperature Rise:	5°F to 15°F (2.8°C to 8.3°C)

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of 27°F (–2.8°C) or less for freeze protection are not covered by this standard.

Non-standard part-load value (NPLV) is defined as a single-number part-load efficiency figure of merit for chillers referenced to conditions other than IPLV conditions.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *aa* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on April 28, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The following addendum updates Section 12, "Normative References." The addendum deletes references that are no longer referred to in the standard, adds one new reference, corrects references that were incorrect, and updates references that have been revised or reaffirmed since the 2001 edition of Standard 90.1 was published.

Addendum *aa* to 90.1-2001 (I-P and SI editions)

Make the following changes to the normative references in Section 12:

12. NORMATIVE REFERENCES

Reference	Title
10 CFR Part 430, App ~~E~~N	Uniform Test Method for Measuring the Energy Consumption of Furnaces
AMCA ~~500-1989~~500-D-98	Test Methods for Louvers, Dampers, and Shutters
ANSI Z21.47-~~1993~~ (2001)	Gas-Fired Central Furnaces (Except Direct Vent and Separated Combustion System Furnaces)
ANSI Z83.8-~~1990~~ (2002)	Gas Unit Heaters and Duct Furnaces
Air-Conditioning and Refrigeration Institute ~~4301 N. Fairfax Drive, Suite 425~~ 4100 North Fairfax Drive, Suite 200, Arlington, VA 22203	
ARI 210/240-~~94~~2003	Unitary Air Conditioning and Air-Source Heat Pump Equipment
ARI 365-~~94~~(2002)	Commercial and Industrial Unitary Air-Conditioning Condensing Units
ARI 550/590-98 with Addenda through July 2002	Water-Chilling Packages Using the Vapor Compression Cycle
ASTM C518-~~91~~ 2002	Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
Hydronics Institute Division of Gama, 35 Russo Place, P.O. Box 218, Berkeley Heights, NJ 07922	
~~H.I. Htg. Boiler Std.~~BTS 2000	~~Testing and Rating Standard for Heating Boilers~~ Testing Standard Method to Determine Efficiency of Commercial Space Heating Boilers

Add the following normative references in Section 12:

12. NORMATIVE REFERENCES

Reference	Title
ARI 460-2000	Remote Mechanical Draft Air Cooled Refrigerant Condensers

Delete the following normative references in Section 12:

12. NORMATIVE REFERENCES

Reference	Title
~~ANSI Z21.13a-1993~~	~~Gas-Fired Low-Pressure Steam and Hot Water Boilers~~
~~ANSI Z21.66-1994~~	~~Automatic Vent Damper Devices for Use with Gas-Fired Appliances~~
~~ANSI Z83.9-1990~~	~~Gas-Fired Duct Furnaces~~
~~ARI 320-98~~	~~Water-Source Heat Pumps~~
~~ARI 325-98~~	~~Ground Water-Source Heat Pumps~~
~~ARI 330-98~~	~~Ground Source Closed-Loop Heat Pumps~~
~~American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10017~~	
~~ASME PTC 4.1-1964~~	~~Steam Generating Units~~
~~UL 726-90~~	~~UL Standard for Safety—Oil-Fired Boiler Assemblies~~
~~UL 795-94~~	~~UL Standard for Safety—Commercial-Industrial Gas Heating Equipment~~

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *ab* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on April 28, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The project committee discovered that NFPA 96 does not contain a Type 1 classification for kitchen hoods as stated in exception (d) to Section 6.3.6.1. Type 1 comes from definitions in the International Mechanical Code (IMC), which defines Type 1 hood as a kitchen hood for collecting and removing grease vapors and smoke. With exception (d) modified to define commercial kitchen hoods according to IMC, the reference to NFPA 96 can be deleted. Also, the wording will now be the same as that in the IMC and, therefore, there is no need to reference it.

Addendum *ab* to 90.1-2001 (I-P and SI editions)

Revise exception (d) to Section 6.3.6.1 as follows:

Exceptions to 6.3.6.1:

d. Commercial kitchen hoods (grease)~~ classified as Type 1 by *NFPA 96*~~ used for collecting and removing grease vapors and smoke.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *ac* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 26, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Hugh F. Crowther
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

[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.]

FOREWORD

Addendum ac consists of a number of unrelated changes to the Energy Cost Budget (ECB) Method section of Standard 90.1. The changes are intended to add clarity and specificity to a number of different paragraphs.

During the development of the draft for the Appendix G Performance Rating Method, many sections from Section 11 were examined to determine if items in Appendix G were applicable. Some of these changes are incorporated into Section 11 by this addendum.

This addendum also includes some paragraphs that were refined based on feedback from various users of the ECB Method.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and strikethrough (for deletions).

Addendum ac to 90.1-2001 (I-P and SI editions)

Revise the following sections and note 7 to Table 11.4.3A as shown:

11.3.1 Proposed Design Model. The simulation model of the *proposed design* shall be consistent with the design documents, including proper accounting of ~~window and wall~~ fenestration and opaque envelope types and area; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls.

Exceptions to 11.3.6: The following building elements are permitted to differ from architectural drawings.

(a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type.

(b) Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described either as a single surface or by using multipliers.

(c) For exterior roofs other than roofs with ventilated attics, 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. The reflectance and emittance shall be tested in accordance with the Exception to 5.3.1.1. All other roof surfaces shall be modeled with a reflectance of 0.3.

(d) Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Permanent shading devices such as fins, overhangs, and light shelves shall be modeled.

11.3.8 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 ~~9.3~~ 9.2.4 and 9.2.5.

c. Where no lighting exists or 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 plans (including lamps, ballasts, task fixtures, and furniture-mounted fixtures).

~~**11.3.9 Other Systems.** Other systems, such as motors, covered by Section 10, may be modeled. If they are modeled, performance shall be as indicated on design drawings. Miscellaneous internal loads, such as those due to office and other equipment, shall be estimated based on the building type or space type category as approved by the *authority having jurisdiction*.~~

11.3.9 Miscellaneous Loads. Receptacle, motor, and process loads shall be modeled and estimated based on the building type or space type category and shall be assumed to be identical in the *proposed* and *budget building design*. These loads shall be included in simulations of the building and shall be included when calculating the *energy cost budget* and *design energy cost*. All end-use load components within and associated with the building shall be modeled, unless specifically excluded by 11.3.10, including, but not limited to, exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.

Table 11.4.3A (Note 7)

7. ~~The boiler in the *budget building design* system shall use the same fuel as the *proposed design* and shall be natural draft. If no boilers exist in the *proposed design*, the budget building boilers shall be fossil fuel. Other boiler parameters shall be as described in Note 6.~~ Water-source heat pumps shall be connected to a common heat pump water loop controlled to maintain temperatures between 60×F (16×C) and 90×F (32×C). Heat rejection from the loop shall be provided by an axial fan closed circuit evaporative fluid cooler with two-speed fans if required in 6.3.5. Heat addition to the loop shall be provided by a boiler that uses the same fuel as the *proposed design* and shall be natural draft. If no boilers exist in the *proposed design*, the budget building boilers shall be fossil fuel. The *budget building design* boiler plant shall be modeled with a single boiler if the *budget building design* plant load is 600,000 Btu/h (176 kW) or less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h (176 kW). Boilers shall be staged as required by the load. Piping losses shall not be modeled in either building model. Pump system power shall be the same as the *proposed design*; if the *proposed design* has no pumps, the *budget building design* pump power shall be 22 W/gpm (349 kW/1000L/s), which is equal to a pump operating against a 75 foot (23 m) head, with

a 65% combined impeller and motor efficiency. Loop flow shall be variable with flow shut off at each heat pump when its compressor cycles off as required by 6.3.4.4. Loop pumps shall be modeled as riding the pump curve or with variable speed drives when required by 6.3.4.1.

Section 11.4.3 k(1)

(1) Enter Figure 11.4.3 at "Water" if the *proposed design* system condenser is water or evaporatively cooled; enter at "Air" if the condenser is air-cooled. Closed-circuit dry-coolers shall be considered air-cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is specified or the mechanical cooling system in the *proposed design* does not require heat rejection, the system shall be treated as if the condenser water type were "Air." For proposed designs with ground-source or groundwater-source heat pumps, the budget system shall be water source heat pump (System 6).

11.4.5 Lighting. Lighting power in the *budget 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 9.3. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the proposed and budget building. Lighting controls shall be the minimum required.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *ae* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 26, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Hugh F. Crowther
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

[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.]

FOREWORD

This occupancy sensor control requirement provides limited application of occupancy sensors to provide more complete energy savings than the automatic shutoff control. Much research and study has been done on the effectiveness and cost justification of occupancy sensor controls in building spaces. The development of this requirement by the subcommittee and other interested parties included the review of known information and analysis regarding potential energy savings, cost effectiveness, equipment availability, and application and commissioning issues. The spaces listed in this requirement were those that were determined to be common to many building types, easily outfitted with occupancy controls, and, based on the available analysis, were conservatively cost effective applications.

Note: In this addendum, revisions are indicated in the text by underlining (for additions) and strikethrough (for deletions).

Addendum *ae* to 90.1-2001 (I-P and SI editions)

Revise Section 9.2.1.2 as follows:

9.2.1.2 Space Control. Each space enclosed by ceiling-height partitions shall have at least one *control device* to independently *control* the *general lighting* within the space. Each manual device shall be readily accessible and located so the occupants can see the controlled lighting.

a. A control device shall be installed that automatically turns lighting off within 30 minutes of all occupants leaving a space, except spaces with multi-scene control, in:

1. Classrooms (not including shop classrooms, laboratory classrooms, and preschool through 12th grade classrooms)
2. Conference/meeting rooms
3. Employee lunch and break rooms

These spaces are not required to be connected to other automatic lighting shutoff controls.

b. For all other spaces, ~~E~~each *control device* shall be activated either manually by an occupant or automatically by sensing an occupant. Each *control device* shall ~~a.~~ control a maximum of 2500 ft^2 (232 m^2) area for a space 10,000 ft^2 (929 m^2) or less and a maximum of 10,000 ft^2 (929 m^2) area for a space greater than 10,000 ft^2 (929 m^2), and ~~b.~~ be capable of overriding ~~the~~ any time-of-day scheduled shutoff *control* ~~required in 9.2.1.1~~ for no more than four hours~~, and~~.

~~c. be readily accessible and located so the occupant can see the controlled lighting.~~

Exception to 9.2.1.2: Remote location shall be permitted for reasons of safety or security when the remote control device has an indicator pilot light as part of or next to the control device and ~~it~~ the light ~~shall be~~ is clearly labeled to identify the controlled lighting.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *ag* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on April 28, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum corrects the "retail sales area" LPD value that was published in the previously approved Addendum g to the 90.1-2001 standard. When the initial table of space-by-space method LPDs was prepared for Addendum g public review, the "Retail Sales area" was inadvertently left at the previous 90.1-2001 value of 2.1 W/ft^2 (23 W/m^2). The correct value produced by the applicable space type models is 1.7 W/ft^2 (18 W/m^2), which should have been included in Addendum g. This addendum corrects this oversight.

Addendum *ag* to 90.1-2001 (I-P and SI editions)

Revise retail sales area space type LPD to reflect the correct value. Replace the incorrect value with the correct value of 1.7 W/ft^2 (18 W/m^2) in Table 9.3.1.2 as follows:

I-P Version:

TABLE 9.3.1.2
Lighting Power Densities Using the Space-by-Space Method

~~Space-By-Space Method Lighting Power Density (LPD)~~			
Common Space Types[a]	**LPD (W/ft²)**	**Building Specific Space Types**	**LPD (W/ft²)**
Office-enclosed	1.1	Gymnasium/ Exercise Center	
Office-open plan	1.1	Playing Area	1.4
Conference/ Meeting/ Multipurpose	1.3	Exercise Area	0.9
Classroom/ Lecture/ Training	1.4	Courthouse/ Police Station/ Penitentiary	
For Penitentiary	1.3	Courtroom	1.9
Lobby	1.3	Confinement Cells	0.9
For Hotel	1.1	Judges Chambers	1.3
For Performing Arts Theater	3.3	Fire Stations	
For Motion Picture Theatre	1.1	Fire Station Engine room	0.8
Audience/ Seating Area	0.9	Sleeping Quarters	0.3
For Gymnasium	0.4	Post Office—Sorting Area	1.2
For Exercise Center	0.3	Convention Center—Exhibit Space	1.3
For Convention Center	0.7	Library	
For Penitentiary	0.7	Card File & Cataloguing	1.1
For Religious Buildings	1.7	Stacks	1.7
For Sports Arena	0.4	Reading Area	1.2
For Performing Arts Theatre	2.6	Hospital	
For Motion Picture theatre	1.2	Emergency	2.7
For Transportation	0.5	Recovery	0.8
Atrium-first three floors	0.6	Nurse station	1.0
Atrium-each additional floor	0.2	Exam/Treatment	1.5
Lounge/Recreation	1.2	Pharmacy	1.2
For Hospital	0.8	Patient Room	0.7
Dining area	0.9	Operating Room	2.2
For Penitentiary	1.3	Nursery	0.6
For Hotel	1.3	Medical Supply	1.4
For Motel	1.2	Physical Therapy	0.9
For Bar Lounge/Leisure Dining	1.4	Radiology	0.4
For Family Dining	2.1	Laundry—Washing	0.6
Food Preparation	1.2	Automotive—Service/Repair	0.7
Laboratory	1.4	Manufacturing	
Restrooms	0.9	Low Bay (<25 ft Floor to Ceiling Height)	1.2
Dressing/Locker/Fitting Room	0.6	High Bay (>25 ft Floor to Ceiling Height)	1.7
Corridor/Transition	0.5	Detailed Manufacturing	2.1
For Hospital	1.0	Equipment room	1.2
For Manufacturing Facility	0.5	Control room	0.5
Stairs – active	0.6	Hotel/ Motel Guest Rooms	1.1
Active Storage	0.8	Dormitory—Living Quarters	1.1
For Hospital	0.9	Museum	

TABLE 9.3.1.2
Lighting Power Densities Using the Space-by-Space Method (Continued)

Common Space Types[a]	LPD (W/ft^2)	Building Specific Space Types	LPD (W/ft^2)
Inactive storage	0.3	General Exhibition	1.0
For Museum	0.8	Restoration	1.7
Electrical/ mechanical	1.5	Bank/Office—Banking Activity Area	1.5
Workshop	1.9	Religious Buildings	
		Worship-pulpit, choir	2.4
		Fellowship Hall	0.9
		Retail [For accent lighting see 9.3.1.2.1.(c)]	
		Sales area	~~2.1~~ 1.7
		Mall Concourse	1.7
		Sports Arena	
		Ring Sports Area	2.7
		Court Sports Area	2.3
		Indoor Playing Field Area	1.4
		Warehouse	
		Fine Material Storage	1.4
		Medium/Bulky Material Storage	0.9
		Parking Garage—Garage Area	0.2
		Transportation	
		Airport—Concourse	0.6
		Air/Train/Bus—Baggage Area	1.0
		Terminal—Ticket counter	1.5

[a] In cases where both a common space type and a building specific space type are listed, the building specific space type shall apply.

SI Version:

TABLE 9.3.1.2
Lighting Power Densities Using the Space-by-Space Method

~~Space-By-Space Method Lighting Power Density (LPD)~~			
Common Space Types[a]	**LPD (W/m^2)**	**Building Specific Space Types**	**LPD (W/m^2)**
Office-enclosed	12	Gymnasium/ Exercise Center	
Office-open plan	12	Playing Area	15
Conference/ Meeting/ Multipurpose	14	Exercise Area	10
Classroom/ Lecture/ Training	15	Courthouse/ Police Station/ Penitentiary	
For Penitentiary	14	Courtroom	20
Lobby	14	Confinement Cells	10
For Hotel	12	Judges Chambers	14
For Performing Arts Theater	36	Fire Stations	
For Motion Picture Theatre	12	Fire Station Engine room	9
Audience/ Seating Area	10	Sleeping Quarters	3
For Gymnasium	4	Post Office—Sorting Area	13
For Exercise Center	3	Convention Center—Exhibit Space	14
For Convention Center	8	Library	
For Penitentiary	8	Card File & Cataloguing	12
For Religious Buildings	18	Stacks	18
For Sports Arena	4	Reading Area	13
For Performing Arts Theatre	28	Hospital	
For Motion Picture theatre	13	Emergency	29
For Transportation	5	Recovery	9
Atrium-first three floors	6	Nurse station	11
Atrium-each additional floor	2	Exam/Treatment	16
Lounge/Recreation	13	Pharmacy	13
For Hospital	9	Patient Room	8
Dining area	10	Operating Room	24
For Penitentiary	14	Nursery	6
For Hotel	14	Medical Supply	15
For Motel	13	Physical Therapy	10
For Bar Lounge/Leisure Dining	15	Radiology	4
For Family Dining	23	Laundry—Washing	6
Food Preparation	13	Automotive—Service/Repair	8
Laboratory	15	Manufacturing	
Restrooms	10	Low Bay (<25 ft Floor to Ceiling Height)	13
Dressing/Locker/Fitting Room	6	High Bay (>25 ft Floor to Ceiling Height)	18
Corridor/Transition	5	Detailed Manufacturing	23
For Hospital	11	Equipment room	13
For Manufacturing Facility	5	Control room	5
Stairs—active	6	Hotel/ Motel Guest Rooms	12

TABLE 9.3.1.2
Lighting Power Densities Using the Space-by-Space Method (Continued)

Common Space Types[a]	LPD (W/m^2)	Building Specific Space Types	LPD (W/m^2)
Active Storage	9	Dormitory—Living Quarters	12
For Hospital	10	Museum	
Inactive storage	3	General Exhibition	11
For Museum	9	Restoration	18
Electrical/ mechanical	16	Bank/Office—Banking Activity Area	16
Workshop	20	Religious Buildings	
		Worship-pulpit, choir	26
		Fellowship Hall	10
		Retail [For accent lighting see 9.3.1.2.1.(c)]	
		Sales area	~~23~~ 18
		Mall Concourse	18
		Sports Arena	
		Ring Sports Area	29
		Court Sports Area	25
		Indoor Playing Field Area	15
		Warehouse	
		Fine Material Storage	15
		Medium/Bulky Material Storage	10
		Parking Garage—Garage Area	2
		Transportation	
		Airport—Concourse	6
		Air/Train/Bus—Baggage Area	11
		Terminal—Ticket counter	16

[a] In cases where both a common space type and a building specific space type are listed, the building specific space type shall apply.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *ah* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on April 28, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 9.6, System Energy Utilization
SPLS Liaison: Michael H. Tavares
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum adds weather data for eight new locations: the District of Columbia (to remedy an earlier omission), six locations in the U.S. Territories, and a new location in the Philippines. These additions do not impact the stringency of the standard but simply increase its usability. The omission of DC from the current list of weather locations surfaced during training sessions about 90.1-1999/2001 compliance that were presented in the region near Washington, D.C.

Addendum *ah* to 90.1-2001 (I-P and SI editions)

Change the title of Table D-1 in Appendix D as follows (both I-P and SI editions):

TABLE D-1
U.S. and U.S. Territory Climatic Data

Add the following weather data for the District of Columbia and U.S. Territories to Table D-1 in Appendix D. These data should be placed at the end of the Table D-1, after the entries for Wyoming, with a double horizontal line separating these entries from the Wyoming entries.

(I-P Edition)

District or Territory	Location	Table	Latitude		Longitude		Elev. (ft)	HDD65	CDD50	IP Units (°F) Win. Des. 99.6%	Summer DB 1.0%	Summer WB 1.0%	No. Hrs. 8 a.m.-4 p.m. 55<Tdb<69
District of Columbia (DC)													
	Ronald Reagan Airport	B-13	38.85	N	77.03	W	66	4,047	4,391	15	92	76	657
Puerto Rica (PR)													
	San Juan/Isla Verde WSFO	B-1	18.43	N	66.00	W	10	0	11,406	69	90	78	N.A.
Pacific Islands (PI)													
	Guam (GU) - Andersen AFB	B-2	13.58	N	144.93	E	361	0	10,690	74	87	79	N.A.
	Marshall Island (MH) - Kwajalein Atoll	B-1	8.73	N	167.73	E	26	0	11,670	76	88	79	N.A.
	Midway Island (MH) - Midway Island NAF	B-3	28.22	N	177.37	W	13	134	8,323	59	86	75	N.A.
	Samoa (WS) - Pago Pago WSO Airport	B-1	14.33	S	170.72	W	9	0	11,018	72	88	80	N.A.
	Wake Island - Wake Island WSO Airport	B-1	19.28	N	166.65	E	12	0	11,097	71	89	79	N.A.

(SI Edition)

District or Territory	Location	Table	Latitude		Longitude		Elev. (m)	HDD18	CDD10	SI Units (°C) Win. Des. 99.6%	Summer DB 1.0%	Summer WB 1.0%	No. Hrs. 8 a.m.-4 p.m. 13<Tdb<21
District of Columbia (DC)													
	Ronald Reagan Airport	B-13	38.85	N	77.03	W	20	2,248	2,439	-9	34	24	657
Puerto Rica (PR)													
	San Juan/Isla Verde WSFO	B-1	18.43	N	66.00	W	3	0	6,337	21	32	26	N.A.
Pacific Islands (PI)													
	Guam (GU) - Andersen AFB	B-2	13.58	N	144.93	E	185	0	5,939	23	31	26	N.A.
	Marshall Island (MH) - Kwajalein Atoll	B-1	8.73	N	167.73	E	8	0	6,483	24	31	26	N.A.
	Midway Island (MH) - Midway Island NAF	B-3	28.22	N	177.37	W	4	74	4,624	15	30	24	N.A.
	Samoa (WS) - Pago Pago WSO Airport	B-1	14.33	S	170.72	W	3	0	6,121	22	31	27	N.A.
	Wake Island - Wake Island WSO Airport	B-1	19.28	N	166.65	E	4	0	6,165	22	31	26	N.A.

Add the following weather data for the Philippines to Table D-3 in Appendix D (both I-P and S-I shown).

										IP Units (°F)			
										Win.	**Summer**		**No. Hrs.**
							Elev.			**Des.**	**DB**	**WB**	**8 a.m.-4 p.m.**
Country	**City**	**Table**	**Latitude**		**Longitude**		**(ft)**	**HDD65**	**CDD50**	**99.6%**	**1.0%**	**1.0%**	**55<Tdb<69**
Philippines													
	Philippines (PH) - Angeles, Clark AFB	B-1	15.18	N	120.55	E	475	0	11,280	68	95	77	N.A.

										SI Units (^{o}C)			
										Win.	**Summer**		**No. Hrs.**
							Elev.			**Des.**	**DB**	**WB**	**8am-4pm**
Country	**City**	**Table**	**Latitude**		**Longitude**		**(m)**	**HDD18**	**CDD10**	**99.6%**	**1.0%**	**1.0%**	**13<Tdb<21**
Philippines													
	Philippines (PH) - Angeles, Clark AFB	B-1	15.18	N	120.55	E	196	0	6,267	20	35	25	N.A.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *ai* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee June 26, 2004; by the ASHRAE Board of Directors July 1, 2004; and by the American National Standards Institute July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Hugh F. Crowther
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

The change in this addendum to a maximum of 5 watts per face of exit signs is achievable by commonly available technologies, including, but not limited to, LED, electroluminescent, and cold cathode. An example economic analysis for LED technology follows:

Incandescent type: average fixture cost is $25.00 plus two 25-watt lamps @ $.50 each and 10 minutes ($10.00) to change both lamps every 1,000 hours

Energy cost per year: 50 watts × 8760 hours = 438 kWh @ $.08	*$35.08*
Lamp replacement per year - 18 lamps @ $.50 + 9 changes @ $10.00	*$99.00*
Total operating cost per year	*$134.08*

Compact fluorescent type: average fixture cost is $35.00 plus two 7-watt lamps @ $5.00 each and 10 minutes ($10.00) to change both lamps every 10,000 hours

Fixture Wattage = 20 watts (two 7-watt lamps plus ballast losses)	
Energy cost per year – 20 watts × 8760 hours = 175.2 kWh @ $.08	*$14.02*
Lamp replacement per year – 2 lamps @ $5.00 + 1 change @ $10.00	*$20.00*
Total operating cost per year	*$34.02*

LED type: average fixture cost is $45.00; no cost for lamps, 3 to 5 watts total and rated over 100,000 hours, that are part of fixture

Energy cost per year – 5 watts × 8760 hours = 43.8 kWh @ $.08	*$3.51*
Lamp replacement per year	*$0.00*
Total operating cost per year	*$3.51*

Payback compared to incandescent type (394.2 kWh per year saved);	
Initial installation - $45.00/($134.08 - $3.51) =	*0.35 years*

Payback compared to compact fluorescent type (131.4 kWh per year saved);	
Initial installation - $45.00/($34.02 - $3.51) =	*1.5 years*

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and strikethrough (for deletions).

Addendum *ai* to 90.1-2001 (I-P and SI editions)

Revise Section 9.2.3 as follows:

9.2.3 Exit Signs. Internally illuminated exit signs shall not exceed 5 watts per face. ~~Exit sign luminaries operating at greater than 20 watts shall have a minimum source efficacy of 35 lm/W.~~

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *al* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 26, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Hugh F. Crowther
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

Several of the informative references related to Section 11 in Appendix E are out of date in ANSI/ASHRAE/IESNA Standard 90.1-2001. This addendum updates the references related to building energy simulation software programs and annual weather data.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and strikethrough (for deletions).

Addendum *al* to 90.1-2001 (I-P and SI editions)

In Informative Appendix E, revise the following references as shown:

INFORMATIVE APPENDIX E

INFORMATIVE REFERENCES

BLAST
Building Systems Laboratory
University of Illinois
1206 West Green Street
Urbana, Illinois 61801
http://www.bso.uiuc.edu/BLAST/index.html
~~American Society of Heating, Refrigerating and~~
~~Air-Conditioning Engineers, Inc.~~
~~1791 Tullie Circle, NE~~
~~Atlanta, GA 30329-2305~~
~~(T) 404-636-8400~~
~~(F) 404-321-5478~~
~~http://www.ashrae.org~~

DOE-2 ~~Data~~
Building Energy Simulation news
http://simulationresearch.lbl.gov/un.html
~~U.S Department of Commerce~~
~~Technology Administration~~
~~National Technical Information Service~~
~~5285 Port Royal Road~~
~~Springfield, VA 22161~~
~~(T) 1-800-553-6847~~
~~(T) 1-888-584-8332~~
~~(T) 1-703-605-6000~~
~~(F) 1-703-321-8547~~
~~http://www.ntis.gov~~

TMY2 Data
National Renewable Energy Laboratory
NREL/RReDC
Attn: Pamela Gray-Hann
1617 Cole Blvd., MS-1612
Golden, Colorado, USA 80401
http://rredc.nrel.gov/solar/old_data/nsrdb/tmy2/

~~TMY Data~~
~~National Climatic Data Center~~
~~National Environmental Satellite, Data, and Information Service~~
~~National Oceanic and Atmospheric Administration~~
~~Climate Services Branch~~
~~Federal Building~~
~~Room 468~~
~~151 Patton Avenue~~
~~Asheville, NC 28801-5001~~
~~(T) 828-271-4800~~
~~(F) 828-271-4876~~
~~info@ncdc.noaa.gov~~
~~Free download at http://doe2.com/Download/Weather/TMY~~

WYEC2 Data
American Society of Heating, Refrigerating and
Air-Conditioning Engineers, Inc.
ASHRAE Bookstore
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
(T) 404-636-8400
(F) 404-321-5478
http://resourcecenter.ashrae.org/store/ashrae/

~~WYEC Data~~
~~American Society of Heating, Refrigerating and~~
~~Air-Conditioning Engineers, Inc.~~
~~ASHRAE Customer Service~~
~~1791 Tullie Circle, NE~~
~~Atlanta, GA 30329-2305~~
~~(T) 404-636-8400~~
~~(F) 404-321-5478~~
~~orders@ashrae.org~~
~~Free download at http://doe2.com/Download/Weather/WYEC~~

IWEC Data
American Society of Heating, Refrigerating and
Air-Conditioning Engineers, Inc.
ASHRAE Bookstore
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
(T) 404-636-8400
(F) 404-321-5478

~~CWEC Data~~
~~Canadian Climatic Service~~
~~Atmospheric Environment Service~~
~~4905 Dufferin Street~~
~~Downsview, Ontario~~
~~Canada M3H 5T4~~
~~(T) 416-739-4328~~
~~(F) 416-739-4446~~
~~Climate.services@ec.gc.ca~~

Subsection No.	Reference	Title/Source
11.2.1	DOE-2	~~National Technical Information Service~~ Support provided by Lawrence Berkeley National Laboratory at the referenced web site
11.2.2	IWEC	International Weather for Energy Calculations
11.2.2	TMY2 Data	Typical Meteorological Year
~~11.2.2~~	~~CWEC Data~~	~~Canadian Weather for Energy Calculations~~

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE/IESNA Addendum *am* to
ANSI/ASHRAE/IESNA Standard 90.1-2001

ASHRAE® STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 26, 2004; by the ASHRAE Board of Directors on July 1, 2004; and by the American National Standards Institute on July 1, 2004.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

ISSN 1041-2336

Approved American National Standard ANSI

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, NE • Atlanta, GA 30329

ASHRAE Standing Standard Project Committee 90.1
Cognizant TC: TC 7.6, Systems Energy Utilization
SPLS Liaison: Hugh F. Crowther
ASHRAE Staff Liaison: Mark Weber
IESNA Liaison: Rita M. Harrold

Jerry W. White, Jr., *Chair**
James M. Calm, *Vice-Chair**
Donald F. Steiner, *Vice-Chair**
Karim Amrane*
William P. Bahnfleth*
Van D. Baxter*
Denise M. Beach
Donald L. Beaty*
Valerie L. Block*
Donald M. Brundage*
Ernest A. Conrad
Charles C. Cottrell*
Roy Crane*
Joseph J. Deringer*
Keith I. Emerson*
Thomas A. Farkas*
Alan Fraser*
James A. Garrigus*
Jason J. Glazer*
Katherine G. Hammack*
Richard V. Heinisch*
Randall T. Higa*
Billy G. Hinton, Jr.*
John F. Hogan*
William G. Holy*
Hyman M. Kaplan*
Larry Kouma*
Ronald D. Kurtz*
Samantha H. LaFleur
Michael D. Lane*
Dean E. Lewis
Steven J. Lit*
Richard Lord
Kenneth Luther*
Ronald Majette*
Itzhak H. Maor*
Carol E. Marriott*
R. Christopher Mathis*
Merle F. McBride
Harry P. Misuriello
Louis J. Molinini*
John Montgomery*
Frank Myers*
Ronald G. Nickson*
Edward P. O'Brien*
Jim A. Ranfone*
Eric E. Richman*
Michael L. Rosenberg*
Steven Rosenstock
Robert D. Ross*
David A. Schaaf, Jr.*
Leonard C. Sciarra*
Bipin Vadilal Shah
Peter Simmonds*
Stephen V. Skalko*
Frank A. Stanonik*
Joseph K. Ting*
Cedric S. Trueman*
Martha G. VanGeem
Carl Wagus*
McHenry Wallace, Jr.*
Richard D. Watson*
David Weitz*
Robin Wilson*
Michael W. Woodford
Thomas R. Worlledge*
Donald R. Wulfinghoff*
Stanley W. Zajac*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2003-2004

Van D. Baxter, *Chair*
Davor Novosel, *Vice-Chair*
Donald B. Bivens
Dean S. Borges
Paul W. Cabot
Charles W. Coward, Jr.
Hugh F. Crowther
Brian P. Dougherty
Hakim Elmahdy
Matt R. Hargan
Richard D. Hermans
John F. Hogan
Frank E. Jakob
Stephen D. Kennedy
David E. Knebel
Frederick H. Kohloss
Merle F. McBride
Mark P. Modera
Cyrus H. Nasseri
Gideon Shavit
David R. Tree
Thomas H. Williams
James E. Woods
Ross D. Montgomery, *BOD ExO*
Kent W. Peterson, *CO*

Claire B. Ramspeck, *Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Consensus is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard,
d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(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.)

FOREWORD

This addendum reduces the number of climate zones from 26 to 8. This change should reduce the size of 90.1 and simplify compliance. Also, these changes should increase the consistency in the treatment of climate zones between 90.1 and other standard and code documents.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and strikethrough (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum *am* to 90.1-2001 (I-P and SI editions)

[Delete the existing Table 3.2 and replace it with the following new Table 3.2.]

(I-P edition)

TABLE 3.2
Heated Space Criteria

Heating Output (Btu/h·ft^2)	Climate Zone
5	1 and 2
10	3
15	4 and 5
20	6 and 7
25	8

(SI edition)

TABLE 3.2
Heated Space Criteria

Heating Output (W/m^2)	Climate Zone
15	1 and 2
30	3
45	4 and 5
60	6 and 7
75	8

[Revise Sections 5.1.3, 5.1.3.1, and 5.2.3.2 as shown below.]

5.1.3 Climate. ~~The climate shall be determined based on the *cooling degree-days base 50°F, CDD50 (10°C, CDD10)*, and *heating degree-days base 65°F, HDD65 (18 °C, HDD18)*.~~ Determine the climate zone for the location. For locations in the United States, follow the procedure in 5.1.3.1. For international locations in Canada and other countries, follow the procedure in 5.1.3.2.

5.1.3.1 United States Locations ~~Listed~~. ~~For those locations listed in Normative Appendix D, use the published climatic data to determine compliance. In the case of cities or urban regions with several climatic data entries, the designer shall select the location within the region or city that best represents the climate of the construction site.~~ Use Figure B-1 or Table B-1 in Appendix B to determine the required climate zone.

5.1.3.2 International Locations ~~Not Listed~~. ~~For locations not listed in Normative Appendix D, designers shall select the location that best represents the climatic conditions of the construction site being analyzed to determine compliance. If there are recorded historical climatic data available for a construction site, they may be used to determine compliance if approved by the building official.~~. For locations in Canada that are listed in Table B-2 in Appendix B, use this table to determine the required climate zone number and, when a climate zone letter is also required, use Table B-4 and the Major Climate Type Definitions in Appendix B to determine the letter (A, B, or C). For locations in other international countries that are listed in Table B-3, use this table to determine the required climate zone number and, when a climate zone letter is also required, use Table B-4 and the Major Climate Type Definitions in Appendix B to determine the letter (A, B, or C). For all international locations that are not listed either in Table B-2 or B-3, use Table B-4 and the Major Climate Type Definitions in Appendix B to determine both the climate zone letter and number.

[Revise Section 5.1.4 as shown.]

5.1.4 Envelope Requirements Are Specified by Space-Conditioning Categories. Separate *exterior building envelope* requirements are specified for each of two categories of conditioned space:

a. nonresidential conditioned space,
b. residential conditioned space.

Spaces shall be assumed to be *conditioned space* and shall comply with the requirements for *conditioned space* at the time of construction, regardless of whether mechanical or electrical equipment is included in the building permit application or installed at that time.

Exceptions to 5.1.4: For buildings that contain *spaces* that will be only *semi-heated* or *unconditioned*, and if alternative compliance is sought for such spaces, then all *semi-heated* or *unconditioned* spaces shall be clearly indicated on the floor plan as such, and the following *semi-exterior building envelope* requirements apply:

(a) If a *space* will be only *semiheated*, the *space* shall be considered *semiheated*.
(b) If a *space* will remain *unconditioned*, the *space* shall be considered *unconditioned*.

In ~~climates that exceed 1800 *HDD 65 (1000 HDD18)*~~ Climate Zones 3 through 8, a space may be designated as either *semiheated* or *unconditioned* only if approved by the *building official*.

[Revise Tables 5.3.1.1A and 5.3.1.1B as shown below.]

(I-P edition)

TABLE 5.3.1.1A
Single Rafter Roofs

~~HDD65~~ Climate Zone	Minimum Insulation R-Value or Maximum Assembly U-Factor		
	Wood Rafter Depth, *d (actual)*)		
	d 8 in.	8 < *d* 10 in.	10 < *d* 12 in.
~~0-12,600~~ 1-7	R-19	R-30	R-38
	U-0.055	U-0.036	U-0.028
~~>12,600~~ 8	R-21	R-30	R-38
	U-0.052	U-0.036	U-0.028

(SI edition)

TABLE 5.3.1.1A
Single Rafter Roofs

~~HDD18~~ Climate Zone	Minimum Insulation R-Value or Maximum Assembly U-Factor		
	Wood Rafter Depth, *d (actual)*)		
	d 200 mm	200 < *d* 250 mm	250 < *d* 300 mm
~~0-7000~~ 1-7	R-3.3	R-5.3	R-6.7
	U-0.31	U-0.0.20	U-0.16
~~>7000~~ 8	R-3.7	R-5.3	R-6.7
	U-0.29	U-0.20	U-0.16

(I-P edition)

TABLE 5.3.1.1B
Roof U-Factor Multipliers for Exception to 5.3.1.1

~~HDD65~~ Climate Zone	Roof U-Factor Multiplier
~~0-900~~ 1	0.77
~~901-1800~~ 2	0.83
~~1801-2700~~ 3	0.85
~~2701-3600~~	~~0.86~~
~~>3600~~ 4 through 8	1.00

TABLE 5.3.1.1B
Roof U-Factor Multipliers for Exception to 5.3.1.1

~~HDD18~~ Climate Zone	Roof U-Factor Multiplier
~~0-500~~ 1	0.77
~~501-1000~~ 2	0.83
~~1001-1500~~ 3	0.85
~~1501-2000~~	~~0.86~~
~~>2000~~ 4 through 8	1.00

[Revise Section 5.3 as follows.]

5.3 Prescriptive Building Envelope Option

For *conditioned space*, the *exterior building envelope* shall comply with either the "nonresidential" or "residential" requirements in Table 5.3 ~~(located in Normative Appendix B)~~ for the appropriate climate.

~~(Table 5.3: When adopted the appropriate tables are to be inserted here by the adopting jurisdiction (state, province, county, city, etc.). Only a limited number of tables in Normative Appendix B are applicable to any one particular jurisdiction. The remainder of Normative Appendix B need not be adopted. See Appendix B for the process to select the applicable tables. Then, select the actual tables from the Normative Appendix B and insert them here: An example table is shown on the next page.)~~

If a building contains any semiheated space or unconditioned space, as noted in the exceptions to 5.1.1, then the *semi-exterior building envelope* shall comply with the requirements for *semiheated space* in Table 5.3 for the appropriate climate. (See Figure 5.3, Exterior and Semi-Exterior Building Envelope.)

[Revise Section 5.3.2.3 as follows.]

5.3.2.3 Fenestration Solar Heat Gain Coefficient (SHGC). *Vertical fenestration* shall have an *SHGC* not greater than that specified for "all" orientations in Table 5.3 for the appropriate total *vertical fenestration area*. *Skylights*, including glass *skylights* with a curb, plastic *skylights* with a curb, and all *skylights* without a curb, shall have an *SHGC* not greater than that specified for "all" orientations in Table 5.3 for the appropriate total *skylight area*. *SHGC* for *fenestration* shall be determined in accordance with 5.2.2. There are no *SHGC* requirements for *semiheated spaces* or for buildings in ~~climates with greater than 10800 HDD65 (6000 HDD18)~~ Climate Zone 8.

[Revise Section 5.3.3.3 as follows.]

5.5.3.3 Loading Dock Weatherseals. In ~~climates that exceed 3600 HDD65 (2000 HDD18)~~ Climate Zones 4 through 8, cargo *doors* and loading dock *doors* shall be equipped with weatherseals to restrict *infiltration* when vehicles are parked in the doorway.

[Revise Section 5.5.3.4 as follows.]

5.5.3.4 Vestibules. A *door* that separates *conditioned space* from the exterior shall be protected with an enclosed vestibule, with all *doors* opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior *doors* to open at the same time. Interior and exterior *doors* shall have a minimum distance between them of not less than 7 ft (21. m) when in the closed position.

Exceptions to 5.5.3.4:

(a) *Doors* in buildings in ~~climates that have less than 1800 HDD65 (1000 HDD18)~~ Climate Zones 1 and 2

(b) *Doors* in buildings less than four stories above grade

(c) *Doors* not intended to be used as a *building entrance door*, such as mechanical or electrical equipment rooms

(d) *Doors* opening directly from a *dwelling unit*

(e) *Doors* that open directly from a space less than 3000 ft^2 (300 m^2) in area

(f) *Doors* in building entrances with revolving *doors*

(g) *Doors* used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

[Move the following tables from Appendix B and insert them here. Change the titles of the tables as follows to create Tables 5.3-1 through 5.3-8. The I-P and SI versions of the tables appear on the following eighteen pages.]

(I-P edition)

TABLE ~~B-2~~5.3-1
Building Envelope Requirements For Climate Zone 1 (A,B) ~~(HDD65: 0-900, CDD50: 9001-10800)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	NR
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.44	U_{oper}-1.27	$SHGC_{north}$-0.44	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22	$SHGC_{all}$-0.19	U_{fixed}-1.22	$SHGC_{all}$-0.19	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.33	U_{oper}-1.27	$SHGC_{north}$-0.33	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a]Exception to 5.3.1.2a applies.

(SI edition)

TABLE ~~B-2~~5.3-1
Building Envelope Requirements For Climate Zone 1 (A,B) ~~(HDD18: 0-500, CDD10: 5001-6000)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.360	R-2.6 ci	U-0.360	R-2.6 ci	U-7.280	NR
Metal Building	U-0.369	R-3.3	U-0.369	R-3.3	U-7.268	NR
Attic and Other	U-0.192	R-5.3	U-0.153	R-6.7	U-3.483	NR
Walls, Above Grade						
Mass	U-3.293	NR	U-0.857[a]	R-1.0 ci[a]	U-3.293	NR
Metal Building	U-0.642	R-2.3	U-0.642	R-2.3	U-6.700	NR
Steel Framed	U-0.705	R-2.3	U-0.705	R-2.3	U-1.998	NR
Wood Framed and Other	U-0.504	R-2.3	U-0.504	R-2.3	U-1.660	NR
Wall, Below Grade						
Below Grade Wall	C-6.473	NR	C-6.473	NR	C-6.473	NR
Floors						
Mass	U-1.825	NR	U-1.825	NR	U-1.825	NR
Steel Joist	U-1.986	NR	U-1.986	NR	U-1.986	NR
Wood Framed and Other	U-1.599	NR	U-1.599	NR	U-1.599	NR
Slab-On-Grade Floors						
Unheated	F-1.264	NR	F-1.264	NR	F-1.264	NR
Heated	F-1.766	R-1.3 for 300 mm	F-1.766	R-1.3 for 300 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						
Swinging	U-3.975		U-3.975		U-3.975	
Non-Swinging	U-8.233		U-8.233		U-8.233	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
10.1-20.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
20.1-30.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
30.1-40.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.44	Uoper-7.21	$SHGC_{north}$- 0.44	Uoper-7.21	$SHGC_{north}$- NR
40.1-50.0%	Ufixed-6.93	$SHGC_{all}$- 0.19	Ufixed-6.93	$SHGC_{all}$- 0.19	Ufixed-5.54	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.33	Uoper-7.21	$SHGC_{north}$- 0.33	Uoper-5.77	$SHGC_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-11.24	$SHGC_{all}$- 0.36	Uall-11.24	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- NR
2.1-5.0%	Uall-11.24	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- 0.16	Uall-11.24	$SHGC_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-10.79	$SHGC_{all}$- 0.34	Uall-10.79	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- NR
2.1-5.0%	Uall-10.79	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-7.72	$SHGC_{all}$- 0.36	Uall-7.72	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- NR
2.1-5.0%	Uall-7.72	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- NR

[a] Exception to 5.3.1.2a applies

(I-P edition)

TABLE ~~B-5~~5.3-2
Building Envelope Requirements For Climate Zone 2 (A,B) ~~(HDD65: 901-1800, CDD50: 7201+)~~

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	R-4.2 ci	U-0.107	R-6.3 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-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	

Fenestration	Nonresidential Assembly Max. U (Fixed/ Operable)	Nonresidential Assembly Max. SHGC (All Orientations/ North-Oriented)	Residential Assembly Max. U (Fixed/ Operable)	Residential Assembly Max. SHGC (All Orientations/ North-Oriented)	Semiheated Assembly Max. U (Fixed/ Operable)	Semiheated Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing,% of Wall						
0-10.0%	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.25}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.39}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-NR}$
	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{NR}$
10.1-20.0%	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.25}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.25}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-NR}$
	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{NR}$
20.1-30.0%	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.25}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.25}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-NR}$
	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{NR}$
30.1-40.0%	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.25}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.25}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-NR}$
	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.61}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{NR}$
40.1-50.0%	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.17}$	$U_{fixed}^{-1.22}$	$SHGC_{all}^{-0.17}$	$U_{fixed}^{-0.98}$	$SHGC_{all}^{-NR}$
	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.44}$	$U_{oper}^{-1.27}$	$SHGC_{north}^{-0.43}$	$U_{oper}^{-1.02}$	$SHGC_{north}^{NR}$
Skylight with Curb, Glass,% of Roof						
0-2.0%	$U_{all}^{-1.98}$	$SHGC_{all}^{-0.36}$	$U_{all}^{-1.98}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.98}$	$SHGC_{all}^{-NR}$
2.1-5.0%	$U_{all}^{-1.98}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.98}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.98}$	$SHGC_{all}^{-NR}$
Skylight with Curb, Plastic,% of Roof						
0-2.0%	$U_{all}^{-1.90}$	$SHGC_{all}^{-0.39}$	$U_{all}^{-1.90}$	$SHGC_{all}^{-0.27}$	$U_{all}^{-1.90}$	$SHGC_{all}^{-NR}$
2.1-5.0%	$U_{all}^{-1.90}$	$SHGC_{all}^{-0.34}$	$U_{all}^{-1.90}$	$SHGC_{all}^{-0.27}$	$U_{all}^{-1.90}$	$SHGC_{all}^{-NR}$
Skylight without Curb, All,% of Roof						
0-2.0%	$U_{all}^{-1.36}$	$SHGC_{all}^{-0.36}$	$U_{all}^{-1.36}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.36}$	$SHGC_{all}^{-NR}$
2.1-5.0%	$U_{all}^{-1.36}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.36}$	$SHGC_{all}^{-0.19}$	$U_{all}^{-1.36}$	$SHGC_{all}^{-NR}$

[a] Exception to 5.3.1.2a applies.

(SI edition)

TABLE ~~B-5~~5.3-2
Building Envelope Requirements For Climate Zone 2 (A,B) ~~(HDD18: 501-1000, CDD10: 4001+)~~

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.360	R-2.6 ci	U-0.360	R-2.6 ci	U-1.240	R-0.7 ci
Metal Building	U-0.369	R-3.3	U-0.369	R-3.3	U-0.948	R-1.1
Attic and Other	U-0.192	R-5.3	U-0.153	R-6.7	U-0.459	R-2.3
Walls, Above Grade						
Mass	U-3.293	NR	U-0.857[a]	R-1.0 ci[a]	U-3.293	NR
Metal Building	U-0.642	R-2.3	U-0.642	R-2.3	U-1.045	R-6.0
Steel Framed	U-0.705	R-2.3	U-0.705	R-2.3	U-1.998	NR
Wood Framed and Other	U-0.504	R-2.3	U-0.504	R-2.3	U-1.660	NR
Wall, Below Grade						
Below Grade Wall	C-6.473	NR	C-6.473	NR	C-6.473	NR
Floors						
Mass	U-0.780	R-0.7 ci	U-0.606	R-1.1 ci	U-1.825	NR
Steel Joist	U-0.296	R-3.3	U-0.296	R-3.3	U-1.986	NR
Wood Framed and Other	U-0.288	R-3.3	U-0.288	R-3.3	U-1.599	NR
Slab-On-Grade Floors						
Unheated	F-1.264	NR	F-1.264	NR	F-1.264	NR
Heated	F-1.766	R-1.3 for 300 mm	F-1.766	R-1.3 for 300 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						
Swinging	U-3.975		U-3.975		U-3.975	
Non-Swinging	U-8.233		U-8.233		U-8.233	

Fenestration	Nonresidential Assembly Max. U (Fixed/ Operable)	Nonresidential Assembly Max. SHGC (All Orientations/ North-Oriented)	Residential Assembly Max. U (Fixed/ Operable)	Residential Assembly Max. SHGC (All Orientations/ North-Oriented)	Semiheated Assembly Max. U (Fixed/ Operable)	Semiheated Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
10.1-20.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
20.1-30.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
30.1-40.0%	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
40.1-50.0%	Ufixed-6.93	$SHGC_{all}$- 0.17	Ufixed-6.93	$SHGC_{all}$- 0.17	Ufixed-5.54	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.44	Uoper-7.21	$SHGC_{north}$- 0.43	Uoper-5.77	$SHGC_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-11.24	$SHGC_{all}$- 0.36	Uall-11.24	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- NR
2.1-5.0%	Uall-11.24	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-10.79	$SHGC_{all}$- 0.39	Uall-10.79	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- NR
2.1-5.0%	Uall-10.79	$SHGC_{all}$- 0.34	Uall-10.79	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-7.72	$SHGC_{all}$- 0.36	Uall-7.72	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- NR
2.1-5.0%	Uall-7.72	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- NR

[a]Exception to 5.3.1.2a applies

(I-P edition)

TABLE ~~B-10~~5.3-3
Building Envelope Requirements For Climate Zone 3 (A,B,C) ~~(HDD65: 2701-3600, CDD50: 5401+)~~

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a,b]	R-5.7 ci[a,b]	U-0.123	R-7.6 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration (for Zones 3A and 3B; see next page for Zone 3C)	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-0.57	$SHGC_{all}$-0.25	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-0.67	$SHGC_{north}$-0.39	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.19	U_{fixed}-0.46	$SHGC_{all}$-0.19	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.26	U_{oper}-0.47	$SHGC_{north}$-0.26	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.17	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.19	U_{all}-1.17	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.69	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-0.69	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a]Exception to 5.3.1.2a applies.
[b]Insulation is not required for non-residential mass walls in Climate Zone 3A located below the "Warm-Humid" line, and in Zone 3B.

TABLE ~~B-9~~5.3-3 (continued)
Building Fenestration Requirements For Climate Zone 3C

Fenestration (for Zone 3C)	Nonresidential Assembly Max. U (Fixed/ Operable)	Nonresidential Assembly Max. SHGC (All Orientations/ North-Oriented)	Residential Assembly Max. U (Fixed/ Operable)	Residential Assembly Max. SHGC (All Orientations/ North-Oriented)	Semiheated Assembly Max. U (Fixed/ Operable)	Semiheated Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.82	U_{oper}-1.27	$SHGC_{north}$-0.82	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-0.61	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22	$SHGC_{all}$-0.34	U_{fixed}-1.22	$SHGC_{all}$-0.34	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$-0.61	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22	$SHGC_{all}$-0.20	U_{fixed}-0.73	$SHGC_{all}$-0.25	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-1.27	$SHGC_{north}$-0.30	U_{oper}-0.81	$SHGC_{north}$-0.61	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.61	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.61	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

~~[a]Exception to 5.3.1.2a applies.~~

(SI edition)

TABLE ~~B-10~~5.3-3
Building Envelope Requirements For Climate Zone 3 (A,B,C) ~~(HDD18: 1501-2000, CDD10: 3001+)~~

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Maximum	Min. R-Value	Maximum	Min. R-Value	Maximum	Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.360	R-2.6 ci	U-0.360	R-2.6 ci	U-1.240	R-0.7 ci
Metal Building	U-0.369	R-3.3	U-0.369	R-3.3	U-0.551	R-1.8
Attic and Other	U-0.192	R-5.3	U-0.153	R-6.7	U-0.459	R-2.3
Walls, Above Grade						
Mass	U-0.857[a,b]	R-1.0 ci[a,b]	U-0.701	R-1.3 ci	U-3.293	NR
Metal Building	U-0.642	R-2.3	U-0.642	R-2.3	U-1.045	R-1.1
Steel Framed	U-0.705	R-2.3	U-0.479	R-2.3 + R-0.7 ci	U-1.998	NR
Wood Framed and Other	U-0.504	R-2.3	U-0.504	R-2.3	U-0.504	R-2.3
Wall, Below Grade						
Below Grade Wall	C-6.473	NR	C-6.473	NR	C-6.473	NR
Floors						
Mass	U-0.606	R-1.1	U-0.496	R-1.5	U-1.825	NR
Steel Joist	U-0.296	R-3.3	U-0.296	R-3.3	U-0.390	R-2.3
Wood Framed and Other	U-0.288	R-3.3	U-0.188	R-5.3	U-1.599	NR
Slab-On-Grade Floors						
Unheated	F-1.264	NR	F-1.264	NR	F-1.264	NR
Heated	F-1.766	R-1.3 for 300 mm	F-1.644	R-1.3 for 600 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						
Swinging	U-3.975		U-3.975		U-3.975	
Non-Swinging	U-8.233		U-2.839		U-8.233	
Fenestration (for Zones 3A and 3B; see next page for Zone 3C)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
10.1-20.0%	Ufixed-3.24	$SHGC_{all}$- 0.25	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
20.1-30.0%	Ufixed-3.24	$SHGC_{all}$- 0.25	Ufixed-3.24	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.39	Uoper-3.80	$SHGC_{north}$- 0.39	Uoper-7.21	$SHGC_{north}$- NR
30.1-40.0%	Ufixed-3.24	$SHGC_{all}$- 0.25	Ufixed-3.24	$SHGC_{all}$- 0.25	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.39	Uoper-3.80	$SHGC_{north}$- 0.39	Uoper-7.21	$SHGC_{north}$- NR
40.1-50.0%	Ufixed-2.61	$SHGC_{all}$- 0.19	Ufixed-2.61	$SHGC_{all}$- 0.19	Ufixed-5.54	$SHGC_{all}$- NR
	Uoper-2.67	$SHGC_{north}$- 0.26	Uoper-2.67	$SHGC_{north}$- 0.26	Uoper-5.77	$SHGC_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-6.64	$SHGC_{all}$- 0.39	Uall-6.64	$SHGC_{all}$- 0.36	Uall-11.24	$SHGC_{all}$- NR
2.1-5.0%	Uall-6.64	$SHGC_{all}$- 0.19	Uall-6.64	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-7.38	$SHGC_{all}$- 0.65	Uall-7.38	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- NR
2.1-5.0%	Uall-7.38	$SHGC_{all}$- 0.34	Uall-7.38	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-3.92	$SHGC_{all}$- 0.39	Uall-3.92	$SHGC_{all}$- 0.36	Uall-7.72	$SHGC_{all}$- NR
2.1-5.0%	Uall-3.92	$SHGC_{all}$- 0.19	Uall-3.92	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- NR

[a] Exception to 5.3.1.2a applies
[b] Insulation is not required for non-residential mass walls in Climate Zone 3A located below the "Warm-Humid" line, and in Zone 3B.

TABLE ~~B-9~~5.3-3 (continued)
Building Envelope Requirements For Climate Zone 3C ~~(HDD18: 1001-1500, CDD10: 0-3000)~~

Fenestration (for Zone 3C)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-6.93	$SHGC_{all}$- 0.61	Ufixed-6.93	$SHGC_{all}$- 0.61	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.82	Uoper-7.21	$SHGC_{north}$- 0.82	Uoper-7.21	$SHGC_{north}$- NR
10.1-20.0%	Ufixed-6.93	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- 0.61	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
20.1-30.0%	Ufixed-6.93	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
30.1-40.0%	Ufixed-6.93	$SHGC_{all}$- 0.34	Ufixed-6.93	$SHGC_{all}$- 0.34	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- 0.61	Uoper-7.21	$SHGC_{north}$- NR
40.1-50.0%	Ufixed-6.93	$SHGC_{all}$- 0.20	Ufixed-4.14	$SHGC_{all}$- 0.25	Ufixed-5.54	$SHGC_{all}$- NR
	Uoper-7.21	$SHGC_{north}$- 0.30	Uoper-4.60	$SHGC_{north}$- 0.61	Uoper-5.77	$SHGC_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-11.24	$SHGC_{all}$- 0.61	Uall-11.24	$SHGC_{all}$- 0.39	Uall-11.24	$SHGC_{all}$- NR
2.1-5.0%	Uall-11.24	$SHGC_{all}$- 0.39	Uall-11.24	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-10.79	$SHGC_{all}$- 0.65	Uall-10.79	$SHGC_{all}$- 0.65	Uall-10.79	$SHGC_{all}$- NR
2.1-5.0%	Uall-10.79	$SHGC_{all}$- 0.39	Uall-10.79	$SHGC_{all}$- 0.34	Uall-10.79	$SHGC_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-7.72	$SHGC_{all}$- 0.61	Uall-7.72	$SHGC_{all}$- 0.39	Uall-7.72	$SHGC_{all}$- NR
2.1-5.0%	Uall-7.72	$SHGC_{all}$- 0.39	Uall-7.72	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- NR

~~[a] Exception to 5.3.1.2a applies~~

(I-P edition)

TABLE ~~B-13~~5.3-4
Building Envelope Requirements For Climate Zone 4 (A,B,C) ~~(HDD65: 3601-5400, CDD50: 3601+)~~

Opaque Elements	Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value	Residential Assembly Maximum	Residential Insulation Min. R-Value	Semiheated Assembly Maximum	Semiheated Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above Grade						
Mass	U-0.151[a]	R-5.7 ci[a]	U-0.104	R-9.5 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0
Steel Framed	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.950	R-7.5 for 24 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.25	U_{fixed}-0.46	$SHGC_{all}$-0.25	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.36	U_{oper}-0.47	$SHGC_{north}$-0.36	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-0.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.58	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a]Exception to 5.3.1.2a applies.

(SI edition)

TABLE ~~B-13~~5.3-4
Building Envelope Requirements For Climate Zone 4 (A,B,C) ~~(HDD18: 2001-3000, CDD10: 2001+)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.360	R-2.6 ci	U-0.360	R-2.6 ci	U-1.240	R-0.7 ci
Metal Building	U-0.369	R-3.3	U-0.369	R-3.3	U-0.551	R-1.8
Attic and Other	U-0.192	R-5.3	U-0.153	R-6.7	U-0.459	R-2.3
Walls, Above Grade						
Mass	U-0.857[a]	R-1.0 ci[a]	U-0.592	R-1.7 ci	U-3.293	NR
Metal Building	U-0.642	R-2.3	U-0.642	R-2.3	U-0.761	R-1.8
Steel Framed	U-0.705	R-2.3	U-0.365	R-2.3 + R-1.3 ci	U-0.705	R-2.3
Wood Framed and Other	U-0.504	R-2.3	U-0.504	R-2.3	U-0.504	R-2.3
Wall, Below Grade						
Below Grade Wall	C-6.473	NR	C-6.473	NR	C-6.473	NR
Floors						
Mass	U-0.606	R-1.1	U-0.496	R-1.5	U-1.825	NR
Steel Joist	U-0.296	R-3.3	U-0.214	R-5.3	U-0.390	R-2.3
Wood Framed and Other	U-0.288	R-3.3	U-0.188	R-5.3	U-0.376	R-2.3
Slab-On-Grade Floors						
Unheated	F-1.264	NR	F-1.264	NR	F-1.264	NR
Heated	F-1.644	R-1.3 for 600 mm	F-1.454	R-1.8 for 900 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						
Swinging	U-3.975		U-3.975		U-3.975	
Non-Swinging	U-8.233		U-2.839		U-8.233	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
10.1-20.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
20.1-30.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
30.1-40.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
40.1-50.0%	Ufixed-2.61	$SHGC_{all}$- 0.25	Ufixed-2.61	$SHGC_{all}$- 0.25	Ufixed-5.54	$SHGC_{all}$- NR
	Uoper-2.67	$SHGC_{north}$- 0.36	Uoper-2.67	$SHGC_{north}$- 0.36	Uoper-5.77	$SHGC_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-6.64	$SHGC_{all}$- 0.49	Uall-5.56	$SHGC_{all}$- 0.36	Uall-11.24	$SHGC_{all}$- NR
2.1-5.0%	Uall-6.64	$SHGC_{all}$- 0.39	Uall-5.56	$SHGC_{all}$- 0.19	Uall-11.24	$SHGC_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-7.38	$SHGC_{all}$- 0.65	Uall-7.38	$SHGC_{all}$- 0.62	Uall-10.79	$SHGC_{all}$- NR
2.1-5.0%	Uall-7.38	$SHGC_{all}$- 0.34	Uall-7.38	$SHGC_{all}$- 0.27	Uall-10.79	$SHGC_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-3.92	$SHGC_{all}$- 0.49	Uall-3.29	$SHGC_{all}$- 0.36	Uall-7.72	$SHGC_{all}$- NR
2.1-5.0%	Uall-3.92	$SHGC_{all}$- 0.39	Uall-3.29	$SHGC_{all}$- 0.19	Uall-7.72	$SHGC_{all}$- NR

[a] Exception to 5.3.1.2a applies

(I-P edition)

TABLE ~~B-17~~5.3-5
Building Envelope Requirements For Climate Zone 5 (A,B,C) ~~(HDD65: 5401-7200, CDD50: 1801-3600)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.123	R-7.6 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	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-0.087	R-8.3 ci	U-0.074	R-10.4 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.36	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.10	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.10	$SHGC_{all}$-0.62	U_{all}-1.10	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

(SI edition)

TABLE ~~B-17~~5.3-5
Building Envelope Requirements For Climate Zone 5 (A,B,C) ~~(HDD18: 3001-4000, CDD10: 1001-2000)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.360	R-2.6 ci	U-0.360	R-2.6 ci	U-0.982	R-0.9 ci
Metal Building	U-0.369	R-3.3	U-0.369	R-3.3	U-0.551	R-1.8
Attic and Other	U-0.192	R-5.3	U-0.153	R-6.7	U-0.300	R-3.3
Walls, Above Grade						
Mass	U-0.701	R-1.3 ci	U-0.513	R-2.0 ci	U-3.293	NR
Metal Building	U-0.642	R-2.3	U-0.324	R-2.3 + R-2.3	U-0.698	R-1.9
Steel Framed	U-0.479	R-2.3 + R-0.7 ci	U-0.365	R-2.3 + R-1.3 ci	U-0.705	R-2.3
Wood Framed and Other	U-0.504	R-2.3	U-0.504	R-2.3	U-0.504	R-2.3
Wall, Below Grade						
Below Grade Wall	C-6.473	NR	C-6.473	NR	C-6.473	NR
Floors						
Mass	U-0.496	R-1.5	U-0.420	R-1.8	U-1.825	NR
Steel Joist	U-0.296	R-3.3	U-0.214	R-5.3	U-0.390	R-2.3
Wood Framed and Other	U-0.188	R-5.3	U-0.188	R-5.3	U-0.376	R-2.3
Slab-On-Grade Floors						
Unheated	F-1.264	NR	F-1.264	NR	F-1.264	NR
Heated	F-1.454	R-1.8 for 900 mm	F-1.454	R-1.8 for 900 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						
Swinging	U-3.975		U-3.975		U-3.975	
Non-Swinging	U-8.233		U-2.839		U-8.233	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-3.24	SHGC$_{all}$- 0.49	Ufixed-3.24	SHGC$_{all}$- 0.49	Ufixed-6.93	SHGC$_{all}$- NR
	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-7.21	SHGC$_{north}$- NR
10.1-20.0%	Ufixed-3.24	SHGC$_{all}$- 0.39	Ufixed-3.24	SHGC$_{all}$- 0.39	Ufixed-6.93	SHGC$_{all}$- NR
	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-7.21	SHGC$_{north}$- NR
20.1-30.0%	Ufixed-3.24	SHGC$_{all}$- 0.39	Ufixed-3.24	SHGC$_{all}$- 0.39	Ufixed-6.93	SHGC$_{all}$- NR
	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-7.21	SHGC$_{north}$- NR
30.1-40.0%	Ufixed-3.24	SHGC$_{all}$- 0.39	Ufixed-3.24	SHGC$_{all}$- 0.39	Ufixed-6.93	SHGC$_{all}$- NR
	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-3.80	SHGC$_{north}$- 0.49	Uoper-7.21	SHGC$_{north}$- NR
40.1-50.0%	Ufixed-2.61	SHGC$_{all}$- 0.26	Ufixed-2.61	SHGC$_{all}$- 0.26	Ufixed-5.54	SHGC$_{all}$- NR
	Uoper-2.67	SHGC$_{north}$- 0.36	Uoper-2.67	SHGC$_{north}$- 0.49	Uoper-5.77	SHGC$_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-6.64	SHGC$_{all}$- 0.49	Uall-6.64	SHGC$_{all}$- 0.49	Uall-11.24	SHGC$_{all}$- NR
2.1-5.0%	Uall-6.64	SHGC$_{all}$- 0.39	Uall-6.64	SHGC$_{all}$- 0.39	Uall-11.24	SHGC$_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-6.25	SHGC$_{all}$- 0.77	Uall-6.25	SHGC$_{all}$- 0.77	Uall-10.79	SHGC$_{all}$- NR
2.1-5.0%	Uall-6.25	SHGC$_{all}$- 0.62	Uall-6.25	SHGC$_{all}$- 0.62	Uall-10.79	SHGC$_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-3.92	SHGC$_{all}$- 0.49	Uall-3.92	SHGC$_{all}$- 0.49	Uall-7.72	SHGC$_{all}$- NR
2.1-5.0%	Uall-3.92	SHGC$_{all}$- 0.39	Uall-3.92	SHGC$_{all}$- 0.39	Uall-7.72	SHGC$_{all}$- NR

(I-P edition)

TABLE ~~B-19~~5.3-6
Building Envelope Requirements For Climate Zone 6 (A,B) ~~(HDD65: 7201-9000, CDD50: 1801+)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.104	R-9.5 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	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-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 ci	U-0.064	R-12.5 ci	U-0.322	NR
Steel Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-.0066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-0.57	$SHGC_{all}$-0.39	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-0.67	$SHGC_{north}$-0.49	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.46	$SHGC_{all}$-0.26	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-0.47	$SHGC_{north}$-0.49	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.46	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.74	$SHGC_{all}$-0.65	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-0.58	U_{all}-0.74	$SHGC_{all}$-0.55	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.49	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.39	U_{all}-1.36	$SHGC_{all}$-NR

(SI edition)

TABLE ~~B-19~~5.3-6
Building Envelope Requirements For Climate Zone 6 (A,B) ~~(HDD18: 4001-5000, CDD10: 1001+)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.360	R-2.6 ci	U-0.360	R-2.6 ci	U-0.982	R-0.9 ci
Metal Building	U-0.369	R-3.3	U-0.369	R-3.3	U-0.551	R-1.8
Attic and Other	U-0.153	R-6.7	U-0.153	R-6.7	U-0.300	R-3.3
Walls, Above Grade						
Mass	U-0.592	R-1.7 ci	U-0.513	R-2.0 ci	U-3.293	NR
Metal Building	U-0.642	R-2.3	U-0.324	R-2.3 + R-2.3	U-0.642	R-2.3
Steel Framed	U-0.479	R-2.3 + R-0.7 ci	U-0.365	R-2.3 + R-1.3 ci	U-0.705	R-2.3
Wood Framed and Other	U-0.504	R-2.3	U-0.365	R-2.3 + R-0.7 ci	U-0.504	R-2.3
Wall, Below Grade						
Below Grade Wall	C-6.473	NR	C-0.678	R-1.3 ci	C-6.473	NR
Floors						
Mass	U-0.496	R-1.5	U-0.363	R-2.2 ci	U-1.825	NR
Steel Joist	U-0.214	R-5.3	U-0.214	R-5.3	U-0.390	R-2.3
Wood Framed and Other	U-0.188	R-5.3	U-0.188	R-5.3	U-0.376	R-2.3
Slab-On-Grade Floors						
Unheated	F-1.264	NR	F-1.260	NR	F-1.264	NR
Heated	F-1.454	R-1.8 for 900 mm	F-1.35	R-1.8 for 1200 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						
Swinging	U-3.975		U-2.839		U-3.975	
Non-Swinging	U-2.839		U-2.839		U-8.233	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-3.24	$SHGC_{all}$- 0.49	Ufixed-3.24	$SHGC_{all}$- 0.49	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.64	Uoper-7.21	$SHGC_{north}$- NR
10.1-20.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
20.1-30.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
30.1-40.0%	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-3.24	$SHGC_{all}$- 0.39	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-3.80	$SHGC_{north}$- 0.49	Uoper-7.21	$SHGC_{north}$- NR
40.1-50.0%	Ufixed-2.61	$SHGC_{all}$- 0.26	Ufixed-2.61	$SHGC_{all}$- 0.26	Ufixed-5.54	$SHGC_{all}$- NR
	Uoper-2.67	$SHGC_{north}$- 0.49	Uoper-2.67	$SHGC_{north}$- 0.49	Uoper-5.77	$SHGC_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-6.64	$SHGC_{all}$- 0.49	Uall-5.56	$SHGC_{all}$- 0.46	Uall-11.24	$SHGC_{all}$- NR
2.1-5.0%	Uall-6.64	$SHGC_{all}$- 0.49	Uall-5.56	$SHGC_{all}$- 0.36	Uall-11.24	$SHGC_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-4.94	$SHGC_{all}$- 0.71	Uall-4.20	$SHGC_{all}$- 0.65	Uall-10.79	$SHGC_{all}$- NR
2.1-5.0%	Uall-4.94	$SHGC_{all}$- 0.58	Uall-4.20	$SHGC_{all}$- 0.55	Uall-10.79	$SHGC_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-3.92	$SHGC_{all}$- 0.49	Uall-3.29	$SHGC_{all}$- 0.49	Uall-7.72	$SHGC_{all}$- NR
2.1-5.0%	Uall-3.92	$SHGC_{all}$- 0.49	Uall-3.29	$SHGC_{all}$- 0.39	Uall-7.72	$SHGC_{all}$- NR

(I-P edition)

TABLE ~~B-22~~5.3-7
Building Envelope Requirements For Climate Zone 7~~(HDD65: 9001-10800, CDD50: 0-1800)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.090	R-11.4 ci	U-0.080	R-13.3 ci	U-0.580	NR
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 ci	U-0.064	R-12.5 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-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.780	R-10 for 48 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-0.57	$SHGC_{all}$-0.49	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-0.67	$SHGC_{north}$-0.64	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.46	$SHGC_{all}$-0.36	U_{fixed}-0.46	$SHGC_{all}$-0.36	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-0.64	U_{oper}-0.47	$SHGC_{north}$-0.64	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.17	$SHGC_{all}$-0.68	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.17	$SHGC_{all}$-0.64	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.87	$SHGC_{all}$-0.77	U_{all}-0.61	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.87	$SHGC_{all}$-0.71	U_{all}-0.61	$SHGC_{all}$-0.77	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.69	$SHGC_{all}$-0.68	U_{all}-0.69	$SHGC_{all}$-0.64	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.69	$SHGC_{all}$-0.64	U_{all}-0.69	$SHGC_{all}$-0.64	U_{all}-1.36	$SHGC_{all}$-NR

(SI edition)

TABLE ~~B-22~~5.3-7
Building Envelope Requirements For Climate Zone 7 ~~(HDD18: 5001-6000, CDD10: 0-1000)~~

	Nonresidential		Residential		Semiheated	
	Assembly	Insulation	Assembly	Insulation	Assembly	Insulation
Opaque Elements	Maximum	Min. R-Value	Maximum	Min. R-Value	Maximum	Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.360	R-2.6 ci	U-0.360	R-2.6 ci	U-0.982	R-0.9 ci
Metal Building	U-0.369	R-3.3	U-0.369	R-3.3	U-0.551	R-1.8
Attic and Other	U-0.153	R-6.7	U-0.153	R-6.7	U-0.300	R-3.3
Walls, Above Grade						
Mass	U-0.513	R-2.0 ci	U-0.453	R-2.3 ci	U-3.293	NR
Metal Building	U-0.324	R-2.3 + R-2.3	U-0.324	R-2.3 + R-2.3	U-0.642	R-2.3
Steel Framed	U-0.365	R-2.3 + R-1.3 ci	U-0.365	R-2.3 + R-1.3 ci	U-0.705	R-2.3
Wood Framed and Other	U-0.504	R-2.3	U-0.291	R-2.3 + R-1.3 ci	U-0.504	R-2.3
Wall, Below Grade						
Below Grade Wall	C-0.678	R-1.3 ci	C-0.678	R-1.3 ci	C-6.473	NR
Floors						
Mass	U-0.496	R-1.5	U-0.363	R-2.2	U-0.780	R-0.7 ci
Steel Joist	U-0.214	R-5.3	U-0.214	R-5.3	U-0.296	R-3.3
Wood Framed and Other	U-0.188	R-5.3	U-0.188	R-5.3	U-0.376	R-2.3
Slab-On-Grade Floors						
Unheated	F-1.264	NR	F-0.935	R-1.8 for 600 mm	F-1.264	NR
Heated	F-1.454	R-1.8 for 900 mm	F-1.350	R-1.8 for 1200 mm	F-1.766	R-1.3 for 300 mm
Opaque Doors						
Swinging	U-3.975		U-2.839		U-3.975	
Non-Swinging	U-2.839		U-2.839		U-8.233	

	Nonresidential			Residential			Semiheated		
Fenestration	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)		Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)		Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	
Vertical Glazing, % of Wall									
0-10.0%	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-6.93	$SHGC_{all}$-	NR
	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-7.21	$SHGC_{north}$-	NR
10.1-20.0%	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-6.93	$SHGC_{all}$-	NR
	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-7.21	$SHGC_{north}$-	NR
20.1-30.0%	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-6.93	$SHGC_{all}$-	NR
	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-7.21	$SHGC_{north}$-	NR
30.1-40.0%	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-3.24	$SHGC_{all}$-	0.49	Ufixed-6.93	$SHGC_{all}$-	NR
	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-3.80	$SHGC_{north}$-	0.64	Uoper-7.21	$SHGC_{north}$-	NR
40.1-50.0%	Ufixed-2.61	$SHGC_{all}$-	0.36	Ufixed-2.61	$SHGC_{all}$-	0.36	Ufixed-5.54	$SHGC_{all}$-	NR
	Uoper-2.67	$SHGC_{north}$-	0.64	Uoper-2.67	$SHGC_{north}$-	0.64	Uoper-5.77	$SHGC_{north}$-	NR
Skylight with Curb, Glass, % of Roof									
0-2.0%	Uall-6.64	$SHGC_{all}$-	0.68	Uall-6.64	$SHGC_{all}$-	0.64	Uall-11.24	$SHGC_{all}$-	NR
2.1-5.0%	Uall-6.64	$SHGC_{all}$-	0.64	Uall-6.64	$SHGC_{all}$-	0.64	Uall-11.24	$SHGC_{all}$-	NR
Skylight with Curb, Plastic, % of Roof									
0-2.0%	Uall-4.94	$SHGC_{all}$-	0.77	Uall-3.46	$SHGC_{all}$-	0.77	Uall-10.79	$SHGC_{all}$-	NR
2.1-5.0%	Uall-4.94	$SHGC_{all}$-	0.71	Uall-3.46	$SHGC_{all}$-	0.77	Uall-10.79	$SHGC_{all}$-	NR
Skylight without Curb, All, % of Roof									
0-2.0%	Uall-3.92	$SHGC_{all}$-	0.68	Uall-3.92	$SHGC_{all}$-	0.64	Uall-7.72	$SHGC_{all}$-	NR
2.1-5.0%	Uall-3.92	$SHGC_{all}$-	0.64	Uall-3.92	$SHGC_{all}$-	0.64	Uall-7.72	$SHGC_{all}$-	NR

(I-P edition)

TABLE ~~B-24~~5.3-8
Building Envelope Requirements For Cimate Zone 8 (~~HDD65: 12601+ -16200, CDD50: 0+~~)

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 ci	U-0.048	R-20.0 ci	U-0.093	R-10.0 ci
Metal Building	U-0.049	R-13.0 + R-19.0	U-0.049	R-13.0 + R-19.0	U-0.072	R-16.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	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-0.151[a]	R-5.7 ci[a]
Metal Building	U-0.057	R-13.0 + R-13.0	U-0.057	R-13.0 + R-13.0	U-0.113	R-13.0
Steel Framed	U-0.064	R-13.0 + R-7.5 ci	U-0.055	R-13.0 + R-10.0 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.051	R-13.0 + R-7.5 ci	U-0.051	R-13.0 + R-7.5 ci	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-0.119	R-7.5 ci	C-0.119	R-7.5 ci	C-1.140	NR
Floors						
Mass	U-0.064	R-12.5 ci	U-0.057	R-14.6 ci	U-0.137	R-4.2 ci
Steel Joist	U-0.038	R-30.0	U-0.032	R-38.0	U-0.052	R-19.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	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-0.730	NR
Heated	F-0.780	R-10 for 48 in.	F-0.780	R-10 for 48 in.	F-0.950	R-7.5 for 24 in.
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Non-Swinging	U-0.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-1.27	$SHGC_{north}$NR
10.1-20.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-1.27	$SHGC_{north}$NR
20.1-30.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-1.27	$SHGC_{north}$NR
30.1-40.0%	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-0.46	$SHGC_{all}$-NR	U_{fixed}-1.22	$SHGC_{all}$-NR
	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-0.47	$SHGC_{north}$-NR	U_{oper}-1.27	$SHGC_{north}$NR
40.1-50.0%	U_{fixed}-0.35	$SHGC_{all}$-NR	U_{fixed}-0.35	$SHGC_{all}$-NR	U_{fixed}-0.98	$SHGC_{all}$-NR
	U_{oper}-0.39	$SHGC_{north}$-NR	U_{oper}-0.39	$SHGC_{north}$-NR	U_{oper}-1.02	$SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-0.98	$SHGC_{all}$-NR	U_{all}-1.30	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-0.61	$SHGC_{all}$-NR	U_{all}-1.10	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.58	$SHGC_{all}$-NR	U_{all}-0.81	$SHGC_{all}$-NR

[a] Exception to 5.3.1.2a applies

(SI edition)

TABLE ~~B-24~~5.3-8
Building Envelope Requirements For Climate Zone 8 ~~(HDD18: 7001-9000, CDD10: 0+)~~

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.273	R-3.5 ci	U-0.273	R-3.5 ci	U-0.527	R-1.8 ci
Metal Building	U-0.278	R-2.3 + R-3.3	U-0.278	R-2.3 + R-3.3	U-0.409	R-2.8
Attic and Other	U-0.153	R-6.7	U-0.153	R-6.7	U-0.192	R-5.3
Walls, Above Grade						
Mass	U-0.453	R-2.3 ci	U-0.404	R-2.7 ci	U-0.857[a]	R-1.0 ci[a]
Metal Building	U-0.324	R-2.3 + R-2.3	U-0.324	R-2.3 + R-2.3	U-0.642	R-2.3
Steel Framed	U-0.365	R-2.3 + R-1.3 ci	U-0.315	R-2.3 + R-1.8 ci	U-0.705	R-2.3
Wood Framed and Other	U-0.291	R-2.3 + R-1.3 ci	U-0.291	R-2.3 + R-1.3 ci	U-0.504	R-2.3
Wall, Below Grade						
Below Grade Wall	C-0.678	R-1.3 ci	C-0.678	R-1.3 ci	C-6.473	NR
Floors						
Mass	U-0.363	R-2.2 ci	U-0.321	R-2.6 ci	U-0.780	R-0.7 ci
Steel Joist	U-0.214	R-5.3	U-0.183	R-6.7	U-0.296	R-3.3
Wood Framed and Other	U-0.188	R-5.3	U-0.188	R-5.3	U-0.288	R-3.3
Slab-On-Grade Floors						
Unheated	F-0.935	R-1.8 for 600 mm	F-0.900	R-2.6 for 600 mm	F-1.264	NR
Heated	F-1.350	R-1.8 for 1200 mm	F-1.350	R-1.8 for 1200 mm	F-1.644	R-1.3 for 600 mm
Opaque Doors						
Swinging	U-2.839		U-2.839		U-3.975	
Non-Swinging	U-2.839		U-2.839		U-8.233	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing, % of Wall						
0-10.0%	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-2.67	$SHGC_{north}$- NR	Uoper-2.67	$SHGC_{north}$- NR	Uoper-7.21	$SHGC_{north}$- NR
10.1-20.0%	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-2.67	$SHGC_{north}$- NR	Uoper-2.67	$SHGC_{north}$- NR	Uoper-7.21	$SHGC_{north}$- NR
20.1-30.0%	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-2.67	$SHGC_{north}$- NR	Uoper-2.67	$SHGC_{north}$- NR	Uoper-7.21	$SHGC_{north}$- NR
30.1-40.0%	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-2.61	$SHGC_{all}$- NR	Ufixed-6.93	$SHGC_{all}$- NR
	Uoper-2.67	$SHGC_{north}$- NR	Uoper-2.67	$SHGC_{north}$- NR	Uoper-7.21	$SHGC_{north}$- NR
40.1-50.0%	Ufixed-1.99	$SHGC_{all}$- NR	Ufixed-1.99	$SHGC_{all}$- NR	Ufixed-5.54	$SHGC_{all}$- NR
	Uoper-2.21	$SHGC_{north}$- NR	Uoper-2.21	$SHGC_{north}$- NR	Uoper-5.77	$SHGC_{north}$- NR
Skylight with Curb, Glass, % of Roof						
0-2.0%	Uall-5.56	$SHGC_{all}$- NR	Uall-5.56	$SHGC_{all}$- NR	Uall-7.38	$SHGC_{all}$- NR
2.1-5.0%	Uall-5.56	$SHGC_{all}$- NR	Uall-5.56	$SHGC_{all}$- NR	Uall-7.38	$SHGC_{all}$- NR
Skylight with Curb, Plastic, % of Roof						
0-2.0%	Uall-3.46	$SHGC_{all}$- NR	Uall-3.46	$SHGC_{all}$- NR	Uall-6.25	$SHGC_{all}$- NR
2.1-5.0%	Uall-3.46	$SHGC_{all}$- NR	Uall-3.46	$SHGC_{all}$- NR	Uall-6.25	$SHGC_{all}$- NR
Skylight without Curb, All, % of Roof						
0-2.0%	Uall-3.29	$SHGC_{all}$- NR	Uall-3.29	$SHGC_{all}$- NR	Uall-4.60	$SHGC_{all}$- NR
2.1-5.0%	Uall-3.29	$SHGC_{all}$- NR	Uall-3.29	$SHGC_{all}$- NR	Uall-4.60	$SHGC_{all}$- NR

[a] Exception to 5.3.1.2a applies

[In Section 6, revise Table 6.1.3 as shown below.]

(I-P Units)

TABLE 6.1.3
Eliminate Required Economizer by Increasing Cooling Efficiency

Unitary Systems with Heat Pump Heating

System Size (kBtu/h)	Mandatory Minimum EER	~~Cooling Degree-Days (CDD50)~~Climate Zones: ~~0 – 3600~~ 5 to 8	~~3601 – 5400~~ 4	~~5401 – 7200~~ 3	~~7201 – 9000~~ 2	~~9001 – 0800~~	Test Procedure[c]
		Minimum Cooling Efficiency Required (EER)[a]					
≥65 and <135	10.1	N/A[b]	12.1	11.6	11.1	~~10.7~~	ARI 210/240
≥135 and ≤240	9.3	N/A[b]	11.3	10.8	10.4	~~9.9~~	ARI 340/360
>240 and <760	9.0	N/A[b]	10.9	10.5	10.0	~~9.6~~	

Other Unitary Systems

System Size (kBtu/h)	Mandatory Minimum EER	~~Cooling Degree-Days (CDD50)~~Climate Zones: ~~0 – 3600~~ 5 to 8	~~3601 – 5400~~ 4	~~5401 – 7200~~ 3	~~7201 – 9000~~ 2	9001 - 10800	Test Procedure[c]
		Minimum Cooling Efficiency Required (EER)[a]					
≥65 and <135	10.3	N/A[b]	12.5	12.0	11.5	~~11.0~~	ARI 210/240
≥135 and ≤240	9.7	N/A[b]	11.5	11.1	10.6	~~10.1~~	ARI 340/360
>240 and <760	9.5	N/A[b]	11.2	10.7	10.3	~~9.9~~	

[a] Each EER shown below should be reduced by 0.2 for units with a heating section other than electric resistance heat.

[b] Elimination of required economizer is not allowed.

[c] Section 12 contains complete specification of the referenced test procedure, including the referenced year version of the test procedure.

(SI Units)

TABLE 6.1.3
Eliminate Required Economizer by Increasing Cooling Efficiency

Unitary Systems with Heat Pump Heating

System Size (kW)	Mandatory Minimum COP_c	~~0-3600~~ 5-8	~~3601-5400~~ 4	~~5401-7200~~ 3	~~7201-9000~~ 2	9001-10800	Test Procedure[c]
		~~Cooling Degree-Days (CDD10)~~ Climate Zones					
		Minimum Cooling Efficiency Required (COP_c)[a]					
≥19 and <40	2.96	N/A[b]	3.55	3.40	3.25	~~2.84~~	ARI 210/240
≥40 and ≤70	2.72	N/A[b]	3.31	3.16	3.05	~~2.90~~	ARI 340/360
>70 and <223	2.64	N/A[b]	3.19	3.08	2.93	~~2.81~~	

Other Unitary Systems

System Size (kW)	Mandatory Minimum COP_c	~~0-3600~~ 5-8	~~3601-5400~~ 4	~~5401-7200~~ 3	~~7201-9000~~ 2	9001-10800	Test Procedure[c]
		~~Cooling Degree-Days (CDD10)~~ Climate Zones					
		Minimum Cooling Efficiency Required (COP_c)[a]					
≥19 and <40	3.02	N/A[b]	3.66	3.52	3.37	~~3.22~~	ARI 210/240
≥40 and ≤70	2.84	N/A[b]	3.37	3.24	3.11	~~2.96~~	ARI 340/360
>70 and <223	2.78	N/A[b]	3.28	3.14	3.02	~~2.87~~	

[a] Each EER shown below should be reduced by 0.2 for units with a heating section other than electric resistance heat.

[b] Elimination of required economizer is not allowed.

[c] Section 12 contains complete specification of the referenced test procedure, including the referenced year version of the test procedure

[Revise Section 6.2.3.2.2 as follows.]

6.2.3.2.2 Setback Controls. Heating systems located ~~where the *heating design temperature* is 40°F (4ºC) or less~~ in climate zones 2-8 shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain *zone* temperatures above a heating setpoint adjustable down to 55°F (13ºC) or lower. (See Appendix D for *heating design temperatures*.)

Cooling systems located ~~where the *cooling design temperature* is greater than 100°F (38ºC)~~ in climate zones 1b, 2b, and 3b shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain *zone* temperatures below a cooling setpoint adjustable up to 90°F (32ºC) or higher or to prevent high space humidity levels. (See Appendix D for *cooling design temperatures*.)

Exception to 6.2.3.2.2: Radiant floor and ceiling heating *systems.*

[Revise the exceptions to Sections 6.2.3.3.2 and 6.2.3.3.3 as follows.]

6.2.3.3.2 6.2.3.3.2 Gravity Hoods, Vents, and Ventilators. All outdoor air supply and exhaust hoods, vents, and ventilators shall be equipped with motorized dampers that will automatically shut when the spaces served are not in use.

Exceptions to 6.2.3.3.1 and 6.2.3.3.2:

(a) Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height above grade and for buildings of any height located in ~~climates with less than 2700 HDD65 (1500 HDD18)~~ Climate Zones 1,2 and 3.

(b) Ventilation systems serving unconditioned spaces.

6.2.3.3.3 Shutoff Damper Controls. Both outdoor air supply and exhaust systems shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use. Ventilation outside air dampers shall be capable of automatically shutting off during preoccupancy building warmup, cooldown, and *setback,* except when *ventilation* reduces energy costs (e.g., night purge) or when ventilation must be supplied to meet code requirements.

Exceptions to 6.2.3.3.3:

(a) Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height and for buildings of any height located in ~~climates with less than 2700 HDD65 (1500 HDD18)~~ Climate Zones 1,2 and 3.

(b) Gravity (nonmotorized) dampers are acceptable in systems with a design outside air intake or exhaust capacity of 300 cfm (140 L/s) or less.

[Delete Table 6.2.3.3.4 as shown below and replace it with the following new version of the table. For the deleted table, only the I-P version is shown. The replacement table shows both I-P and SI versions.]

~~TABLE 6.2.3.3.4~~
~~Maximum Damper Leakage~~

~~Climate~~	~~Maximum Damper Leakage at 1.0 in w.g.cfm per ft²~~ ~~Motorized~~	~~of damper area~~ ~~Non-motorized~~
~~HDD65>7200 or CDD50>7200~~	~~4~~	~~Not allowed~~
~~HDD65<2701 and CDD50<3601~~	~~20~~	~~20[a]~~
~~All others~~	~~10~~	~~20[a]~~

~~Notes:~~

~~[a] Dampers smaller than 24 in. in either dimension may have leak-age of 40 cfm/ft².~~

(I-P edition)

TABLE 6.2.3.3.4
Maximum Damper Leakage

Climate Zones	Maximum Damper Leakage at 1.0 in. w.g. cfm/ft² of damper area	
	Motorized	Non-Motorized
1, 2, 6, 7, 8	4	Not Allowed
All other climates	10	20[a]

Notes:

[a]Dampers smaller than 24 in. in either dimension may have leak-age of 40 cfm/ft².

(SI edition)

TABLE 6.2.3.3.4
Maximum Damper Leakage

Climate Zones	Maximum Damper Leakage at 250 Pa (l/s per m² of damper area	
	Motorized	Non-Motorized
1, 2, 6, 7, 8	20	Not Allowed
All other climates	50	100[a]

Notes:

[a] Dampers smaller than 0.6 m in either dimension may have leakage of 200L/s per m².

[Delete the I-P and SI versions of Table 6.2.4.2A and B and replace them with the new I-P and SI versions that follow each deleted table. The order of the deleted and replacement tables is as follows on this page and the next seven pages: deleted Table 6.2.4.2A (I-P version), new Table 6.2.4.2A (I-P version), deleted Table 6.2.4.2B (I-P version), new Table 6.2.4.2B (I-P version), deleted Table 6.2.4.2A (SI version), new Table 6.2.4.2A (SI version), deleted Table 6.2.4.2B (SI version), new Table 6.2.4.2B (SI version).

(I-P edition)

~~TABLE 6.2.4.2A~~

~~Minimum Duct Insulation R-Value,[a] Cooling and Heating Only, Supply Ducts and Return Ducts~~

~~Climate Zone~~			~~Duct Location~~						
~~Envelope Criteria Table~~	~~HDD65~~	~~CDD50~~	~~Exterior~~	~~Ventilated Attic~~	~~Unvented Attic with Backloaded Ceiling~~	~~Unvented Attic with Roof Insulation~~	~~Unconditioned Space[b]~~	~~Indirectly Conditioned Space[c]~~	~~Buried~~
				~~Heating Ducts Only~~					
~~B-1 to B-7~~	~~0-1800~~	~~all~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~
~~B-8 to B-12~~	~~1801-3600~~	~~all~~	~~R-3.5~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~
~~B-13 to B-15~~	~~3601-5400~~	~~all~~	~~R-3.5~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~
~~B-16 to B-18~~	~~5401-7200~~	~~all~~	~~R-6~~	~~R-3.5~~	~~none~~	~~none~~	~~none~~	~~none~~	~~R-3.5~~
~~B-19 to B-20~~	~~7201-9000~~	~~all~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~none~~	~~none~~	~~none~~	~~R-3.5~~
~~B-21 to B-22~~	~~9001-10800~~	~~all~~	~~R-8~~	~~R-6~~	~~R-6~~	~~none~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-23~~	~~10801-12600~~	~~all~~	~~R-8~~	~~R-6~~	~~R-6~~	~~none~~	~~R-6~~	~~none~~	~~R-6~~
~~B-24~~	~~12601-16200~~	~~all~~	~~R-8~~	~~R-8~~	~~R-6~~	~~none~~	~~R-6~~	~~none~~	~~R-6~~
~~B-25~~	~~16201-19800~~	~~all~~	~~R-10~~	~~R-8~~	~~R-8~~	~~none~~	~~R-6~~	~~none~~	~~R-6~~
~~B-26~~	~~19801+~~	~~all~~	~~R-10~~	~~R-10~~	~~R-8~~	~~none~~	~~R-8~~	~~none~~	~~R-6~~
				~~Cooling Only Ducts~~					
~~B-15, 18, 20, 22 to 26~~	~~all~~	~~0-1800~~	~~R-1.9~~	~~R-1.9~~	~~R-1.9~~	~~R-1.9~~	~~R-1.9~~	~~none~~	~~none~~
~~B-12, 14, 17, 19, 21~~	~~all~~	~~1801-3600~~	~~R-3.5~~	~~R-1.9~~	~~R-3.5~~	~~R-1.9~~	~~R-1.9~~	~~none~~	~~none~~
~~B-7, 9, 11, 13, 16~~	~~all~~	~~3601-5400~~	~~R-3.5~~	~~R-3.5~~	~~R-6~~	~~R-1.9~~	~~R-1.9~~	~~none~~	~~none~~
~~B-4, 6, 8, 10~~	~~all~~	~~5401-7200~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-1.9~~	~~none~~	~~none~~
~~B-3, B-5~~	~~all~~	~~7201-9000~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-2~~	~~all~~	~~9001-10800~~	~~R-6~~	~~R-6~~	~~R-8~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-1~~	~~all~~	~~10801+~~	~~R-8~~	~~R-8~~	~~R-8~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
				~~Return Ducts~~					
~~B-1 to B-26~~	~~all climates~~		~~R-3.5~~	~~R-3.5~~	~~R-3.5~~	~~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 6.2.4.2 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 unventilated.~~
~~[c] Includes return air plenums with or without exposed roofs above.~~

(I-P edition)

TABLE 6.2.4.2A

Minimum Duct Insulation R-Value,[a] Cooling and Heating Only, Supply Ducts and Return Ducts

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

[a] Insulation R-values, measured in (h·ft^2·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of 6.2.4.2 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 unventilated.

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

(I-P edition)

~~TABLE 6.2.4.2B~~

~~Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Ducts~~

~~Envelope Criteria Table~~	~~Climate Zone HDD65~~	~~Climate Zone CDD50~~	~~Duct Location Exterior~~	~~Ventilated Attic~~	~~Unvented Attic w/ Backloaded Ceiling~~	~~Unvented Attic w/ Roof Insulation[a]~~	~~Unconditioned Space[b]~~	~~Indirectly Conditioned Space[c]~~	~~Buried~~
~~B-1~~	~~0-900~~	~~10801+~~	~~R-8~~	~~R-6~~	~~R-8~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-2~~	~~0-900~~	~~9001-10800~~	~~R-6~~	~~R-6~~	~~R-8~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-3~~	~~0-900~~	~~7201-9000~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-4~~	~~0-900~~	~~0-7200~~	~~R-6~~	~~R-3.5~~	~~R-6~~	~~R-3.5~~	~~R-1.9~~	~~none~~	~~R-3.5~~
~~B-5~~	~~901-1800~~	~~7201+~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-6~~	~~901-1800~~	~~5401-7200~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-7~~	~~901-1800~~	~~0-5400~~	~~R-3.5~~	~~R-3.5~~	~~R-6~~	~~R-1.9~~	~~R-1.9~~	~~none~~	~~R-1.9~~
~~B-8~~	~~1801-2700~~	~~5401+~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-9~~	~~1801-2700~~	~~0-5400~~	~~R-6~~	~~R-3.5~~	~~R-6~~	~~R-1.9~~	~~R-1.9~~	~~none~~	~~R-1.9~~
~~B-10~~	~~2701-3600~~	~~5401+~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-11~~	~~2701-3600~~	~~3601-5400~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-1.9~~
~~B-12~~	~~2701-3600~~	~~0-3600~~	~~R-3.5~~	~~R-3.5~~	~~R-3.5~~	~~R-1.9~~	~~R-1.9~~	~~none~~	~~R-1.9~~
~~B-13~~	~~3601-5400~~	~~3601+~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-14~~	~~3601-5400~~	~~1801-3600~~	~~R-6~~	~~R-3.5~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-1.9~~
~~B-15~~	~~3601-5400~~	~~0-1800~~	~~R-3.5~~	~~R-3.5~~	~~R-3.5~~	~~R-1.9~~	~~R-1.9~~	~~none~~	~~R-1.9~~
~~B-16~~	~~5401-7200~~	~~3601+~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-17~~	~~5401-7200~~	~~1801-3600~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-18~~	~~5401-7200~~	~~0-1800~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~

~~**TABLE 6.2.4.2B**~~ *(Continued)*

~~**Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Ducts**~~

~~B-19~~	~~7201-9000~~	~~1801+~~	~~R-8~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-20~~	~~7201-9000~~	~~0-1800~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-21~~	~~9001-10800~~	~~1801+~~	~~R-8~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-6~~	~~none~~	~~R-3.5~~
~~B-22~~	~~9001-10800~~	~~0-1800~~	~~R-8~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~B-23~~	~~10801-12600~~	~~all~~	~~R-8~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-6~~	~~none~~	~~R-6~~
~~B-24~~	~~12601-16200~~	~~all~~	~~R-8~~	~~R-8~~	~~R-8~~	~~R-1.9~~	~~R-6~~	~~none~~	~~R-6~~
~~B-25~~	~~16201-19800~~	~~all~~	~~R-10~~	~~R-8~~	~~R-8~~	~~R-3.5~~	~~R-6~~	~~none~~	~~R-6~~
~~B-26~~	~~19801+~~	~~all~~	~~R-10~~	~~R-10~~	~~R-8~~	~~R-3.5~~	~~R-8~~	~~R-3.5~~	~~R-6~~

~~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 6.2.4.2 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.~~

(I-P edition)

TABLE 6.2.4.2B
Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Ducts

Climate Zone	Duct Location						
Climate Zone	Exterior	Ventilated Attic	Unvented Attic w/ Backloaded Ceiling	Unvented Attic w/ Roof Insulation[a]	Uncon-ditioned Space[b]	Indirectly Condi-tioned Space[c]	Buried
1	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
4	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
5	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
6	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
7	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
8	R-8	R-8	R-8	R-1.9	R-6	none	R-6

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 6.2.4.2 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 unventilated.

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

(SI edition)

~~TABLE 6.2.4.2A~~

~~Minimum Duct Insulation R-Value,[a] Cooling and Heating Only Supply Ducts and Return Ducts~~

~~Climate Zone~~			~~Duct Location~~						
~~Envelope Criteria Table~~	~~HDD18~~	~~CDD10~~	~~Exterior~~	~~Ventilated Attic~~	~~Unvented Attic with Backloaded Ceiling~~	~~Unvented Attic with Roof Insulation~~	~~Unconditioned Space~~[b]	~~Indirectly Conditioned Space~~[c]	~~Buried~~
				~~Heating Ducts Only~~					
~~B-1 to B-7~~	~~0-1000~~	~~all~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~
~~B-8 to B-12~~	~~1001-2000~~	~~all~~	~~R-0.62~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~
~~B-13 to B-15~~	~~2001-3000~~	~~all~~	~~R-0.62~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~	~~none~~
~~B-16 to B-18~~	~~3001-4000~~	~~all~~	~~R-1.06~~	~~R-0.62~~	~~none~~	~~none~~	~~none~~	~~none~~	~~R-0.62~~
~~B-19 to B-20~~	~~4001-5000~~	~~all~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~none~~	~~none~~	~~none~~	~~R-0.62~~
~~B-21 to B-22~~	~~5001-6000~~	~~all~~	~~R-1.41~~	~~R-1.06~~	~~R-1.06~~	~~none~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-23~~	~~6001-7000~~	~~all~~	~~R-1.41~~	~~R-1.06~~	~~R-1.06~~	~~none~~	~~R-1.06~~	~~none~~	~~R-1.06~~
~~B-24~~	~~7001-9000~~	~~all~~	~~R-1.41~~	~~R-1.41~~	~~R-1.06~~	~~none~~	~~R-1.06~~	~~none~~	~~R-1.06~~
~~B-25~~	~~9001-11000~~	~~all~~	~~R-1.76~~	~~R-1.41~~	~~R-1.41~~	~~none~~	~~R-1.06~~	~~none~~	~~R-1.06~~
~~B-26~~	~~11001+~~	~~all~~	~~R-1.76~~	~~R-1.76~~	~~R-1.41~~	~~none~~	~~R-1.41~~	~~none~~	~~R-1.06~~
				~~Cooling Only Ducts~~					
~~B-15, 18, 20, 22 to 26~~	~~all~~	~~0-1000~~	~~R-0.34~~	~~R-0.34~~	~~R-0.34~~	~~R-0.34~~	~~R-0.34~~	~~none~~	~~none~~
~~B-12, 14, 17, 19, 21~~	~~all~~	~~1001-2000~~	~~R-0.62~~	~~R-0.34~~	~~R-0.62~~	~~R-0.34~~	~~R-0.34~~	~~none~~	~~none~~
~~B-7, 9, 11, 13, 16~~	~~all~~	~~2001-3000~~	~~R-0.62~~	~~R-0.62~~	~~R-1.06~~	~~R-0.34~~	~~R-0.34~~	~~none~~	~~none~~
~~B-4, 6, 8, 10~~	~~all~~	~~3001-4000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.34~~	~~none~~	~~none~~
~~B-3, B-5~~	~~all~~	~~4001-5000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-2~~	~~all~~	~~5001-6000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.41~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-1~~	~~all~~	~~6001+~~	~~R-1.41~~	~~R-1.41~~	~~R-1.41~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
				~~Return Ducts~~					
~~B-1 to B-26~~	~~all climates~~		~~R-3.5~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~none~~	~~none~~	~~none~~

[a] ~~Insulation R-values, measured in (m^2·k)/W, 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 6.2.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 23.9°C at the installed thickness.~~

[b] ~~Includes crawl spaces, both ventilated and nonventilated.~~

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

(SI edition)

TABLE 6.2.4.2A
Minimum Duct Insulation R-Value,[a] Cooling and Heating Only Supply Ducts and Return Ducts

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic with Backloaded Ceiling	Unvented Attic with Roof Insulation	Unconditioned Space[b]	Indirectly Condi- tioned Space[c]	Buried
			Heating Ducts Only				
1, 2	None	none	none	none	none	none	none
3	R-0.62	none	none	none	none	none	none
4	R-0.62	none	none	none	none	none	none
5	R-1.06	R-0.62	none	none	none	none	R-0.62
6	R-1.06	R-1.06	R-0.62	none	none	none	R-0.62
7	R-1.41	R-1.06	R-1.06	none	R-0.62	none	R-0.62
8	R-1.41	R-1.41	R-1.06	none	R-1.06	none	R-1.06
			Cooling Only Ducts				
7, 8	R-0.34	R-0.34	R-0.34	R-0.34	R-0.34	none	none
5, 6	R-0.62	R-0.34	R-0.62	R-0.34	R-0.34	none	none
4	R-0.62	R-0.62	R-1.06	R-0.34	R-0.34	none	none
3	R-1.06	R-1.06	R-1.06	R-0.62	R-0.34	none	none
2	R-1.06	R-1.06	R-1.06	R-0.62	R-0.62	none	R-0.62
1	R-1.06	R-1.06	R-1.41	R-0.62	R-0.62	none	R-0.62
			Return Ducts				
1 to 8	R-0.62	R-0.62	R-0.62	none	none	none	none

[a] Insulation R-values, measured in ($m^2 \cdot K$)/W, 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 6.2.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 23.9°C at the installed thickness.

[b] Includes crawl spaces, both ventilated and unventilated.

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

(SI edition)

~~TABLE 6.2.4.2B~~
~~Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Ducts~~

~~Envelope Criteria~~	~~Climate Zone~~			~~Duct Location~~					
~~Table~~	~~HDD18~~	~~CDD10~~	~~Exterior~~	~~Ventilated Attic~~	~~Unvented Attic w/ Backloaded Ceiling~~	~~Unvented Attic w/ Roof Insulation[a]~~	~~Unconditioned Space[b]~~	~~Indirectly Conditioned Space[c]~~	~~Buried~~
~~B-1~~	~~0-500~~	~~6001+~~	~~R-1.41~~	~~R-1.06~~	~~R-1.41~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-2~~	~~0-500~~	~~5001-6000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.41~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-3~~	~~0-500~~	~~4001-5000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-4~~	~~0-500~~	~~0-4000~~	~~R-1.06~~	~~R-0.62~~	~~R-1.06~~	~~R-0.62~~	~~R-0.34~~	~~none~~	~~R-0.62~~
~~B-5~~	~~501-1000~~	~~4001+~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-6~~	~~501-1000~~	~~3001-4000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-7~~	~~501-1000~~	~~0-3000~~	~~R-0.62~~	~~R-0.62~~	~~R-1.06~~	~~R-0.34~~	~~R-0.34~~	~~none~~	~~R-0.34~~
~~B-8~~	~~1001-1500~~	~~3001+~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-9~~	~~1001-1500~~	~~0-3000~~	~~R-1.06~~	~~R-0.62~~	~~R-1.06~~	~~R-0.34~~	~~R-0.34~~	~~none~~	~~R-0.34~~
~~B-10~~	~~1501-2000~~	~~3001+~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-11~~	~~1501-2000~~	~~2001-3000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.34~~
~~B-12~~	~~1501-2000~~	~~0-2000~~	~~R-0.62~~	~~R-0.62~~	~~R-0.62~~	~~R-0.34~~	~~R-0.34~~	~~none~~	~~R-0.34~~
~~B-13~~	~~2001-3000~~	~~2001+~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-14~~	~~2001-3000~~	~~1001-2000~~	~~R-1.06~~	~~R-0.62~~	~~R-1.06~~	~~R-0.34~~	~~R-0.62~~	~~none~~	~~R-0.34~~
~~B-15~~	~~2001-3000~~	~~0-1000~~	~~R-0.62~~	~~R-0.62~~	~~R-0.62~~	~~R-0.34~~	~~R-0.34~~	~~none~~	~~R-0.34~~
~~B-16~~	~~3001-4000~~	~~2001+~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-17~~	~~3001-4000~~	~~1001-2000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.34~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-18~~	~~3001-4000~~	~~0-1000~~	~~R-1.06~~	~~R-0.62~~	~~R-0.62~~	~~R-0.34~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-19~~	~~4001-5000~~	~~1001+~~	~~R-1.41~~	~~R-1.06~~	~~R-1.06~~	~~R-0.34~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-20~~	~~4001-5000~~	~~0-1000~~	~~R-1.06~~	~~R-1.06~~	~~R-1.06~~	~~R-0.34~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-21~~	~~5001-6000~~	~~1001+~~	~~R-1.41~~	~~R-1.06~~	~~R-1.06~~	~~R-0.34~~	~~R-1.06~~	~~none~~	~~R-0.62~~
~~B-22~~	~~5001-6000~~	~~0-1000~~	~~R-1.41~~	~~R-1.06~~	~~R-1.06~~	~~R-0.34~~	~~R-0.62~~	~~none~~	~~R-0.62~~
~~B-23~~	~~6001-7000~~	~~all~~	~~R-1.41~~	~~R-1.06~~	~~R-1.06~~	~~R-0.34~~	~~R-1.06~~	~~none~~	~~R-1.06~~
~~B-24~~	~~7001-9000~~	~~all~~	~~R-1.41~~	~~R-1.41~~	~~R-1.41~~	~~R-0.34~~	~~R-1.06~~	~~none~~	~~R-1.06~~
~~B-25~~	~~9001-11000~~	~~all~~	~~R-1.76~~	~~R-1.41~~	~~R-1.41~~	~~R-0.62~~	~~R-1.06~~	~~none~~	~~R-1.06~~
~~B-26~~	~~11001+~~	~~all~~	~~R-1.76~~	~~R-1.76~~	~~R-1.41~~	~~R-0.62~~	~~R-1.41~~	~~R-0.62~~	~~R-1.06~~

[a]Insulation R-values, measured in $(m^2 \cdot k)/W$, 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 6.2.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 23.9ºC at the installed thickness.

[b]Includes crawl spaces, both ventilated and non-ventilated.

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

(SI edition)

TABLE 6.2.4.2B
Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Ducts

Climate Zone	Duct Location						
Climate Zone	Exterior	Ventilated Attic	Unvented Attic w/ Backloaded Ceiling	Unvented Attic w/ Roof Insulation[a]	Uncon-ditioned Space[b]	Indirectly Condi-tioned Space[c]	Buried
1	R-1.06	R-1.06	R-1.41	R-0.62	R-0.62	none	R-0.62
2	R-1.06	R-1.06	R-1.06	R-0.62	R-0.62	none	R-0.62
3	R-1.06	R-1.06	R-1.06	R-0.62	R-0.62	none	R-0.62
4	R-1.06	R-1.06	R-1.06	R-0.62	R-0.62	none	R-0.62
5	R-1.06	R-1.06	R-1.06	R-0.34	R-0.62	none	R-0.62
6	R-1.41	R-1.06	R-1.06	R-0.34	R-0.62	none	R-0.62
7	R-1.41	R-1.06	R-1.06	R-0.34	R-0.62	none	R-0.62
8	R-1.41	R-1.41	R-1.41	R-0.34	R-1.06	none	R-1.06

a Insulation R-values, measured in $(m^2 \cdot K)/W$, 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 6.2.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 23.9°C at the installed thickness.

b Includes crawl spaces, both ventilated and unventilated.

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

[Revise Exception "c" to Section 6.3.1.3 as shown below.]

6.3.1.3 Integrated Economizer Control. Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

Exceptions to 6.3.1.3:

(a) Direct expansion systems that include controls that reduce the quantity of outdoor air required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is no greater than 25% of the total system capacity.

(b) Individual direct expansion units that have a rated cooling capacity less than 65,000 Btu/h (19kW) and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.

(c) Systems in ~~locations having less than 800 average hours per year between 8 a.m. and 4 p.m. when the ambient dry-bulb temperatures are between 55°F (13°C) and 69°F (21°C) inclusive. (See Appendix D for climatic data.)~~Climate Zones 1, 2, 3a, 4a, 5a, 5b, 6, 7, 8.

[Delete Table 6.3.1 as shown below and replace it with the following new version of the table. For the deleted table, only the I-P version is shown.]

(I-P edition)

~~**TABLE 6.3.1**~~
~~**Minimum System Size for Which an Economizer is Required**~~

		~~**1% Cooling Design Wet-Bulb Temperature**~~	
	~~T_{wb} < 69°F~~	~~69°F ≤ T_{wb} ≤ 73°F~~	~~T_{wb} > 73°F~~
~~**No. of Hours Between 8 a.m. and 4 p.m. with 55°F < T_{db} < 69°F**~~	~~**Minimum System Size (Btu/h)**~~	~~**Minimum System Size (Btu/h)**~~	~~**Minimum System Size (Btu/h)**~~
~~0-199~~	~~N.R.[a]~~	~~N.R.~~	~~N.R.~~
~~200-399~~	~~135,000~~	~~N.R.~~	~~N.R.~~
~~400-599~~	~~135,000~~	~~N.R.~~	~~N.R.~~
~~600-799~~	~~65,000~~	~~135,000~~	~~N.R.~~
~~800-999~~	~~65,000~~	~~135,000~~	~~135,000~~
~~1000-1199~~	~~65,000~~	~~65,000~~	~~135,000~~
~~>1199~~	~~65,000~~	~~65,000~~	~~65,000~~

~~[a]N.R. means that there is no system size for which an economizer is a requirement in this climate.~~

(I-P edition)

TABLE 6.3.1
Minimum System Size for Which an Economizer is Required

Climate Zones	Cooling Capacity for Which an Economizer is Required
1a, 1b, 2a, 3a, 4a	No Economizer Requirement
2b, 5a, 6a, 7, 8	≥135,000 Btu/h
3b, 3c, 4b, 4c, 5b, 5c, 6b	≥65,000 Btu/h

(SI edition)

TABLE 6.3.1
Minimum System Size for Which an Economizer is Required

Climate Zones	Cooling Capacity for Which an Economizer is Required
1a, 1b, 2a, 3a, 4a	No Economizer Requirement
2b, 5a, 6a, 7, 8	≥40kW
3b, 3c, 4b, 4c, 5b, 5c, 6b	≥19kW

[Revise Tables 6.3.1.1.3 A and B as shown below.]

(I-P edition)

TABLE 6.3.1.1.3A
High Limit Shutoff Control Options for Air Economizers

Climate Zones	Allowed Control Types	Prohibited Control Types
~~Dry~~ ~~T_{wb} < 69°F~~ ~~**or**~~ ~~(T_{wb} < 75°F~~ ~~and T_{db} ≥ 100°F)[a]~~ 1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	Fixed Dry Bulb Differential Dry Bulb Electronic Enthalpy[b] Differential Enthalpy	Fixed Enthalpy
~~Intermediate~~ ~~69°F ≤ T_{wb} ≤ 73°F~~ ~~T_{db} < 100°F~~ All Other Climates	Fixed Dry Bulb Differential Dry Bulb Fixed Enthalpy Electronic Enthalpy[~~b~~a] Differential Enthalpy	
~~Humid~~ ~~T_{wb} > 73°F~~ 1a, 2a, 3a, 4a	Fixed Dry Bulb Fixed Enthalpy Electronic Enthalpy[~~b~~a] Differential Enthalpy	Differential Dry Bulb

~~[a] T_{wb} is the 1% *cooling design* wet-bulb temperature. T_{db} is the 1% *cooling design* dry-bulb temperature.~~

[a~~b~~] Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm

(SI edition)

TABLE 6.3.1.1.3A
High Limit Shutoff Control Options for Air Economizers

Climate Zones	Allowed Control Types	Prohibited Control Types
~~Dry~~ ~~T_{wb} < 21°C~~ ~~**or**~~ ~~(T_{wb} < 24°C~~ ~~and T_{db} ≥ 38°C)[a]~~ 1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	Fixed Dry Bulb Differential Dry Bulb Electronic Enthalpy[b] Differential Enthalpy	Fixed Enthalpy
~~Intermediate~~ ~~21°C ≤ T_{wb} ≤ 23°C~~ ~~T_{db} < 38°C~~ All Other Climates	Fixed Dry Bulb Differential Dry Bulb Fixed Enthalpy Electronic Enthalpy[~~b~~a] Differential Enthalpy	
~~Humid~~ ~~T_{wb} > 23°C~~ 1a, 2a, 3a, 4a	Fixed Dry Bulb Fixed Enthalpy Electronic Enthalpy[~~b~~a] Differential Enthalpy	Differential Dry Bulb

~~[a] T_{wb} is the 1% *cooling design* wet-bulb temperature. T_{db} is the 1% *cooling design* dry-bulb temperature.~~

[a~~b~~] Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm

(I-P edition)

TABLE 6.3.1.1.3B
High Limit Shutoff Control Settings for Air Economizers

Device Type	Climate Zones	Required High Limit (Economizer Off When):	
		Equation	Description
Fixed Dry Bulb	~~Dry~~ 1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	$T_{OA} > 75°F$	Outside air temperature exceeds 75°F
	~~Intermediate~~ 5a, 6a, 7a	$T_{OA} > 70°F$	Outside air temperature exceeds 70°F
	~~Humid~~ All Other Zones	$T_{OA} > 65°F$	Outside air temperature exceeds 65°F
Differential Dry Bulb	~~All~~ 1b, 2b, 3b, 3c, 4b, 4c, 5a, 5b, 5c, 6a, 6b, 7, 8	$T_{OA} > T_{RA}$	Outside air temperature exceeds return air temperature
Fixed Enthalpy	All	$h_{OA} > 28$ Btu/lb [b]	Outside air enthalpy exceeds 28 Btu/lb of dry air[b]
Electronic Enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outside air temperature/RH exceeds the "A" setpoint curve[a]
Differential Enthalpy	All	$h_{OA} > h_{RA}$	Outside air enthalpy exceeds return air enthalpy

[a] Setpoint "A" corresponds to a curve on the psychometric chart that goes through a point at approximately 75°F and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

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

(SI edition)

TABLE 6.3.1.1.3B
High Limit Shutoff Control Settings for Air Economizers

Device Type	Climate Zones	Required High Limit (Economizer Off When):	
		Equation	Description
Fixed Dry Bulb	~~Dry~~ 1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	$T_{OA} > 24°C$	Outside air temperature exceeds 24°C
	~~Intermediate~~ 5a, 6a, 7a	$T_{OA} > 21°C$	Outside air temperature exceeds 21°C
	~~Humid~~ All Other Zones	$T_{OA} > 18°C$	Outside air temperature exceeds 18°C
Differential Dry Bulb	~~All~~ 1b, 2b, 3b, 3c, 4b, 4c, 5a, 5b, 5c, 6a, 6b, 7, 8	$T_{OA} > T_{RA}$	Outside air temperature exceeds return air temperature
Fixed Enthalpy	All	$h_{OA} > 47$ kJ/kg [b]	Outside air enthalpy exceeds 47 kJ/kg of dry air[b]
Electronic Enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outside air temperature/RH exceeds the "A" set-point curve[a]
Differential Enthalpy	All	$h_{OA} > h_{RA}$	Outside air enthalpy exceeds return air enthalpy

[a] Setpoint "A" corresponds to a curve on the psychometric chart that goes through a point at approximately 24°C and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

[b] At altitudes substantially different from sea level, the fixed enthalpy limit value shall be set to the enthalpy value at 24°C and 50% relative humidity. As an example, at approximately 1830 m elevation the fixed enthalpy limit is approximately 53.5 kJ/kg.

[Revise Section 6.3.2.2.3 as shown below.]

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

a. Controls that are capable of providing a heat pump water supply temperature deadband of at least 20°F (12°C) between initiation of heat rejection and heat addition by the central devices (e.g., tower and boiler).

b. For ~~climates with greater than 1800 HDD65 (1000 HDD18)~~Climate Zones 3 through 8, if a closed-circuit tower (fluid cooler) is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection) or low-leakage positive closure dampers shall be provided. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. If an open-circuit tower is used in conjunction with a separate heat exchanger to isolate the tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

Exception to 6.3.2.2.3: Where a system loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of demand and capacity, dead bands of less than 20°F (12°C) shall be allowed.

[Revise Section 6.3.5.2 as shown below.]

6.3.5.2 Fan Speed Control. Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

Exceptions to 6.3.5.2:

(a) Condenser fans serving multiple refrigerant circuits.

(b) Condenser fans serving flooded condensers.

(c) Installations located in ~~climates with greater than 7200 CDD50 (4000 CDD10).~~Climate Zones 1 and 2.

(d) Up to one-third of the fans on a condenser or tower with multiple fans, where the lead fans comply with the speed control requirement

[Revise the exceptions to Section 6.3.6.1 as follows.]

6.3.6 Energy Recovery

6.3.6.1 Exhaust Air Energy Recovery. Individual fan systems that have both a design supply air capacity of 5000 cfm (2400 L/s) or greater and have a minimum outside air supply of 70% or greater of the design supply air quantity shall have an energy recovery system with at least 50% recovery effectiveness. Fifty percent energy recovery effectiveness shall mean a change in the enthalpy of the outdoor air supply equal to 50% of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by 6.3.1.1.

Exceptions to 6.3.6.1:

(a) (a) Laboratory systems meeting 6.3.7.2.

(b) Systems serving spaces that are not cooled and that are heated to less than 60°F (16°C).

(c) Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

(d) Commercial kitchen hoods (grease) classified as Type 1 by *NFPA 96*.

(e) Where more than 60% of the outdoor air heating energy is provided from site-recovered or site solar energy.

(f) Heating systems in ~~climates with less than 3600 HDD65 (2000 HDD18).~~Climate Zones 1 through 3.

(g) Cooling systems~~ in climates with a 1% cooling design wet-bulb temperature less than 65°F (18°C).~~in Climate Zones 3c, 4c, 5b, 5c, 6b, 7 and 8.

(h) Where the largest exhaust source is less than 75% of the design outdoor airflow.

(i) Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil.

[Delete the entire existing Appendix B and replace it with the following new version of Appendix B.]

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

NORMATIVE APPENDIX B

BUILDING ENVELOPE CLIMATE CRITERIA

B1 General. This normative appendix provides the information to determine both United States and International climate zones. For U.S locations, use either Figure B-1 or Table B-1 to determine the climate zone number and letter that is required for determining compliance regarding various sections and tables in this standard. Figure B-1 contains the county-by-county climate zone map for the United States. Table B-1 lists each state and major counties within the state and shows the climate number and letter for each county listed.

Table B-2 shows the climate zone number for a wide variety of Canadian locations. When the climate zone letter is required to determine compliance with this standard, refer to Table B-4 and the "Major Climate Type Definitions" in Section B2 to determine the letter (A, B, or C).

Table B-3 shows the climate zone number for a wide variety of other international locations besides Canada. When the climate zone letter is required to determine compliance with this standard, refer to Table B-4 and the "Major Climate Type Definitions" in Section B2 to determine the letter (A, B, or C).

For all international locations that are not listed either in Table B-2 or B-3, use Table B-4 and the "Major Climate Type Definitions" in Section B2 to determine both the climate zone letter and number.

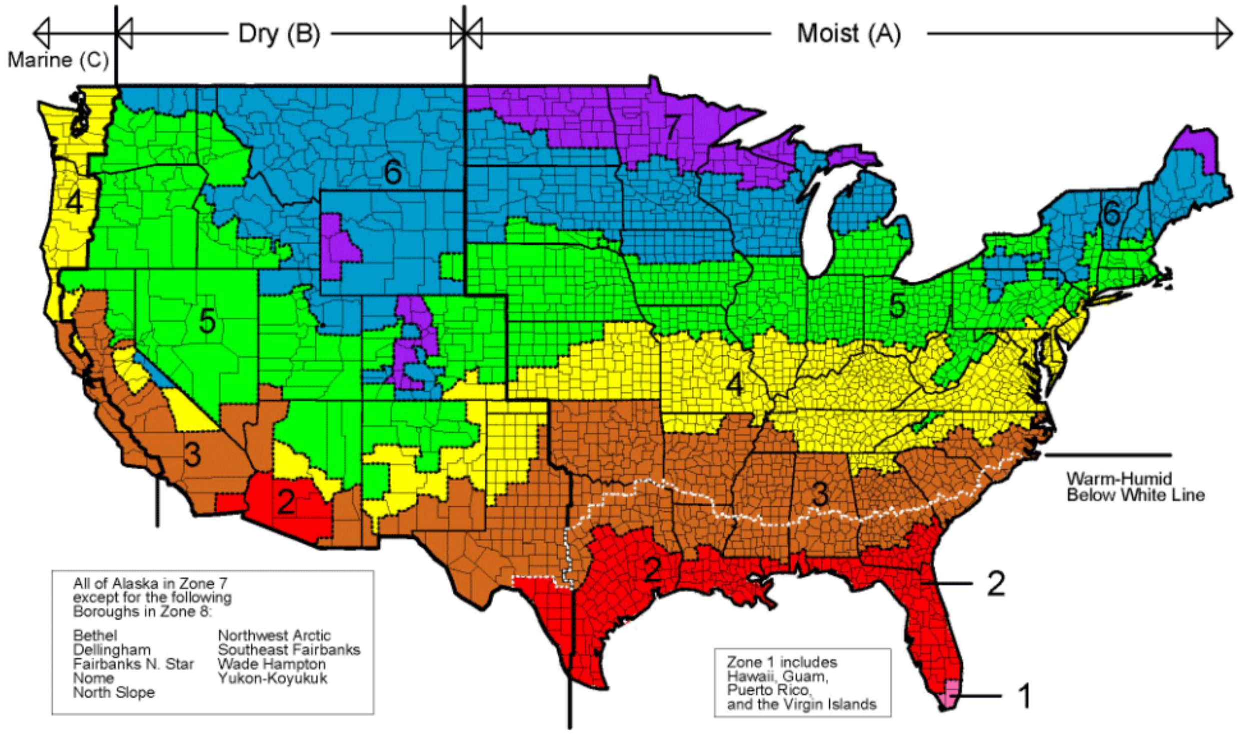

Figure B-1 Climate zones for United States locations.

(I-P edition)

Note: CDD50 and HDD65 values may be found in Normative Appendix D.

(SI edition)

Note: CDD10 and HDD18 values may be found in Normative Appendix D.

TABLE B-1
U.S. Climate Zones

State County	Zone
Alabama (AL)	
Zone 3A Except	
Baldwin	2A
Mobile	2A
Alaska (AK)	
Zone 7 Except	
Bethel (CA)	8
Dillingham (CA)	8
Fairbanks North Star	8
Nome (CA)	8
North Slope	8
Northwest Arctic	8
Southeast Fairbanks (CA)	8
Wade Hampton (CA)	8
Yukon-Koyukuk (CA)	8
Arizona (AZ)	
Zone 3B Except	
La Paz	2B
Maricopa	2B
Pima	2B
Pinal	2B
Yuma	2B
Gila	4B
Yavapai	4B
Apache	5B
Coconino	5B
Navajo	5B
Arkansas (AR)	
Zone 3A Except	
Baxter	4A
Benton	4A
Boone	4A
Carroll	4A
Fulton	4A
Izard	4A
Madison	4A
Marion	4A
Newton	4A
Searcy	4A
Stone	4A
Washington	4A
California (CA)	
Zone 3B Except	
Imperial	2B
Alameda	3C
Marin	3C
Mendocino	3C
Monterey	3C
Napa	3C
San Benito	3C
San Francisco	3C
San Luis Obispo	3C
San Mateo	3C
Santa Barabara	3C
Santa Clara	3C
Santa Cruz	3C
Sonoma	3C
Ventura	3C
Amador	4B
Calaveras	4B
Del Norte	4B
El Dorado	4B
Humboldt	4C
Inyo	4B
Lake	4B
Mariposa	4B
Trinity	4B
Tuolumne	4B
Lassen	5B
Modoc	5B
Nevada	5B
Plumas	5B
Sierra	5B
Siskiyou	5B
Alpine	6B
Mono	6B
Colorado (CO)	
Zone 5B Except	
Baca	4B
Las Animas	4B
Otero	4B
Alamosa	6B
Archuleta	6B
Chaffee	6B
Conejos	6B
Costilla	6B
Custer	6B
Dolores	6B
Eagle	6B
Moffat	6B
Ouray	6B
Rio Blanco	6B
Saguache	6B
San Miguel	6B
Clear Creek	7
Grand	7
Gunnison	7
Hinsdale	7
Jackson	7
Lake	7
Mineral	7
Park	7
Pitkin	7
Rio Grande	7
Routt	7
San Juan	7
Summit	7
Connecticut (CT)	
Zone 5A	
Delaware (DE)	
Zone 4A	
District of Columbia (DC)	
Zone 4A	
Florida (FL)	
Zone 2A Except	
Broward	1A
Miami-Dade	1A
Monroe	1A
Georgia (GA)	
Zone 3A Except	
Appling	2A
Atkinson	2A
Bacon	2A
Baker	2A
Berrien	2A
Brantley	2A
Brooks	2A
Bryan	2A
Camden	2A
Charlton	2A
Chatham	2A
Clinch	2A
Colquitt	2A
Cook	2A
Decatur	2A
Echols	2A
Effingham	2A
Evans	2A
Glynn	2A
Grady	2A
Jeff Davis	2A
Lanier	2A
Liberty	2A
Long	2A
Lowndes	2A
McIntosh	2A
Miller	2A
Mitchell	2A
Pierce	2A
Seminole	2A
Tattnall	2A
Thomas	2A

TABLE B-1 *(Continued)*
U.S. Climate Zones

State County	Zone
Toombs	2A
Ware	2A
Wayne	2A
Banks	4A
Catoosa	4A
Chattooga	4A
Dade	4A
Dawson	4A
Fannin	4A
Floyd	4A
Franklin	4A
Gilmer	4A
Gordon	4A
Habersham	4A
Hall	4A
Lumpkin	4A
Murray	4A
Pickens	4A
Rabun	4A
Stephens	4A
Towns	4A
Union	4A
Walker	4A
White	4A
Whitfield	4A
Hawaii (HI)	
Zone 1A	
Idaho (ID)	
Zone 6B Except	
Ada	5B
Benewah	5B
Canyon	5B
Cassia	5B
Clearwater	5B
Elmore	5B
Gem	5B
Gooding	5B
Idaho	5B
Jerome	5B
Kootenai	5B
Latah	5B
Lewis	5B
Lincoln	5B
Minidoka	5B
Nez Perce	5B
Owyhee	5B
Payette	5B
Power	5B
Shoshone	5B
Twin Falls	5B
Washington	5B
Illinois (IL)	
Zone 5A Except	
Alexander	4A
Bond	4A
Christian	4A
Clay	4A
Clinton	4A
Crawford	4A
Edwards	4A
Effingham	4A
Fayette	4A
Franklin	4A
Gallatin	4A
Hamilton	4A
Hardin	4A
Jackson	4A
Jasper	4A
Jefferson	4A
Johnson	4A
Lawrence	4A
Macoupin	4A
Madison	4A
Monroe	4A
Montgomery	4A
Perry	4A
Pope	4A
Pulaski	4A
Randolph	4A
Richland	4A
Saline	4A
Shelby	4A
St. Clair	4A
Union	4A
Wabash	4A
Washington	4A
Wayne	4A
White	4A
Williamson	4A
Indiana (IN)	
Zone 5A Except	
Brown	4A
Clark	4A
Crawford	4A
Daviess	4A
Dearborn	4A
Dubois	4A
Floyd	4A
Gibson	4A
Greene	4A
Harrison	4A
Jackson	4A
Jefferson	4A
Jennings	4A
Knox	4A
Lawrence	4A
Martin	4A
Monroe	4A
Ohio	4A
Orange	4A
Perry	4A
Pike	4A
Posey	4A
Ripley	4A
Scott	4A
Spencer	4A
Sullivan	4A
Switzerland	4A
Vanderburgh	4A
Warrick	4A
Washington	4A
Iowa (IA)	
Zone 5A Except	
Allamakee	6A
Black Hawk	6A
Bremer	6A
Buchanan	6A
Buena Vista	6A
Butler	6A
Calhoun	6A
Cerro Gordo	6A
Cherokee	6A
Chickasaw	6A
Clay	6A
Clayton	6A
Delaware	6A
Dickinson	6A
Emmet	6A
Fayette	6A
Floyd	6A
Franklin	6A
Grundy	6A
Hamilton	6A
Hancock	6A
Hardin	6A
Howard	6A
Humboldt	6A
Ida	6A
Kossuth	6A
Lyon	6A
Mitchell	6A
O'Brien	6A
Osceola	6A
Palo Alto	6A
Plymouth	6A
Pocahontas	6A
Sac	6A
Sioux	6A
Webster	6A
Winnebago	6A
Winneshiek	6A
Worth	6A
Wright	6A
Kansas (KS)	
Zone 4A Except	
Cheyenne	5A
Cloud	5A
Decatur	5A

TABLE B-1 *(Continued)*
U.S. Climate Zones

State County	Zone
Ellis	5A
Gove	5A
Graham	5A
Greeley	5A
Hamilton	5A
Jewell	5A
Lane	5A
Logan	5A
Mitchell	5A
Ness	5A
Norton	5A
Osborne	5A
Phillips	5A
Rawlins	5A
Republic	5A
Rooks	5A
Scott	5A
Sheridan	5A
Sherman	5A
Smith	5A
Thomas	5A
Trego	5A
Wallace	5A
Wichita	5A
Kentucky (KY)	
Zone 4A	
Louisiana (LA)	
Zone 2A Except	
Bienville	3A
Bossier	3A
Caddo	3A
Caldwell	3A
Catahoula	3A
Claiborne	3A
Concordia	3A
De Soto	3A
East Carroll	3A
Franklin	3A
Grant	3A
Jackson	3A
La Salle	3A
Lincoln	3A

State County	Zone
Madison	3A
Morehouse	3A
Natchitoches	3A
Ouachita	3A
Red River	3A
Richland	3A
Sabine	3A
Tensas	3A
Union	3A
Vernon	3A
Webster	3A
West Carroll	3A
Winn	3A
Maine (ME)	
Zone 6A Except	
Aroostook	7
Maryland (MD)	
Zone 4A Except	
Garrett	5A
Massachusetts (MA)	
Zone 5	
Michigan (MI)	
Zone 5A Except	
Alcona	6A
Alger	6A
Alpena	6A
Antrim	6A
Arenac	6A
Benzie	6A
Charlevoix	6A
Cheboygan	6A
Clare	6A
Crawford	6A
Delta	6A
Dickinson	6A
Emmet	6A
Gladwin	6A
Grand Traverse	6A
Huron	6A
Iosco	6A
Isabella	6A
Kalkaska	6A

State County	Zone
Lake	6A
Leelanau	6A
Manistee	6A
Marquette	6A
Mason	6A
Mecosta	6A
Menominee	6A
Missaukee	6A
Montmorency	6A
Newaygo	6A
Oceana	6A
Ogemaw	6A
Osceola	6A
Oscoda	6A
Otsego	6A
Presque Isle	6A
Roscommon	6A
Sanilac	6A
Wexford	6A
Baraga	7
Chippewa	7
Gogebic	7
Houghton	7
Iron	7
Keweenaw	7
Luce	7
Mackinac	7
Ontonagon	7
Schoolcraft	7
Minnesota (MN)	
Zone 6A Except	
Aitkin	7
Becker	7
Beltrami	7
Carlton	7
Cass	7
Clay	7
Clearwater	7
Cook	7
Crow Wing	7
Grant	7
Hubbard	7

State County	Zone
Itasca	7
Kanabec	7
Kittson	7
Koochiching	7
Lake	7
Lake of the Woods	7
Mahnomen	7
Marshall	7
Mille Lacs	7
Norman	7
Otter Tail	7
Pennington	7
Pine	7
Polk	7
Red Lake	7
Roseau	7
St. Louis	7
Wadena	7
Wilkin	7
Mississippi (MS)	
Zone 3A Except	
Hancock	2A
Harrison	2A
Jackson	2A
Pearl River	2A
Stone	2A
Missouri (MO)	
Zone 4A Except	
Adair	5A
Andrew	5A
Atchison	5A
Buchanan	5A
Caldwell	5A
Chariton	5A
Clark	5A
Clinton	5A
Daviess	5A
Gentry	5A
Grundy	5A
Harrison	5A
Holt	5A
Knox	5A

TABLE B-1 ***(Continued)***
U.S. Climate Zones

State County	Zone
Lewis	5A
Linn	5A
Livingston	5A
Macon	5A
Marion	5A
Mercer	5A
Nodaway	5A
Pike	5A
Putnam	5A
Ralls	5A
Schuyler	5A
Scotland	5A
Shelby	5A
Sullivan	5A
Worth	5A
Montana (MT)	
Zone 6B	
Nebraska (NE)	
Zone 5A	
Nevada (NV)	
Zone 5B Except	
Clark	3B
New Hampshire (NH)	
Zone 6A Except	
Cheshire	5A
Hillsborough	5A
Rockingham	5A
Strafford	5A
New Jersey (NJ)	
Zone 4A Except	
Bergen	5A
Hunterdon	5A
Mercer	5A
Morris	5A
Passaic	5A
Somerset	5A
Sussex	5A
Warren	5A
New Mexico (NM)	
Zone 5B Except	
Chaves	3B
Dona Ana	3B
Eddy	3B
Hidalgo	3B
Lea	3B
Luna	3B
Otero	3B
Bernalillo	4B
Curry	4B
DeBaca	4B
Grant	4B
Guadalupe	4B
Lincoln	4B
Quay	4B
Roosevelt	4B
Sierra	4B
Socorro	4B
Union	4B
Valencia	4B
New York (NY)	
Zone 5A Except	
Bronx	4A
Kings	4A
Nassau	4A
New York	4A
Queens	4A
Richmond	4A
Suffolk	4A
Westchester	4A
Allegany	6A
Broome	6A
Cattaraugus	6A
Chenango	6A
Clinton	6A
Delaware	6A
Essex	6A
Franklin	6A
Fulton	6A
Hamilton	6A
Herkimer	6A
Jefferson	6A
Lewis	6A
Madison	6A
Montgomery	6A
Oneida	6A
Otsego	6A
Schoharie	6A
Schuyler	6A
St. Lawrence	6A
Steuben	6A
Sullivan	6A
Tompkins	6A
Ulster	6A
Warren	6A
Wyoming	6A
North Carolina (NC)	
Zone 4A Except	
Anson	3A
Beaufort	3A
Bladen	3A
Brunswick	3A
Cabarrus	3A
Camden	3A
Carteret	3A
Chowan	3A
Columbus	3A
Craven	3A
Cumberland	3A
Currituck	3A
Dare	3A
Davidson	3A
Duplin	3A
Edgecombe	3A
Gaston	3A
Greene	3A
Hoke	3A
Hyde	3A
Johnston	3A
Jones	3A
Lenoir	3A
Martin	3A
Mecklenburg	3A
Montgomery	3A
Moore	3A
New Hanover	3A
Onslow	3A
Pamlico	3A
Pasquotank	3A
Pender	3A
Perquimans	3A
Pitt	3A
Randolph	3A
Richmond	3A
Robeson	3A
Rowan	3A
Sampson	3A
Scotland	3A
Stanly	3A
Tyrrell	3A
Union	3A
Washington	3A
Wayne	3A
Wilson	3A
Alleghany	5A
Ashe	5A
Avery	5A
Mitchell	5A
Watauga	5A
Yancey	5A
North Dakota (ND)	
Zone 7 Except	
Adams	6A
Billings	6A
Bowman	6A
Burleigh	6A
Dickey	6A
Dunn	6A
Emmons	6A
Gold Valley	6A
Grant	6A

TABLE B-1 *(Continued)*
U.S. Climate Zones

State County	Zone	State County	Zone	State County	Zone	State County	Zone
Hettinger	6A	Hood River	5B	Yankton	5A	Cherokee	2A
LaMoure	6A	Jefferson	5B	Tennessee (TN)		Colorado	2A
Logan	6A	Klamath	5B	Zone 4A Except		Comal	2A
McIntosh	6A	Lake	5B	Chester	3A	Coryell	2A
McKenzie	6A	Malheur	5B	Crockett	3A	DeWitt	2A
Mercer	6A	Morrow	5B	Dyer	3A	Dimmit	2B
Morton	6A	Sherman	5B	Fayette	3A	Duval	2A
Oliver	6A	Umatilla	5B	Hardeman	3A	Edwards	2B
Ransom	6A	Union	5B	Hardin	3A	Falls	2A
Richland	6A	Wallowa	5B	Haywood	3A	Fayette	2A
Sargent	6A	Wasco	5B	Henderson	3A	Fort Bend	2A
Sioux	6A	Wheeler	5B	Lake	3A	Freestone	2A
Slope	6A	Pennsylvania (PA)		Lauderdale	3A	Frio	2B
Stark	6A	Zone 5A Except		Madison	3A	Galveston	2A
Ohio (OH)		Bucks	4A	McNairy	3A	Goliad	2A
Zone 5A Except		Chester	4A	Shelby	3A	Gonzales	2A
Adams	4A	Delaware	4A	Tipton	3A	Grimes	2A
Brown	4A	Montgomery	4A	Texas (TX)		Guadalupe	2A
Clermont	4A	Philadelphia	4A	Zone 3A Except		Hardin	2A
Gallia	4A	York	4A	Anderson	2A	Harris	2A
Hamilton	4A	Rhode Island (RI)		Angelina	2A	Hays	2A
Lawrence	4A	Zone 5A		Aransas	2A	Hidalgo	2A
Pike	4A	South Carolina (SC)		Atascosa	2A	Hill	2A
Scioto	4A	Zone 3A		Austin	2A	Houston	2A
Washington	4A	South Dakota (SD)		Bandera	2B	Jackson	2A
Oklahoma (OK)		Zone 6A Except		Bastrop	2A	Jasper	2A
Zone 3A Except		Bennett	5A	Bee	2A	Jefferson	2A
Beaver	4A	Bon Homme	5A	Bell	2A	Jim Hogg	2A
Cimarron	4A	Charles Mix	5A	Bexar	2A	Jim Wells	2A
Texas	4A	Clay	5A	Bosque	2A	Karnes	2A
Oregon (OR)		Douglas	5A	Brazoria	2A	Kenedy	2A
Zone 4C Except		Gregory	5A	Brazos	2A	Kinney	2B
Baker	5B	Hutchinson	5A	Brooks	2A	Kleberg	2A
Crook	5B	Jackson	5A	Burleson	2A	La Salle	2B
Deschutes	5B	Mellette	5A	Caldwell	2A	Lavaca	2A
Gilliam	5B	Todd	5A	Calhoun	2A	Lee	2A
Grant	5B	Tripp	5A	Cameron	2A	Leon	2A
Harney	5B	Union	5A	Chambers	2A	Liberty	2A

TABLE B-1 *(Continued)*
U.S. Climate Zones

State County	Zone	State County	Zone	State County	Zone	State County	Zone
Limestone	2A	Andrews	3B	Knox	3B	Castro	4B
Live Oak	2A	Baylor	3B	Lipscomb	3B	Cochran	4B
Madison	2A	Borden	3B	Loving	3B	Dallam	4B
Matagorda	2A	Brewster	3B	Lubbock	3B	Deaf Smith	4B
Maverick	2B	Callahan	3B	Lynn	3B	Donley	4B
McLennan	2A	Childress	3B	Martin	3B	Floyd	4B
McMullen	2A	Coke	3B	Mason	3B	Gray	4B
Medina	2B	Coleman	3B	McCulloch	3B	Hale	4B
Milam	2A	Concho	3B	Menard	3B	Hansford	4B
Montgomery	2A	Cottle	3B	Midland	3B	Hartley	4B
Newton	2A	Crane	3B	Mitchell	3B	Hockley	4B
Nueces	2A	Crockett	3B	Motley	3B	Hutchinson	4B
Orange	2A	Crosby	3B	Nolan	3B	Lamb	4B
Polk	2A	Culberson	3B	Pecos	3B	Lipscomb	4B
Real	2B	Dawson	3B	Presidio	3B	Moore	4B
Refugio	2A	Dickens	3B	Reagan	3B	Ochiltree	4B
Robertson	2A	Ector	3B	Reeves	3B	Oldham	4B
San Jacinto	2A	El Paso	3B	Runnels	3B	Parmer	4B
San Patricio	2A	Fisher	3B	Schleicher	3B	Potter	4B
Starr	2A	Foard	3B	Scurry	3B	Randall	4B
Travis	2A	Gaines	3B	Shackelford	3B	Roberts	4B
Trinity	2A	Garza	3B	Sterling	3B	Sherman	4B
Tyler	2A	Glasscock	3B	Stonewall	3B	Swisher	4B
Uvalde	2B	Hackell	3B	Sutton	3B	Yoakum	4B
Val Verde	2B	Hall	3B	Taylor	3B	Utah (UT)	
Victoria	2A	Hardeman	3B	Terrell	3B	Zone 5B Except	
Walker	2A	Haskell	3B	Terry	3B	Washington	3B
Waller	2A	Hemphill	3B	Throckmorton	3B	Box Elder	6B
Washington	2A	Howard	3B	Upton	3B	Cache	6B
Webb	2B	Hudspeth	3B	Ward	3B	Carbon	6B
Wharton	2A	Irion	3B	Wheeler	3B	Daggett	6B
Willacy	2A	Jeff Davis	3B	Wilbarger	3B	Duchesne	6B
Williamson	2A	Jones	3B	Winter ?	3B	Morgan	6B
Wilson	2A	Kendall	3B	Armstrong	4B	Rich	6B
Zapata	2B	Kent	3B	Bailey	4B	Summit	6B
Zavala	2B	Kerr	3B	Briscoe	4B	Uintah	6B
Tom Green	3B	King	3B	Carson	4B	Wasatch	6B

TABLE B-1 *(Continued)*
U.S. Climate Zones

State County	Zone
Vermont (VT)	
Zone 6A	
Virginia (VA)	
Zone 4A	
Washington (WA)	
Zone 5B Except	
Clallam	4C
Clark	4C
Cowlitz	4C
Grays Harbor	4C
Jefferson	4C
King	4C
Kitsap	4C
Lewis	4C
Mason	4C
Pacific	4C
Pierce	4C
Skagit	4C
Snohomish	4C
Thurston	4C
Wahkiakum	4C
Whatcom	4C
Ferry	6B
Okanogan	6B
Pend Oreille	6B
Stevens	6B
West Virginia (WV)	
Zone 5A Except	
Berkeley	4A
Boone	4A
Braxton	4A
Cabell	4A
Calhoun	4A
Clay	4A
Gilmer	4A
Jackson	4A
Jefferson	4A
Kanawha	4A
Lincoln	4A
Logan	4A
Mason	4A
McDowell	4A
Mercer	4A
Mingo	4A
Monroe	4A
Morgan	4A
Pleasants	4A
Putnam	4A
Ritchie	4A
Roane	4A
Tyler	4A
Wayne	4A
Wirt	4A
Wood	4A
Wyoming	4A
Wisconsin (WI)	
Zone 6A Except	
Ashland	7A
Bayfield	7A
Burnett	7A
Douglas	7A
Florence	7A
Forest	7A
Iron	7A
Langlade	7A
Lincoln	7A
Oneida	7A
Price	7A
Sawyer	7A
Taylor	7A
Vilas	7A
Washburn	7A
Wyoming (WY)	
Zone 6B Except	
Goshen	5B
Platte	5B
Lincoln	7B
Sublette	7B
Teton	7B
Pacific Rim (PR)	
Zone 1 Except	
Barranquitas 2 SSW	2B
Cayey 1 E	2B
Pacific Islands (PI)	
Zone 1 Except	
Midway Sand Island	2B
Virgin Islands (VI)	
Zone 1A	

TABLE B-2
Canadian Climatic Zones

Province / City	Zone
Alberta (AB)	
Calgary International A	7
Edmonton International A	7
Grande Prairie A	7
Jasper	7
Lethbridge A	6
Medicine Hat A	6
Red Deer A	7
British Columbia (BC)	
Dawson Creek A	7
Ft Nelson A	8
Kamloops	5
Nanaimo A	5
New Westminster BC Pen	5
Penticton A	5
Prince George	7
Prince Rupert A	6
Vancouver International A	5
Victoria Gonzales Hts	5
Manitoba (MB)	
Brandon CDA	7
Churchill A	8
Dauphin A	7
Flin Flon	7
Portage La Prairie A	7
The Pas A	7
Winnipeg International A	7
New Brunswick (NB)	
Chatham A	7
Fredericton A	6
Moncton A	6
Saint John A	6
Newfoundland (NF)	
Corner Brook	6
Gander International A	7
Goose A	7
St John's A	6
Stephenville A	6

TABLE B-2 ***(Continued)***
Canadian Climatic Zones

Province / City	Zone
Northwest Territories (NW)	
Ft Smith A	8
Inuvik A	8
Resolute A	8
Yellowknife A	8
Nova Scotia (NS)	
Halifax International A	6
Kentville CDA	6
Sydney A	6
Truro	6
Yarmouth A	6
Ontario (ON)	
Belleville	6
Cornwall	6
Hamilton RBG	5
Kapuskasing A	7
Kenora A	7
Kingston A	6
London A	6
North Bay A	7
Oshawa WPCP	6
Ottawa International A	6
Owen Sound MOE	6
Peterborough	6
St Catharines	5
Sudbury A	7
Thunder Bay A	7
Timmins A	7
Toronto Downsview A	6
Windsor A	5
Prince Edward Island (PE)	
Charlottetown A	6
Summerside A	6
Quebec (PQ)	
Bagotville A	7
Drummondville	6
Granby	6
Montreal Dorval International A	6
Quebec A	7
Rimouski	7
SeptIles A	7

TABLE B-2 ***(Continued)***
Canadian Climatic Zones

Province / City	Zone
Shawinigan	7
Sherbrooke A	7
St Jean de Cherbourg	7
St Jerome	7
Thetford Mines	7
Trois Rivieres	7
Val d'Or A	7
Valleyfield	6
Saskatchewan (SK)	
Estevan A	7
Moose Jaw A	7
North Battleford A	7
Prince Albert A	7
Regina A	7
Saskatoon A	7
Swift Current A	7
Yorkton A	7
Yukon Territory (YT)	
Whitehorse A	8

TABLE B-3
International Climatic Zones

Country	City	Province or Region	Zone
Argentina			
	Buenos Aires/Ezeiza		3
	Cordoba		3
	Tucuman/Pozo		2
Australia			
	Adelaide	SA	4
	Alice Springs	NT	2
	Brisbane	QL	2
	Darwin Airport	NT	1
	Perth/Guildford	WA	3
	Sydney/K Smith	NSW	3
Azores			
	Lajes	Terceira	3
Bahamas			
	Nassau		1
Belgium			
	Brussels Airport		5
Bermuda			
	St Georges/Kindley		2
Bolivia			
	La Paz/El Alto		5
Brazil			
	Belem		1
	Brasilia		2
	Fortaleza		1
	Porto Alegre		2
	Recife/Curado		1
	Rio de Janeiro		1
	Salvador/Ondina		1
	Sao Paulo		2
Bulgaria			
	Sofia		5
Chile			
	Concepcion		4
	Punta Arenas/Chabunco		6
	Santiago/Pedahuel		4
China			
	Shanghai/Hongqiao		3

TABLE B-3 *(Continued)*
International Climatic Zones

Country	City	Province or Region	Zone
Cuba			
	Guantanamo Bay NAS	Ote.	1
Cyprus			
	Akrotiri		3
	Larnaca		3
	Paphos		3
Czech Republic (Former Czechoslovakia)			
	Prague/Libus		5
Dominican Republic			
	Santo Domingo		1
Egypt			
	Cairo		2
	Luxor		1
Finland			
	Helsinki/Seutula		7
France			
	Lyon/Satolas		4
	Marseille		4
	Nantes		4
	Nice		4
	Paris/ Le Bourget		4
	Strasbourg		5
Germany			
	Berlin/Schoenfeld		5
	Hamburg		5
	Hannover		5
	Mannheim		5
Greece			
	Souda	Crete	3
	Thessalonika/Mikra		4
Greenland			
	Narssarssuaq		7
Hungary			
	Budapest/Lorinc		5
Iceland			
	Reykjavik		7
India			
	Ahmedabad		1
	Bangalore		1
	Bombay/Santa Cruz		1

TABLE B-3 ***(Continued)***
International Climatic Zones

Country	City	Province or Region	Zone
	Calcutta/Dum Dum		1
	Madras		1
	Nagpur Sonegaon		1
	New Delhi/Safdarjung		1
Indonesia			
	Djakarta/Halimperda	Java	1
	Kupang Penfui	Sunda Island	1
	Makassar	Celebes	1
	Medan	Sumatra	1
	Palembang	Sumatra	1
	Surabaja Perak	Java	1
Ireland			
	Dublin Airport		5
	Shannon Airport		4
Israel			
	Jerusalem		3
	Tel Aviv Port		2
Italy			
	Milano/Linate		4
	Napoli/Capodichino		4
	Roma/Fiumicino		4
Jamaica			
	Kingston/Manley		1
	Montego Bay/Sangster		1
Japan			
	Fukaura		5
	Sapporo		5
	Tokyo		3
Jordan			
	Amman		3
Kenya			
	Nairobi Airport		3
Korea			
	Pyonggang		5
	Seoul		4
Malaysia			
	Kuala Lumpur		1
	Penang/Bayan Lepas		1
Mexico			
	Mexico City	Distrito Federal	3

TABLE B-3 *(Continued)*
International Climatic Zones

Country	City	Province or Region	Zone
	Guadalajara	Jalisco	1
	Monterrey	Nuevo Laredo	3
	Tampico	Tamaulipas	1
	Veracruz	Veracruz	4
	Merida	Yucatan	1
Netherlands			
	Amsterdam/Schiphol		5
New Zealand			
	Auckland Airport		4
	Christchurch		4
	Wellington		4
Norway			
	Bergen/Florida		5
	Oslo/Fornebu		6
Pakistan			
	Karachi Airport		1
Papua New Guinea			
	Port Moresby		1
Paraguay			
	Asuncion/Stroessner		1
Peru			
	LimaCallao/Chavez		2
	San Juan de Marcona		2
	Talara		2
Philippines			
	Manila Airport	Luzon	1
Poland			
	Krakow/Balice		5
Romania			
	Bucuresti/Bancasa		5
Russia (Former Soviet Union)			
	Kaliningrad	East Prussia	5
	Krasnoiarsk		7
	Moscow Observatory		6
	Petropavlovsk		7
	RostovNaDonu		5
	Vladivostok		6
	Volgograd		6

TABLE B-3 ***(Continued)***
International Climatic Zones

Country	City	Province or Region	Zone
Saudi Arabia			
	Dhahran		1
	Riyadh		1
Senegal			
	Dakar/Yoff		1
Singapore			
	Singapore/Changi		1
South Africa			
	Cape Town/D F Malan		4
	Johannesburg		4
	Pretoria		3
Spain			
	Barcelona		4
	Madrid		4
	Valencia/Manises		3
Sweden			
	Stockholm/Arlanda		6
Switzerland			
	Zurich		5
Syria			
	Damascus Airport		3
Taiwan			
	Tainan		1
	Taipei		2
Tanzania			
	Dar es Salaam		1
Thailand			
	Bangkok		1
Tunisia			
	Tunis/El Aouina		3
Turkey			
	Adana		3
	Ankara/Etimesgut		4
	Istanbul/Yesilkoy		4
United Kingdom			
	Birmingham	England	5
	Edinburgh	Scotland	5
	Glasgow Apt	Scotland	5
	London/Heathrow	England	4

TABLE B-3 ***(Continued)***
International Climatic Zones

Country	City	Province or Region	Zone
Uruguay			
	Montevideo/Carrasco		3
Venezuela			
	Caracas/Maiquetia		1
Vietnam			
	Hanoi/Gialam		1
	Saigon (Ho Chi Minh)		1

B2 Major Climate Type Definitions. Use the following information along with Table B-4 to determine climate zone numbers and letters for international climate zones.

Marine (C) Definition - Locations meeting all four criteria:

1. Mean temperature of coldest month between –3ºC (27ºF) and 18ºC (65ºF)
2. Warmest month mean < 22ºC (72ºF)
3. At least four months with mean temperatures over 10ºC (50ºF)
4. Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.

Dry (B) Definition—Locations meeting the following criteria: Not Marine and

$$P_{in} < 0.44 \times (TF - 19.5) \qquad \text{(I-P units)}$$

$$P_{cm} < 2.0 \times (TC + 7) \qquad \text{(SI units)}$$

where:

P = annual precipitation in inches (cm)

T = annual mean temperature in ºF (ºC)

Moist (A) Definition—Locations that are not Marine and not Dry.

TABLE B-4 INTERNATIONAL CLIMATE ZONE DEFINITIONS

		THERMAL CRITERIA	
Zone Number	**Description**	**IP Units**	**SI Units**
1	Very Hot – Humid (1A), Dry (1B)	9000 < CDD50°F	5000 < CDD10°C
2	Hot – Humid (2A), Dry (2B)	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	Warm – Humid (3A), Dry (3B)	4500 < CDD50°F ≤ 6300	2500 < CDD10°C ≤ 3500
3C	Warm – Marine	CDD50°F 4500 AND HDD65°F 3600	CDD10°C 2500 AND HDD18°C 2000
4A and 4B	Mixed – Humid (4A), Dry (4B)	CDD50°F ≤ 4500 AND HDD65°F ≤ 5400	CDD10°C ≤ 2500 AND HDD18°C ≤ 3000
4C	Mixed – Marine	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5A, 5B and 5C	Cool– Humid (5A), Dry (5B), Marine (5C)	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤ 4000
6A and 6B	Cold – Humid (6A), Dry (6B)	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	Very Cold	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	Subarctic	12600 < HDD65°F	7000 < HDD18°C

[In Appendix D, delete the column entitled "Table" in Tables D-1, D-2, and D-3. In the current 2001 edition of the standard, this column provides a cross reference to various tables in Appendix B. These cross references are no longer needed and so the column is being deleted in all three tables in Appendix D in this addendum.]

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

INTERPRETATION IC 90.1-2001-1 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

Revision Approved: April 22, 2002

Originally issued as interpretation of Standard 90.1-1999 on February 7, 2000 (IC 90.1-1999-5), but revised based on the publication of 90.1-2001. Revisions made to all Background, Question and Answer statements to reflect Standard 90.1-2001 language.

Request from: Douglas Mahone, Partner, Heschong Mahone Group, 11626 Fair Oaks Blvd. #302, Fair Oaks, CA 95628

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 4.1.2.1, Additions to Existing Buildings, and Section 4.1.2.2, Alterations to Existing Buildings.

Question 1a: Does Exception (b) to Section 4.1.2.1, Additions to Existing Buildings, require that trade-offs between measures be compared on the basis of energy consumption rather than energy cost?

Answer: Yes. Exception (b) to Section 4.1.2.1requires that the basis of comparison be energy consumption.

Question 1b: Does Exception (b) to Section 4.1.2.2, Alterations to Existing Buildings, require that trade-offs between measures be compared on the basis of annual energy usage rather than energy cost?

Answer: Yes. Exception (b) to Section 4.1.2.2 requires that the basis of comparison be annual energy usage.

Question 2a: Does Exception (b) to Section 4.1.2.1, Additions to Existing Buildings, require the use of the ECB method for making trade-off calculations?

Answer: Yes. Compare the energy consumption using the energy analysis methodology of the ECB Chapter (Chapter 11).

Question 2b(1): Does Exception (b) to Section 4.1.2.2, Alterations to Existing Buildings, require the use of the ECB method for making trade-off calculations?

Answer: No.

Question 2b(2): Are there any restrictions intended as to the method of calculation, or may the user apply any method acceptable to the authority having jurisdiction?

Answer: Yes. The comparison must be done using a substantially identical design; annual energy usage must be calculated; it must be verified by the design professional; and, the user may apply any method acceptable to the authority having jurisdiction.

INTERPRETATION IC 90.1-2001-2 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

Revision Approved: April 22, 2002

Originally issued as interpretation of Standard 90.1-1999 on February 6, 2000 (IC 90.1-1999-3), but revised based on the publication of 90.1-2001. Revisions made to all Background, Question and Answer statements to reflect Standard 90.1-2001 language.

Request from: Mark Hydeman, Taylor Engineering, 1305 Marina Village Parkway, Alameda, CA 94501

Reference: This request for interpretation relates to the water heater requirements in Section 7.2.2 and Table 7.2.2 in ANSI/ASHRAE/IESNA Standard 90.1-2001.

Background: In Table 7.2.2, the variable *V* used in determining standby loss (*SL*) limitations is defined to be equal to the "rated" volume. This distinction is not clear in two other instances where water heater storage volume is referenced:

- The exception to 7.2.2 states in part: "All water heaters, hot water storage tanks, and hot water supply boilers having more than 140 gal (530L) of storage capacity are not required…"

- Product categories in Table 7.2.2 are determined in part by the input-to-volume ratio, equal to the input energy to the water heater divided by its volume.

In these two cases, it is not clear whether the volume or capacity referred to is the measured or the rated volume of the storage tank.

Interpretation: Mr. Hydeman offers the following interpretations:

1. The "storage volume" in the Exception to 7.2.2 is the measured volume.

2. The volume used to determine the input-to-volume ratio in Table 7.2.2 is the rated volume.

Question: Are these interpretations correct?

Answer: Yes.

Comment: None.

INTERPRETATION IC 90.1-2001-3 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

April 22, 2002

Request from: Mr. Chris Jones (e-mail: mailto:cjones@islandnet.com), 14 Oneida Avenue, Toronto, Ontario M5J 2E3. ASHRAE Member 5068556.

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 11.4.2(c), relating to budget building envelope model glazing characteristics.

Background: Prescriptive criteria require that the fenestration U-value and solar heat gain coefficient values are set based on the fenestration to wall ratio. 11.4.2(c) states "Fenestration U-factor shall be the minimum required for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation." This statement seems to imply that the budget building model should use the lowest U-factor and the highest solar heat gain coefficient; not based on fenestration to wall ratio.

Interpretation: I have interpreted this section to mean that the budget building envelope model fenestration U-value and solar heat gain coefficient be set based on the fenestration percentage taken from the budget building envelope model. For example, from Table B-18, 35% fenestration percentage, non-residential building with fixed windows, I would set the U-factor at 0.57 and the SHGC at 0.49 all faces.

Question: Is this interpretation correct?

Answer: Yes

Comments: Your interpretation is still based on fenestration percentage. You enter the row based on the percentage you have and use the respective U-factor and SHGC. Please note that if the North-Oriented face had a different SHGC, you would use that value for the north fenestration.

INTERPRETATION IC 90.1-2001-4 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

April 22, 2002

Request from: Mr. Chris Jones (e-mail: mailto:cjones@islandnet.com), 14 Oneida Avenue, Toronto, Ontario M5J 2E3. ASHRAE Member 5068556.

Reference: This request refers to ASHRAE/IES 90.1-2001, Subsections 11.4.3 (a) and (d) in combination with Subsection 6.3.6.1.

Background: The HVAC systems for energy cost budget buildings which have zonal systems (e.g., fan coils or distributed heat pumps) typically are designed with make-up air units (MAUs) which provide 100% preheated outdoor air to the terminal units. The existence of MAUs for Systems 5, 6 and 7 in Table 11.4.3A is not explicitly defined, however. Subsection 11.4.3.(a) states "Components and parameters not listed in Figure 11.4.3 and Table 11.4.3A or otherwise specifically addressed in this subsection shall be identical to those in the proposed design."

If MAUs are intended to be included in these budget building cases, as is typical for most corresponding proposed building designs, it is unclear if heat reclaim should apply to the MAU. The unit to which the preheated outside air is delivered typically has less than 70% of its supply air as outside air, indicating that heat reclaim may not apply. Further, if the make-up air does not cool the outside air (as is typical here) and it preheats the outside air to less than 60°F, then heat reclaim may not apply either according to exception (b). Vagueness is introduced here since *the MAU does not directly serve* the conditioned space but instead pre-conditions the outside air to a terminal heat pump or fan coil.

Interpretation 1: I have interpreted Section 11.4.3 to mean that the budget building model shall include a make-up air system if the proposed building model does. This system shall be modelled with the same characteristics as the proposed building model including heating/cooling efficiencies. Heat reclaim is only to be modelled if the proposed building model includes it.

Question 1: Is this interpretation correct?

Answer 1: Yes to the first sentence. No to the last two sentences.

Comment 1: Energy recovery must be modeled in the budget building, whether it was included in the proposed design or not, unless one of the exceptions to 6.3.6 is applicable. For instance, energy recovery is not required to be modeled in the budget building if the MAU in the proposed design does not cool make-up air nor preheat it to more than 60°F (exception b). If the MAU is a packaged unit or a furnace or any product for which the Standard is regulating efficiency, then the budget model should use the lowest allowed cooling/heating efficiency for the product category.

Interpretation 2: This interpretation holds true for both 90.1-1999 and 90.1-2001.

Answer 2: Yes

INTERPRETATION IC 90.1-2001-5 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

Revision Approved: April 22, 2002

Originally issued as interpretation of Standard 90.1-1999 on February 4, 2000 (IC 90.1-1999-1), but revised based on the publication of 90.1-2001. Revisions made to all Background, Question and Answer statements to reflect Standard 90.1-2001 language.

Request from: Charles Eley, Eley Associates, 142 Minna Street, San Francisco, California 94105

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 9.3.2, relating to the exterior lighting power allowance.

Background: Section 9.3.2 has lighting power limits for exterior building lighting. Table 9.3.2 has limits for building entrances with a canopy, building entrances without a canopy, and building exits. For a single building, the standard permits trade-offs between these three applications.

Interpretation: For multi-building projects, exterior lighting power can be traded off between buildings. Each building does not have to separately meet its exterior lighting power allowance.

Question: Is this interpretation correct?

Answer: Yes. The exterior lighting power allowance of a multi-building project is the sum of lighting power allowances for the applicable exterior entrances (with and without canopies) and exits of all buildings.

Comments: The designer is provided with additional flexibility for relatively minor lighting loads without changing the total amount of exterior power allowance for the total project.

Building facades are not part of the exterior lighting power allowance. Building facade lighting power is "use-it or lose-it".

INTERPRETATION IC 90.1-2001-6 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

Revision Approved: April 22, 2002

Originally issued as interpretation of Standard 90.1-1999 on June 25, 2001 (IC 90.1-1999-7), but revised based on the publication of 90.1-2001. Revisions made to all Background, Question and Answer statements to reflect Standard 90.1-2001 language.

Request from: Jay Enck, CH2M HILL, 115 Perimeter Center Place, NE, Suite 700, Atlanta, GA 30346 (E-mail: mailto:jenck@ch2m.com)

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 5.5.3.4, Vestibules.

Background: Section 5.5.3.4 requires enclosed vestibules for doors that separate conditioned space from the exterior. Several exceptions to Section 5.5.3.4 are given. Exception C states that “Doors not intended to be used as a building entrance door” are not required to have a vestibule.

Interpretation: A door that is not a main public entrance to the building is not required to have a vestibule. A controlled access door that opens to a patio which does not have egress from the building’s exterior would not be considered a building entrance door and therefore would not require a vestibule.

Question: Is this interpretation correct?

Answer: Yes.

Comments: None.

INTERPRETATION IC 90.1-2001-7 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

June 23, 2002

Request from: Jwain C. White, P.E., Biagi, Chance, Cummins, London, Titzer, Inc., Consulting Engineers, 601 Main Street, Shelbyville, KY 40065 (E-mail: white@BCCLT.com)

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 6.3.6.1, Exhaust Air Energy Recovery.

Background: Section 6.3.6.1 requires energy recovery with at least 50% effectiveness for supply fan systems over 5,000 cfm and 70% outside air. The energy recovery effectiveness is explicitly defined in terms of enthalpy differences. This apparently restricts such systems to enthalpy wheels. However, the ASHRAE 90.1-1999 User's Manual regarding this section (page 6-74) states, "For sensible heat exchangers, the designer may replace enthalpy with dry bulb temperature [in the equation] to calculate recovery effectiveness." This suggests the standard allows run-around coils and other sensible-only heat recovery technologies.

Question: Was the intent of this section in the standard to require energy recovery systems with "total" (enthalpic) effectiveness of at least 50%, or to allow systems with "sensible" effectiveness of at least 50%?

Answer: The intent of the standard is to require energy recovery systems that provide an energy recovery effectiveness of at least 50%, based on the enthalpy difference between outside and return air conditions.

Comment: The standard's energy recovery performance requirement may be met using any energy recovery technology; it is not limited to enthalpy wheels that directly achieve both sensible and latent heat recovery. Using a winter heat recovery example, if a sensible-only energy recovery technology is applied, its sensible effectiveness must be sufficient to achieve a dry-bulb temperature rise in the outside air as it passes through the recovery device so that the supply air leaving the device has achieved and enthalpy rise of at least 50% of the outside air, return air enthalpy difference. In practice, this means that if a sensible-only recovery technology is used, its sensible efficiency may have to be greater than 50% in order to achieve the required 50% total (or enthalpic) energy recovery effectiveness.

However, for summer outside air cooling, sensible energy recovery devices may only meet the 50% total energy recovery requirement in cool dry summer climates. In most warm and hot climates, both dry and humid, a total energy, enthalpy recovery device will be required to meet the performance requirement of the standard.

INTERPRETATION IC 90.1-2001-8 OF ANSI/ASHRAE/IESNA STANDARD 90.1-2001 Energy Standard for Buildings Except Low-Rise Residential Buildings

June 24, 2002

Request from: Scott E. Frank, Jaros Baum & Bolles, 80 Pine Street, New York, New York 10005 (E-mail: franks@jbb.com)

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 9.3.1.2, relating to interior lighting power allowance.

Background: Table 9.3.1.2 provides maximum lighting power allowances for various space types, as a function of building type, as part of the space-by-space method of calculation. For Office type buildings, one of the specific space types is "Banking Activity Area".

Interpretation: Banking Activity Areas include dedicated floors or portions of a floor of an office building utilized for financial services trading operations which include densely arranged work surfaces configured without dividing partitions, each containing multiple computer terminal displays and specialized telephone turret systems.

Question 1: Is this interpretation correct?

Answer 1: No.

Question 2: This interpretation holds true for both 90.1-1999 and 90.1-2001.

Answer 2: Yes.

Comments: In preparing Section 9 of the standard for the term "Banking Activity Area" it was the intent of the project committee to refer only to the teller area of a commercial banking service facility.

INTERPRETATION IC 90.1-2001-9 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

January 26, 2003

Request from: Mick Schwedler, PE (E-mail: Mschwedler@trane.com), Trane, 3600 Pammel Creek Road, La Crosse, WI 54601-5199, and Wayne Morris (E-mail: Wmorris@trane.com), Trane, PO Box 10271, Macon, GA 31206.

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 6.3.1 Economizers, specifically Exception 6.3.1i relating to the cooling efficiency and the efficiency requirements in Table 6.1.3.

Background:

(The background information provided is meant to reduce the time SSPC 90.1 needs to find the relevant sections in the standard.)

"**6.3.1 Economizers**. Each cooling system having a fan shall include either an air or water economizer meeting the requirements of 6.3.1.1 through 6.3.1.4.

Exceptions to 6.3.1: Economizers are not required for the systems listed below…

(i) Where the cooling efficiency meets or exceeds the efficiency requirements in Table 6.1.3."

Table 6.1.3 (Partial)

Table 6.1.3 gives the following information for its "Other Unitary Systems" section.

Other Unitary Systems							
System Size (kBtuh/h)	**Mandatory Minimum EER**	**Cooling Degree-Days (CDD50)**					
		0-3600	**3601-5400**	**5401-7200**	**7201-9000**	**9001-10800**	
		Minimum Cooling Efficiency Required (EER)[a]					**Test Procedure[c]**
≥ 65 and < 135	10.3	N/A[b]	12.5	12.0	11.5	11.0	ARI 210/240
≥ 135 and ≤ 240	9.7	N/A[b]	11.5	11.1	10.6	10.1	ARI 340/360
> 240 and < 760	9.5	N/A[b]	11.2	10.7	10.3	9.9	

[a]Each EER shown below should be reduced for units with a heating section other than electric resistance heat.
[b]Elimination of required economizer is not allowed.

[c]Section 12 contains complete specification of the referenced test procedure, including the referenced year version of the test procedure.

Table 6.2.1A (Partial)

Table 6.2.1A Shows the following efficiency requirements for various pieces of equipment. (For simplicity other columns are not shown here, and only the "Electric Resistance (or Non) Heating Section type Efficiencies are shown.)

Equipment Type	Size Category	Minimum Efficiency
Air Conditioners Air-Cooled	<65,000 Btu/h	10.0 SEER
	≥ 65,000 Btu/h and < 135,000 Btu/h	10.3 EER
	≥ 135 Btu/h and ≤ 240 Btu/h	9.7 EER
	> 240 Btu/h and < 760 Btu/h	9.5 EER
Air Conditioners, Water and Evaporatively Cooled	<65,000 Btu/h	12.1 EER
	≥ 65 Btu/h and < 135 Btu/h	11.5 EER
	≥ 135 Btu/h and ≤ 240 Btu/h	11.0 EER
	> 240 Btu/h and < 760 Btu/h	10.8 EER

Background from ASHRAE/IESNA Standard 90.1-1999 User's Manual

Page 6-41, Section 6.3.1i states the following

"i) *High-Efficiency Unitary Equipment Exception*
Where installed in climates with more than 3,600 CDD50, unitary air-cooled cooling equipment that has energy efficiency ratios that meet or exceed the efficiency requirements in Table 6.1.3 are not required to have economizers."

Exception 6.3.1i uses Table 6.1.3 and excepts an economizer from being required if "Unitary" equipment reaches a specific, climate and size dependent efficiency that is greater than the minimum required efficiency.

1. The User's Manual (page 6-41) explicitly states that exception 6.3.1i applies to air-cooled equipment. The manual was approved for publication by SSPC 90.1 and ASHRAE.
2. The Mandatory Minimum EER's in Table 6.1.3 and the ***Air Cooled*** Minimum Efficiency requirements in Table 6.2.1A are the same. This implies the Table 6.1.3 is to apply only to Air Cooled equipment.
3. In Table 6.2.1A, the efficiency for a Water Cooled or Evaporatively Cooled Air Conditioners ≥ 240,000 Btu/h (with electric resistance heat) is 11.0 EER. If Table 6.1.3 was meant to apply to this size and type of equipment, one would be excepted from the economizer requirement in any location that had 5401 or greater CDD(50). We don't believe this is the committee's intent.

We therefore conclude that the term "Unitary" as used in Table 6.1.3 is meant to apply only to "Air-Cooled Unitary" Systems.

Interpretation 1: Exception 6.3.1i and Table 6.1.3 are intended to be used only for air-cooled unitary equipment.

Question 1: Is this interpretation correct?

Answer 1: Yes

Comments 1:

Interpretation 2: This interpretation also applies to Section 6.1.3c with respect to evaporatively cooled unitary equipment.

Question 2: Is this interpretation correct?

Answer 2: No

Comments 2: As clarified in Question 1, Table 6.1.3 is only applicable to air-cooled unitary equipment. Hence, the exception in 6.3.1c also applies only to air-cooled unitary equipment.

Interpretation 3: These interpretations hold true for both 90.1-1999 and 90.1-2001.

Question 3: Is this interpretation correct?

Answer 3: Yes

Comments 3: Additional Information: As a result of you request a change will be proposed to modify the title of Table 6.1.3 to "Other Air-Cooled Unitary Systems".

INTERPRETATION IC 90.1-2001-10 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

January 25, 2004

Request from: Arthur Hallstrom (E-mail: ahallstrom@mail.ashrae.org), Trane, 1515 Mercer Rd., Lexington, KY 40511

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 6.2.3.3.4 and in the accompanying Table 6.2.3.3.4 “Maximum Damper Leakage”.

Background: In the industry there are rectangular and round outside air dampers. Round dampers have OA flow measuring features and typically have a higher design velocity then rectangular dampers. Ball park, 2500 fpm round versus 1000 fpm rectangular. The higher velocity is needed to get an accurate flow reading. The 90.1 leak rate formula is based on square foot of damper. A smaller round damper is therefore required to have a much lower leak rate since the damper surface area is smaller.

Interpretation: The intent of the 90.1 standard was to limit total cfm leak rates. A round damper leak rate is acceptable if it's leak volume is equal or less then the rectangular damper leakage volume used in the same size air handler or rooftop.

Question: Is this interpretation correct?

Answer: No

Comment: While the intent of this section of the standard is to limit the total volume of air leakage through a damper, as currently written, the standard accomplishes this by specifying maximum leakage rates per unit of damper face area. This is the value that is published in AMCA Standard 500, which is the test standard mandated in 6.2.3.3.4 of ASHRAE Standard 90.1. This requirement does not distinguish between damper shapes. If round dampers are used, at higher face velocity than would be feasible with rectangular dampers, it is true that the absolute leakage rate permitted would be lower than for the rectangular dampers. However, the round dampers would be smaller, and thus even at a cost premium per unit area, may not increase absolute cost relative to rectangular dampers. Another important factor is enforcement. By specifying maximum leakage rates, that a particular damper’s published leakage rating either meets, or does not meet, Standard 90.1 creates a specific requirement that a building official can easily check.

INTERPRETATION IC 90.1-2001-11 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

January 25, 2004

Request from: Steve Tredinnick, P.E. (E-mail: stredinnick@aeieng.com), Affiliated Engineers, Inc., PO Box 44991, 5802 Research Park Boulevard, Madison, WI 53744-4991.

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 6.3.3.1 Fan Power Limitation, and Table 6.3.3.1, specifically relating to fan power limitation ratios.

Background: For HVAC systems having a *fan system power* exceeding 5 hp, Section 6.3.3.1a states, "The ratio of the fan system power to the supply fan airflow rate (main fan) of each HVAC system at design conditions shall not exceed the allowable fan system power shown in Table 6.3.3.1." Furthermore, Table 6.3.3.1 indicates maximum allowable nameplate motor horsepower based on either constant volume systems or variable air volume system at a low (<20,000 cfm) and high (>20,000 cfm) supply air flow rates.

These limitations are obtainable for standard office air handling units (AHUs), but are difficult or impossible to obtain for AHUs serving laboratories. Lab spaces require high airflow rates and high outside air percentages or even 100% outside air. Achieving the horsepower rating is still difficult even when the AHU serves adjacent office or administration spaces and does not serve 100% lab space.

High percentages of outside air required for labs result in static pressure requirements that exceed those required by AHUs serving office spaces due to:

- Increased cooling and dehumidification loads requiring greater heat transfer surface area at cooling coils.
- Increased heating loads requiring greater heat transfer surface at preheat coils.
- Potential of inclusion of heat recover coils at AHUs.
- Higher filter pressure drops due to higher levels of filtration as compared to an office.

Furthermore, the relief fan credit component calculation listed at the end of Section 6.3.3.1 is of no assistance in this matter due to the high percentage of outside air to makeup for the high exhaust airflows and hence very little or no return airflow.

Interpretation: Section 2.3c notes that the provisions of the standard do not apply to "equipment and portions of building systems that use energy primarily to provide for industrial, manufacturing, or commercial processes".

Our interpretation is that Section 6.3.3.1 and the fan power limitation ratios listed in Table 6.3.3.1 do not apply to laboratory AHU systems since they are "process" type applications and outside the intended scope of the Standard.

Question: Is this interpretation correct?

Answer: No

Comments: Section 6.3.3.1 Fan Power Limitation and fan power limitation in Table 6.3.3.1 applies to laboratories unless they serve industrial, manufacturing, or commercial processes. Additionally it is important to restate Section 2.5 which requires "This standard shall not be used to circumvent any safety, health, or environmental requirements."

INTERPRETATION IC 90.1-2001-12 OF
ANSI/ASHRAE/IESNA STANDARD 90.1-2001
Energy Standard for Buildings Except Low-Rise Residential Buildings

January 25, 2004

Request from: Kenneth M. Fulk, PE (E-mail: KFulk@rwb.net), Reed Wells Benson & Company, 1400 E. Exchange Parkway, Allen, TX 75002.

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IESNA Standard 90.1-2001, Section 5 Building Envelope, specifically Sections 5.1.4, 5.2.1, 5.3.1d, 5.3.1.4 and Figure 5.3 relating to floor insulation.

Background: Section 5.3.1.4 requires floor insulation per requirements specified in Table 5.3; further delineated in Tables B-1 through B-26. Floors over a ventilated crawl space under Table B-8 (North Central Texas-Dallas), as an example, (Residential) require a continuous insulation system with an R-Value of 6.3 for mass floors, R-19 for steel joist and wood framed floors. Architects are requesting assistance from engineers on how to meet the Standard. Structural engineers indicate that they can not provide for continuous insulation in or above a mass floor condition. Currently it is being suggested that insulation below the structure is the only way to meet the Standard. Most Steel joist systems (a very common structural system) have fluted steel pans laying on top of the joists. Batt insulation between joists allows airflow above the insulation through the flutes and joists. Crawl space conditions further have a high moisture content that severely reduces the effectiveness of this insulation system. Crawl spaces need to be ventilated to reduce the moisture level therein which does allow outside air into this cavity. However, there are many days and hours throughout the year where the cool ground temperature in this area is actually beneficial. The effectiveness of the required insulation system (wet and porous with significant air bypass), the added cost to install it and the potential counterproductive result have raised questions about the proper way to handle insulating these floor systems economically and effectively.

Interpretation 1: For mass floors the insulation shall be on the interior above the slab/structure or on all exposed surfaces below the floor including beams that extend 24 inches and less below the exposed floor. Structural Engineers tell us the insulation must be installed underneath the structure without exception. The Standard suggests otherwise. For steel joist floors the insulation value is for uncompressed insulation installed in the cavity between the steel joists or for sprayed on insulation. This can also be continuous insulation where uninterrupted by framing, either above the floor structure or below the framing cavity completely filled with insulation. We interpret that batt insulation, meeting the R-value listed, suspended between the joists complies. Please note that this type of insulation will be in a high humidity space, will have a questionable installation quality and will have air bypassing the insulation up through the joists and floor pan system.

Question 1: Is this interpretation correct?

Answer 1: Your interpretation is primarily correct, but you have mixed competing issues. Your analysis of the results of using batt insulation in a vented crawl space is also correct – that there will be moisture problems. For a complete answer, the following must be considered:

1. Section 3.2 includes the following definitions:
   - *mass floor*: a floor with a heat capacity that exceeds (1) 7 Btu/ft^2 ºF or (2) 5 Btu/ft^2 ºF provided that the floor has a material unit mass not greater that 120 lb/ft^3.
   - *steel joist floor*: a floor that (1) is not a mass floor and (2) that has steel joist members supported by structural members.

   In other words, if a floor meets the HC requirements above, it is considered a mass floor even if it is supported by steel joists – it is not considered a steel joist floor.

2. Section 5.3.1.4.a requires that for a mass floor "Where framing, including metal and wood joists, is used, compliance shall be based on the maximum assembly *U-factor* rather than the minimum *rated R-value of insulation*." Therefore, if the floor is a mass floor, batt insulation meeting the R-value listed in not acceptable as a basis for compliance. You must use the slightly more complicated, but more accurate, method of calculating the overall U-factor for the assembly and compare that to the U-factor listed.

3. The second portion of your stated interpretation quotes directly from Section 5.3.1.4.b of the Standard for a steel joist floor and is correct that uncompressed batts between framing members complies for the first rated R-value (the only rated R-value currently in Tables B-1 through B-26). However, as stated above, for mass floors the requirements of Section 5.3.1.4.b do not apply.

4. Standard 90.1 does not give guidance for moisture control in conjunction with allowable insulation strategies. There are problems in the assumptions made and the batt insulation solution proposed. Although the project's structural engineer may not allow interior insulation, the Standard does allow this as stated above, and there are several methods for providing insulation above the structure. Extruded polystyrene may be selected with a second wearing slab, cement board or self-leveling underlayment installed above the insulation layer. Extruded polystyrene can be purchased in various compressive strengths appropriate for most bearing conditions. Interior insulation likely to be the best solution because it will avoid the moisture and thermal bridging problems discussed below.

   The choice of venting the crawl space and insulating with batt insulation almost ensures moisture problems. (Once again, if you select this option, compliance requires the use of the U-factor rather than using the minimum R-value.) In your climate, the crawl space will be vented with high moisture content air much of the year. That moisture reduces the effectiveness of batt insulation and the moisture may come in contact with a surface cooled below the dew point by air conditioning or climate conditions, causing condensation, mold growth and corrosion. A better strategy for that climate is to insulate the perimeter walls, provide an unvented crawl space and control ground moisture using a taped polyethylene ground cover. This effectively brings the crawl space inside the thermal envelope and keeps the moisture out of the envelope.

   Assuming you still want to vent the crawl space and insulate the floor from the underside, a better solution would be a closed-cell spray foam insulation, such as spray polyurethane foam (SPF), instead of the glass-fiber batt solution proposed. The SPF would act as an air and vapor barrier as well and will reduce the potential of moist air coming in contact with condensing surfaces (so long as thermal bridges are accounted for, by adding insulation at the joists).

Interpretation 2: This interpretation holds true for both 90.1-1999 and 90.1-2001.

Question 2: Is this interpretation correct?

Answer 2: Yes, with the comments above.

ERRATA SHEET FOR REPRINT 12/03 AND ALL PREVIOUS EDITIONS
ANSI/ASHRAE/IESNA STANDARD 90.1-2001 (I-P edition)
Energy Standard for Buildings Except Low-Rise Residential Buildings

May 20, 2004

The corrections listed in this errata sheet apply to the reprint of ANSI/ASHRAE/IESNA Standard 90.1-2001, I-P edition, identified as “86245 PC 12/03” on the outside back cover and to all earlier editions of the standard. The outside back cover marking identifying the previous reprints are “86245 PC 2/03”, “86245 PC 2/02” and is blank for the first printing.

More than one errata sheet may be required for a specific document. Please review the entire list on the ASHRAE website related to the applicable document and download all that apply.

NOTICE: ASHRAE now has a list server for Standing Standards Project Committee 90.1 (SSPC 90.1). Interested parties can now subscribe and unsubscribe to the list server and be automatically notified via e-mail when activities and information related to the Standard and the User’s Manual is available. To sign up for the list server please visit **Standards List Servers** on the Standards and Codes section of the ASHRAE website at http://www.ashrae.org/template/AssetDetail/assetid/22410.

Page(s)	Erratum
5	**Section 3.2 Definitions.** Delete the “*Design A*”, “*Design B*”, “*Design E*” definitions in Section 3.2.
22	**Table 5.3.2.3, SHGC Multipliers for Permanent Projections.** In the first column titled “Projection Factor” change all of the inequality signs from less than “<” to greater than “>”.
25	**Section 6. Heating, Ventilation, and Air Conditioning.** To be consistent throughout Section 6 (and with ASHRAE Standard 62) change all references to the term “outside air” to “outdoor air”. At minimum this affects Sections 6.1.3c, 6.1.3e, 6.2.3.2.4, Exception to 6.2.3.2.4(a), 6.2.3.3.3, 6.2.3.8, 6.3.1.1.1, 6.3.1.1.3, 6.3.1.1.4, 6.3.1.1.5, 6.3.1.2.1, Exception to 6.3.1.2.1, Exception to 6.3.2.1(a), 6.3.2.2.2a, 6.3.4.3, 6.3.6.1 and Table 6.3.1.1.3B.
27	**Table 6.2.1A, Electrically Operated Unitary Air Conditioners and Condensing Units-Minimum Efficiency Requirements.** In the sixth column titled “Test Procedure[a]” for equipment types “Air Conditioners, Air Cooled” and “Air Conditioners, Water and Evaporatively Cooled” change the test procedure for the size category “≥65,000 Btu/h and <135,000 Btu/h” from “ARI 210/240” to “ARI 340/360”.

28 **Table 6.2.1B, Electrically Operated Unitary and Applied Heat Pumps-Minimum Efficiency Requirements.** In the sixth column titled "Test Procedure[a]" for equipment types "Air Cooled (Cooling Mode)" and "Air Cooled (Heating Mode)" change the test procedure for the size category "≥65,000 Btu/h and <135,000 Btu/h" from "ARI 210/240" to "ARI 340/360".

59 **Table 10.2, Minimum Nominal Efficiency for General Purpose *Design A* and *Design B* Motors.** The terms "*Design* A" and "*Design* B" in the title should not be italicized. Also, add the following text to the current footnote "a" in Table 10.2: "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."

82, 83 and 84 **Tables A-13, A-14, and A-15.** In the third column change the heading from "Overall U-Factor for Entire Base Wall Assembly" to "Overall U-Factor for the Entire Base Floor Assembly".